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A MONTHLY JOURNAL FOR ENGINEERS, ARCHITECTS, SURVEYORS & CONTRACTORS and all interested in CEMENT, CONCRETE, REINFORCED CONCRETE, FIRE-RESISTING CONSTRUCTION and STRUCTURAL STEEL.

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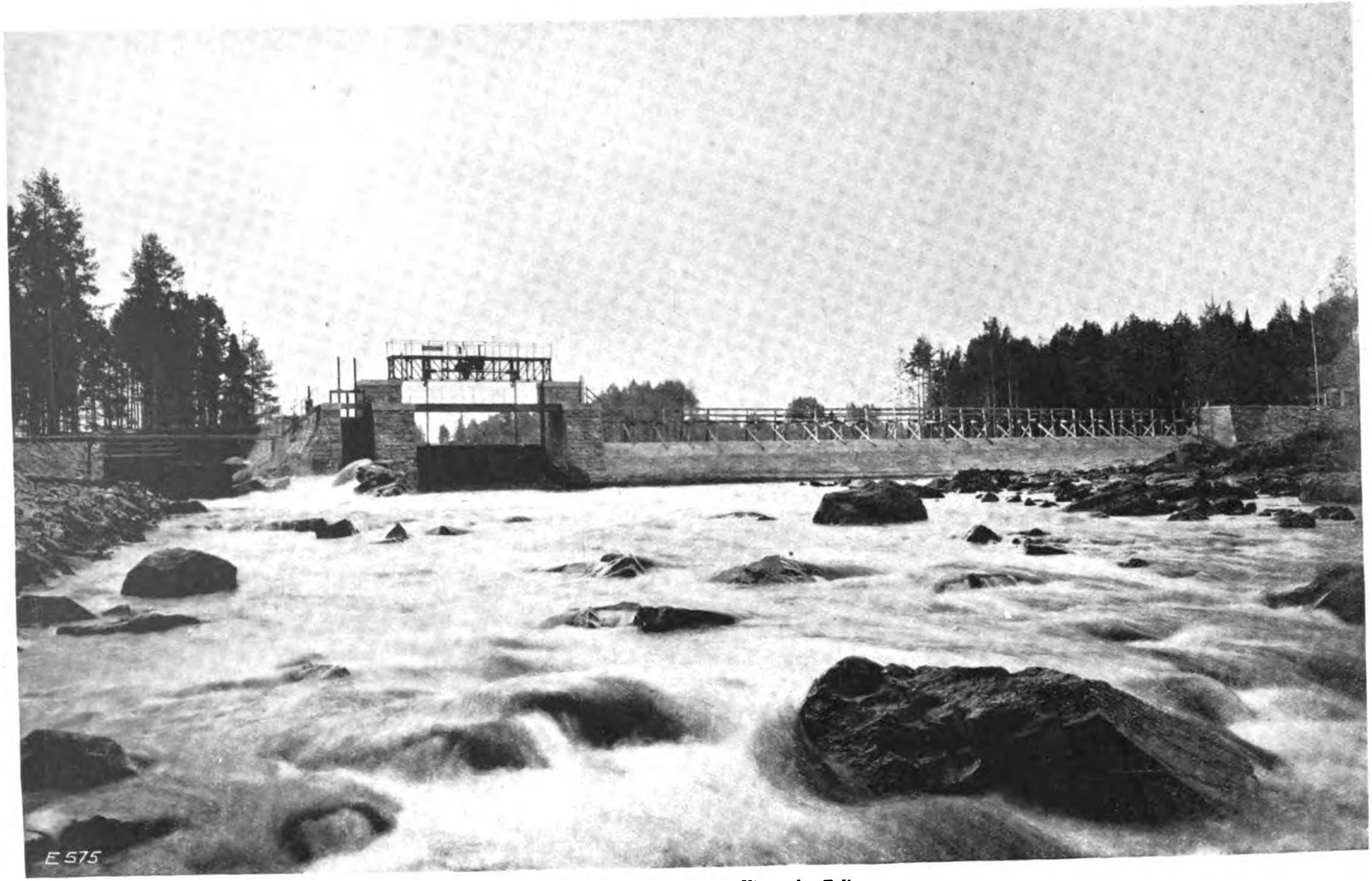


Reinforced Concrete Dam at Kingsadra Falls.

Reinforced Concrete Construction at the Swedish State Power Station at Alfkarleby.

(*For description see page* 23.)

CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume XII. No. 1. LONDON, JANUARY, 1917.

EDITORIAL NOTES.

THE STUDY OF CONCRETE WORK.

WE are at the beginning of the New Year, and we take the opportunity of wishing all our readers prosperity, and trust that ere another New Year's Day arrives we shall have secured a decisive victory, and the industry of the country will have entered into a new phase wherein energy and ability will meet with due reward. Many resolutions will no doubt have been made, all more or less of a worthy character, but we feel that there is one resolution in particular which should be earnestly made by those in whom we are interested, and that is to study concrete work seriously and earnestly. A good deal of progress has been made during the past few years, but there is still much to be done, and we are of the opinion that a more thorough study of the subject is necessary during the coming year if we are to keep pace with other nations in the practical application of scientific methods of building. A great future is in store for those who will make themselves thoroughly conversant with all the theory and practice of modern work, and this can only be accomplished by continual hard work; and in the case of architects and engineers it can truly be said that their days of study are not past until they cease to take an active part in professional life. The study of concrete work can be considered from two aspects—viz., practice and theory—and there is a great tendency to study one side of the subject without the necessary consideration of the conditions and limitations of the other. Those interested in concrete work may be broadly divided into students, architects, engineers and contractors. Students may belong to either of the other three classes, and specialists in reinforced concrete work will come under the heading of either engineers or contractors, or both, according to the nature and extent of their work.

The student who is at the beginning of his career has the finest opportunity of dealing with the important subject of concrete work, as he will have an open mind and can pursue a course of study—based on modern requirements—with a certain amount of consistency, and, not being hampered with the responsibilities of a practice, he will be able to devote sufficient time to the matter if he is ambitious and ready to make the necessary sacrifice of pleasure. He should not be dismayed or discouraged by the apparent complications of reinforced concrete calculations, but should be content to master the essential elementary principles in the first case, and from this he will find that he will be able to progress to a better understanding of advanced problems. He should lose no opportunity of studying actual works in progress, carefully noting all the details of design and execution, and when possible to obtain working drawings of actual schemes, these should be studied in preference to purely theoretical examples such as are often found in text-books. There are a few books available which deal with the theory of design in a simple manner suitable for the student, and it is preferable to work from one of these in the first instance, even if it is not a complete treatise on the subject. Personal tuition is always an advantage, especially to the beginner, but a great deal can be accomplished by the individual efforts of the student, and unless the subject is taken up very earnestly even the best personal tuition will be of little avail. A good knowledge of concrete work from the practical and theoretical side is absolutely essential to the student of building or engineering who is to achieve any marked success in the future, and he will be more than repaid for all the time spent in the study of the subject.

ARCHITECTS AND REINFORCED CONCRETE.

In the case of many architects there is a great tendency to look upon the study of concrete work as something which does not come within their sphere, and in this they make a great mistake. It is their duty to be conversant with any factor which may enter into the construction of a building for which they are responsible, as they cannot otherwise efficiently protect their clients' interests. We do not necessarily mean that all architects should design reinforced concrete and undertake work which is essentially part of the engineer's duty, but he should have sufficient knowledge to enable him to check any portion of the work and generally work in sympathy with the constructional designer.

At the present time many architects do not take sufficient advantage of the adaptability and usefulness of reinforced concrete, and the reason for this is that they do not understand the material and in consequence adhere to old-fashioned methods whether they are suitable or not. Such a state of affairs is not conducive to progress, and it is incumbent upon all architects to realise this fact and keep up to date if their practice is to extend. It will always be found that when an architect once obtains a knowledge of reinforced concrete work he will frequently use the material, to his own and the client's advantage. How often does the architect conscientiously study the practical side of concrete work ? Very seldom, and yet he is supposed to supervise the execution and ensure the best work. It is not possible to control and direct the actual operations unless one has a knowledge of aggregates, sand and cement, proportions, mixing, the amount of water to use, shuttering, the arrangement of the steel and methods of keeping in position, tamping, the time for striking shuttering, and such like matters, and real study is necessary to obtain such knowledge. The architect of to-day must first realise that concrete work is one of the essential factors in modern construction: he must then get in sympathy with the material, and such sympathy can only be present when there is understanding, and he must study the subject in such a thorough manner that he will be fitted to fill the post of master-designer and craftsman which is rightly his.

ENGINEERS AND REINFORCED CONCRETE.

Engineers generally have taken up the study of concrete work more heartily than architects, and this would naturally be expected, as it is so obviously within their sphere. In spite of this fact, however, there are still a number of engineers who are unable to design reinforced concrete, and some have practically no knowledge of the subject. A short time ago a civil engineer was heard to express the opinion that reinforced concrete was not at all a suitable material to employ for bridges, and upon the matter being taken up with him and several of the many excellent examples of work actually executed being put before him, he expressed surprise and admitted that he had no idea of the valuable characteristics of the material. This seems almost incredible in the case of a man who had been in the engineering profession for many years and who was apparently conversant with structural work. A large number of engineers do not study the practical side of concrete work sufficiently, and it would be a great advantage to progress if there were a closer co-operation between the engineer and the practical man. The absence of practical matters is very noticeable in the proceedings of the Concrete Institute and similar bodies, and the reason for this is probably due to the feeling that theoretical matters are more indicative of brain power and more in keeping with the dignity of the professional man. Theory without practical knowledge is, however, of very little use, and every engineer should have a *complete* knowledge of his subject.

There is another aspect of concrete work which calls for the attention of the engineer, and that is its application to buildings from the architectural standpoint. Very little sympathy appears to exist between engineers and architects, and this is due to the former looking upon construction purely from the utilitarian point of view, while the latter so often sacrifice utility to appearance. There should be more co-operation, and appearance and utility should be considered in relation to one another, because it is only on these lines that the highest results can be obtained.

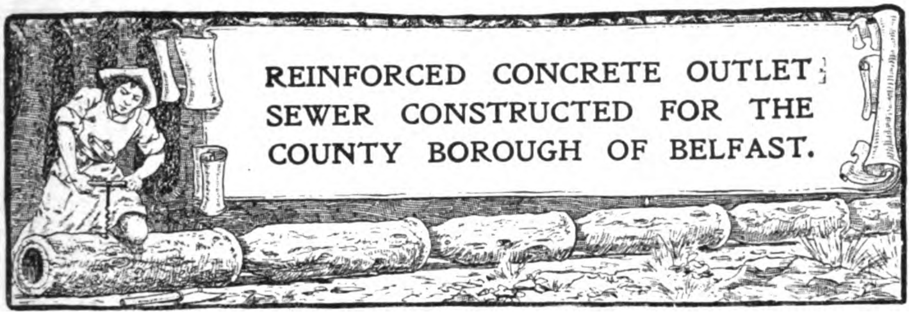
If the engineer would devote some time and thought to the design of concrete work so as to render it more generally in accordance with the principles of true architecture the material would become more universal, and there would be some sort of sympathy between the engineer and architect. The material is capable of great development as regards artistic design, as some examples will show, but a closer study of the subject is necessary.

THE CONTRACTOR AND REINFORCED CONCRETE.

So far as the contractor and practical man are concerned we would urge the necessity of studying the elementary theoretical principles of the design of reinforced concrete. In the supervision of this class of work it will be found that a profound ignorance prevails among foremen as to the junctions of the various parts of the steelwork, and the supervisor has to be very vigilant to prevent errors being made simply because of this ignorance. The practical man does not realise the importance of bending up a rod at a certain point and similar matters, because he does not understand any theory, and we have found that when the principles and reasons are explained in simple language more interest is taken in the execution of the work and errors are less frequent. These remarks apply not only to the foreman who has recently taken up reinforced concrete work but also to those who have carried out many schemes. There is a need for a theoretical guide written in simple language for the training of the practical man, and the progress of good concrete work would be assisted by such a guide.

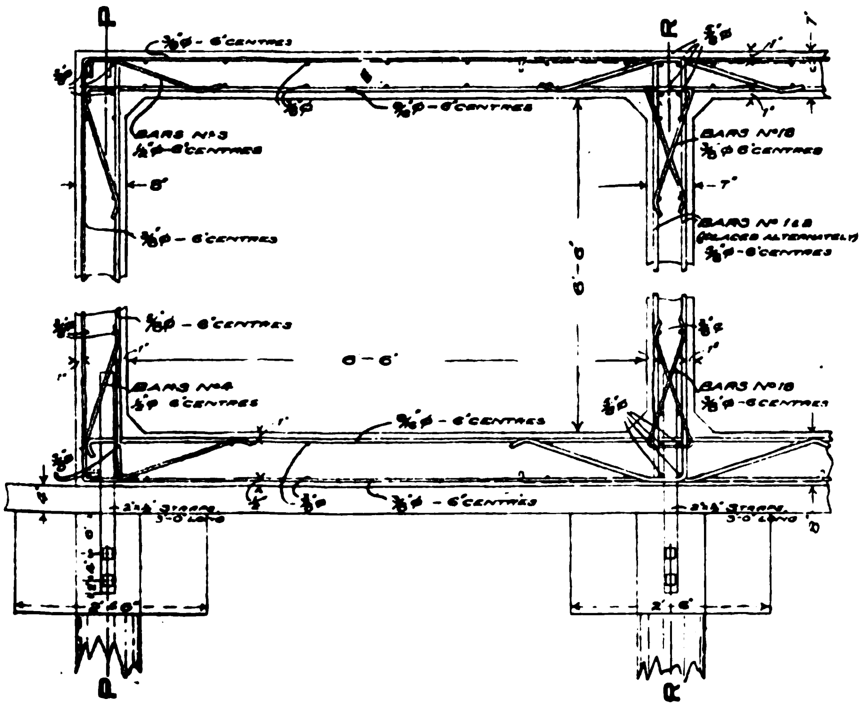
GENERALLY.

It must be remembered that all sections of the community are dependent on one another, and the designer is thus dependent on the practical man for the realisation of his scheme, and for this reason, if for none other, there should be closer co-operation and exchange of ideas, while each should study the work and interests of the other. Research and scientific study should be undertaken by all those who have the opportunity and means to take up the work, and knowledge gained by them in such study should be freely published for the benefit of their fellow-workers, generally, and not merely be gathered for individual purposes. In a very short time we may be again called upon to enter into world competition in designing and erecting buildings, bridges and other structures, and the areas that have suffered so severely during the war will prove a wide field for modern concrete work. In order to reap the full benefits of the opportunities that will be offered, and to maintain our position in the building industry, we must equip ourselves by thorough study, both as regards theory and practice, and the determination to succeed will ensure success if supported by genuine hard work and co-operation.



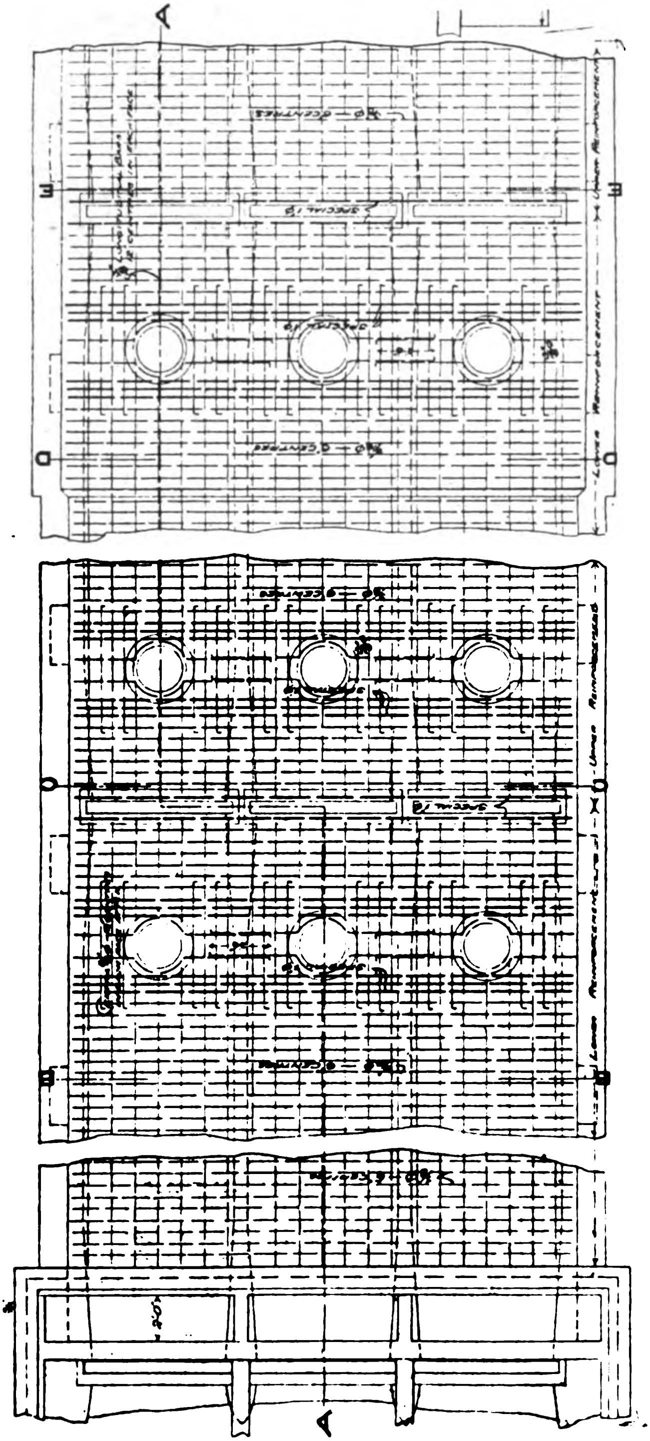
For the following interesting particulars and illustrations we are indebted to the City Surveyor of Belfast, Mr. Henry A. Cutler, M.Inst.C.E.—ED.

UNDER the Belfast Main Drainage Act, 1887, intercepting sewers were constructed to convey the sewage of Belfast, which was previously discharged by numerous outlets into the River Lagan, to one common outfall on the Antrim side of Belfast Lough, and storage tanks were constructed to impound



Cross Section BB.
REINFORCED CONCRETE OUTLET SEWER, BELFAST

the sewage as the period of discharge was limited to the first three and a half hours of each ebb tide. So that the sewage should not be discharged on tidal lands an outlet sewer, one mile long, was constructed across the foreshore to discharge into the Whitehouse Roads. The outlet sewer consisted of two tubes

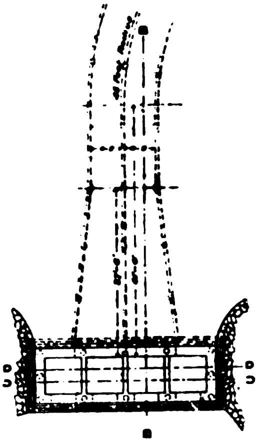


At Mouth.

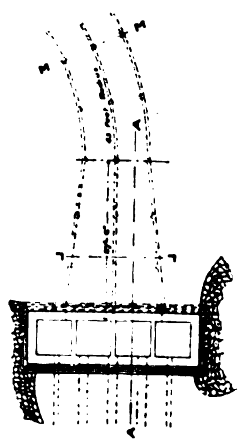
At Penstock Frames.

At Junction Chamber.

Plan showing Reinforcement of Top Slab.

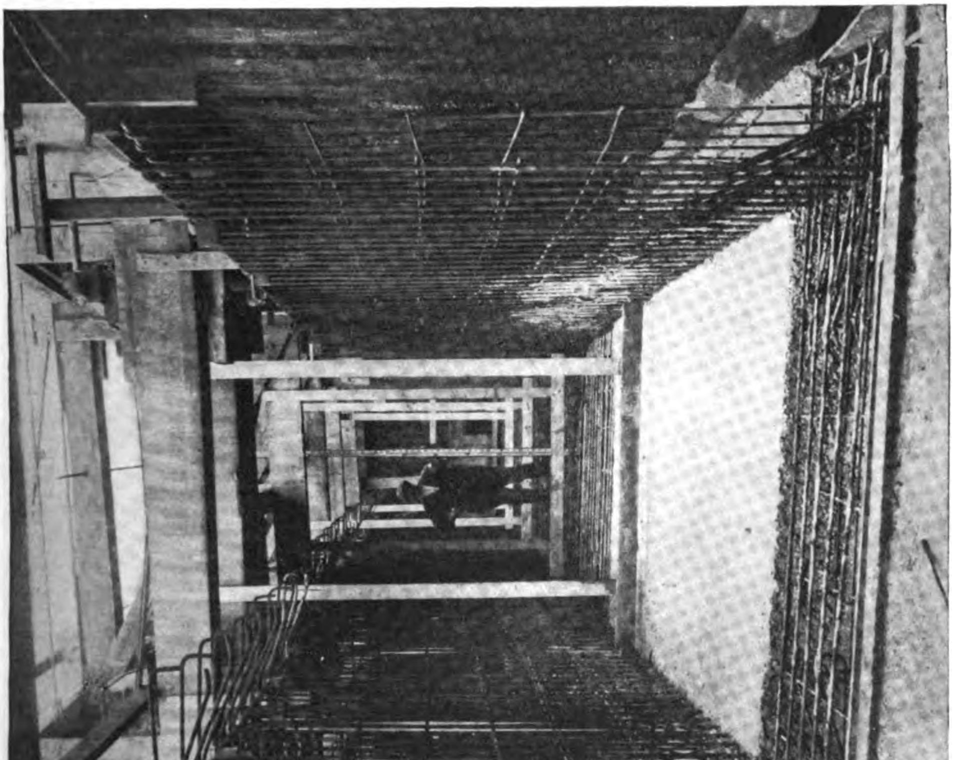


Plan.
Junction of Outlet Sewer with existing Penstock Chamber.

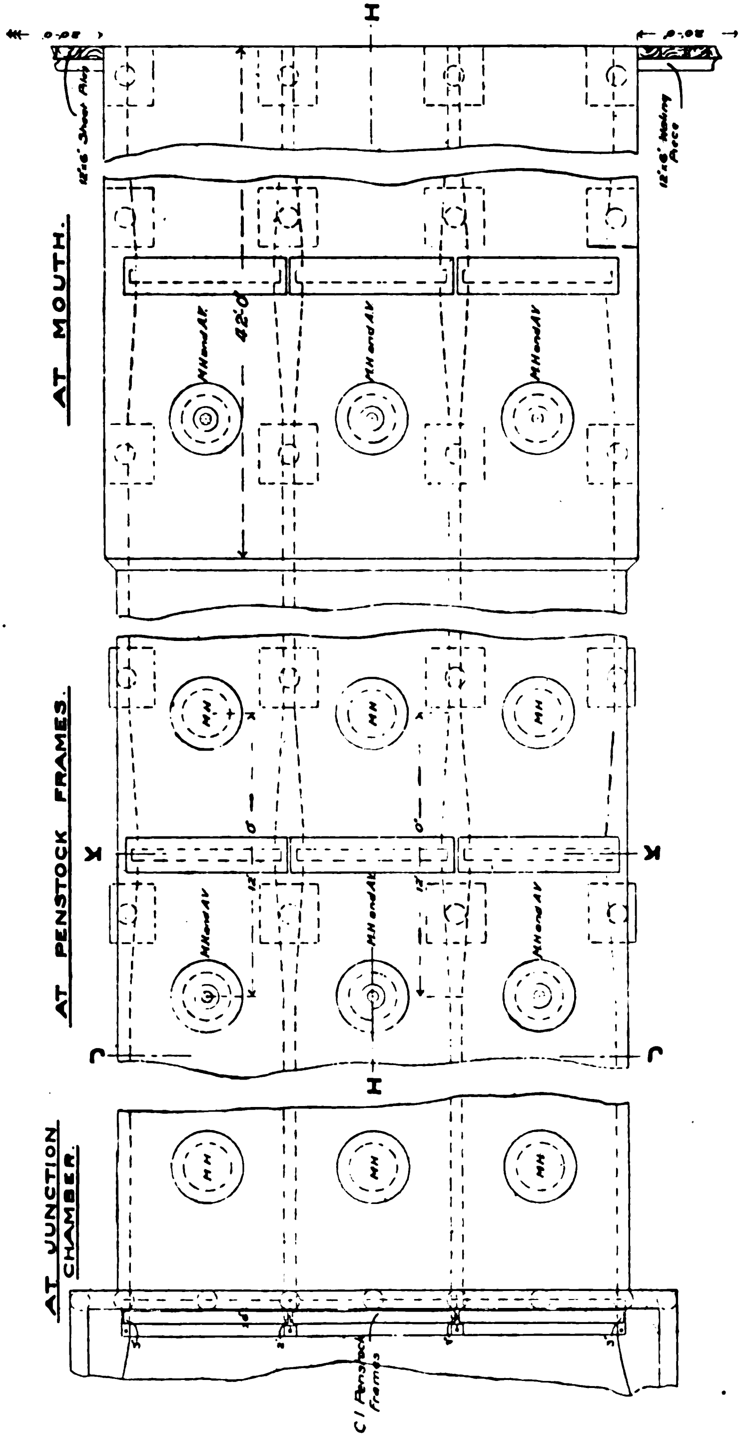


Plan.
Junction of Outlet Sewer with existing Penstock Chamber.

REINFORCED CONCRETE OUTLET SEWER, BELFAST.



Reinforcement to Walls and Floor.
REINFORCED CONCRETE OUTLET SEWER, BELFAST.

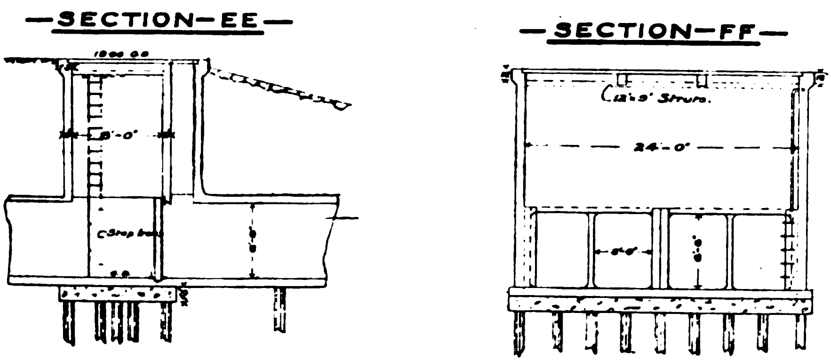


Part Plan, showing Penstocks, Man Holes and Air Valves.
REINFORCED CONCRETE OUTLET SEWER, BELFAST.

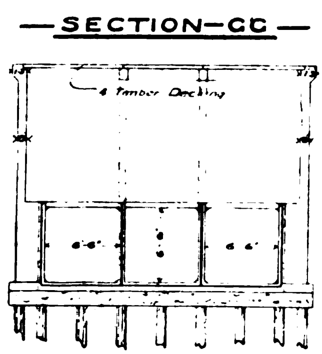
each 8 ft. by 4 ft., and was constructed of timber, but it was never satisfactory and has always been expensive to maintain.

In 1911 Parliamentary powers were obtained for carrying out various works, including a new outlet sewer of reinforced concrete to replace the original wooden structure.

In the Corporation Act of 1899 a clause was inserted providing for the



Section for Penstock and Junction Chambers.



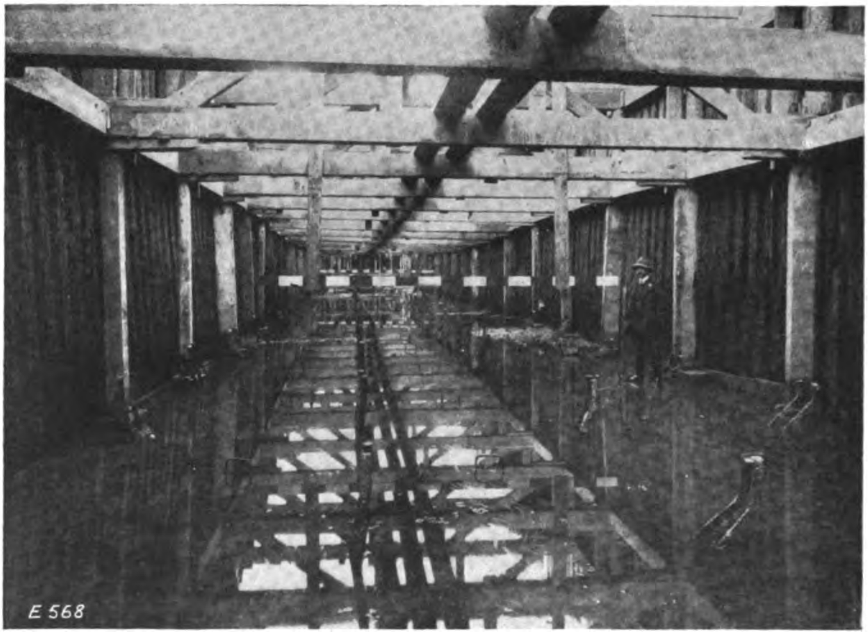
Section for Penstock and Junction Chambers.

REINFORCED CONCRETE OUTLET SEWER, BELFAST.

purification of the sewage before discharge into the Lough, and as the sewage is now all sedimented the outlet sewer only discharges effluent and storm water. The new structure has three tubes, 6 ft. 6 ins. square, constructed *in situ*, it is anchored down to timber piles to prevent flotation when the penstocks are closed and culverts pumped out for cleaning. The underside of the structure at the outlet end is 4·08 ft. below O.D. and the tide levels are as follows:—

Average high-water level (spring tide) 13·1 ft. above O.D.
Highest tide known 17·76 ft. above O.D.
Average low-water (spring tide) 3·69 ft. above O.D.

As the whole site of the culvert is covered with water at half-tide the work had to be carried out in coffer-dams, and borings, which were made before the work was commenced, showed that the sub-soil into which the piles had to be driven consisted of from 20 to 30 ft. of estuarine clay, locally known as sleetch. overlaying sand. To enable the work to be carried out at all states of the tide it was necessary that a gangway should be constructed above high-water connecting the work with the shore, and to save the expense of temporary



Inside of Coffer-dam looking towards mouth.
Reinforced Concrete Outlet Sewer, Belfast.

work it was decided to make use of the timber anchor piles for the purpose of the gangway.

The work was commenced by first partly driving the whole of the anchor piles (which were in four rows, the piles being 10 ft. apart in each row), leaving their heads well above high-water. The pile driving was started at the shore end, the gangway being constructed on the tops of the piles as the pile driving proceeded, and when the whole of the piles had been thus driven and the gangway constructed the coffer-dam was commenced at the seaward end. To facilitate construction, and to enable the culvert, if ever required, to be cleaned out, sets of three penstock frames were built in at distances of about 320 ft., and as the first length of coffer-dam was about 400 ft. it embraced the end of the culvert and two sets of penstock frames.

REINFORCED CONCRETE OUTLET SEWER, BELFAST.

The temporary sheet piling for the coffer-dam was supplied by the Ransome VerMehr Machinery Co., and had to be driven to about 20 ft. below the bottom of the excavation before the work could be satisfactorily proceeded with. When the first dam had been enclosed the anchor piles were re-driven to the depth required, the earth inside the dam excavated and the gangway removed, the framing for the dam being put in as the excavation proceeded. After the excavation was completed the anchor piles were cut off to their proper level and iron anchors bolted to them and surrounded with concrete.

When the coffer-dam was first constructed the toes of the sheet piles were only 10 ft. below the excavated level, but as a rise and fall of the bed inside the dam of about $\frac{1}{4}$ in. occurred with each tide and caused cracks in the concrete before it had time to set it was necessary to re-drive the sheet piles to the depth already mentioned. To avoid any cracking in the culvert due to elasticity of the bottom it was decided to put 12 ins. of base concrete under the ferro-concrete structure, and although cracks did appear in such concrete all movement ceased when it was set, enabling the ferro-concrete work to be constructed without cracks and without the slightest difficulty.

A length of about 400 ft. of the triple culvert has been completed and tested and the coffer-dam drawn, but as owing to the war it has been impossible to obtain materials and labour the work is now practically at a standstill.

The work was designed by Mr. Henry A. Cutler, M.Inst.C.E., City Surveyor, Belfast, and is being carried out by Messrs. J. and R. Thompson, Ltd., contractors, Belfast, under the superintendence of Mr. F. W. Lucas, who is acting as Resident Engineer.

PROBLEMS IN THE THEORY OF CONSTRUCTION.

WIND STRESSES IN BUILDING FRAMES (II.)

By EWART S. ANDREWS, B.Sc.Eng.

The question of wind stresses is one which claims the special attention of engineers, and therefore the following article, which is a continuation of one which appeared in our journal last November, will no doubt be read with interest.—ED.

In an article upon the above subject in Concrete and Constructional Engineering for November, 1915, we explained the "continuous portal" method of determining the stresses in a building frame due to wind forces, and stated that, while the method does not profess to be exact, it may be taken as the best simple one to adopt. We may mention that this method is stated by Professor Ketchum to be the one in most common use in America; and it is in American practice in the past that the present problem has mostly arisen. Shortly after the article had been passed for Press we received a copy of *University of Illinois Bulletin,* No. 80,* on "Wind Stresses in the Steel Frames of Office Buildings," by Messrs. W. M. Wilson and G. A. Maney.

This bulletin comprises a very elaborate and exhaustive examination of the subject, based upon the slopes of the various members under deflection, and contains some experimental verification of the results, although the experiments are not very exhaustive. The authors compare the results of their theory, which is too complicated for the purposes of ordinary practical design, with those obtained by their proposed approximate method and with four other approximate methods—Fleming's three methods (referred to in our previous article) and Smith's method—at present employed in practical design. The method last named is outlined in a paper by Professor Albert Smith in the *Journal of the Western Society of Engineers,* Vol. XX.; this paper contains an application of the principle of least work to the determination of these stresses, and is concerned with that more than with the approximate method.

According to Wilson and Maney's investigations, the continuous portal method, which we explained in the previous article, is unreliable, and Smith's method is much more reliable, though not so accurate as their proposed approximate method. In the present article we propose to explain Smith's method and to illustrate it with reference to the same numerical example as we considered in the previous article. Wilson and Maney's proposed approximate method, although considerably shorter than the complete theory, is very much longer than Smith's method, and necessitates a knowledge of the relative sizes of the various beams and girders composing the frame, as well as the use of special diagrams, for which we must refer the reader to the bulletin.

* Chapman & Hall, Ltd., London.

Assumptions made in Smith's Method.—These are as follows:—

(1) That the vertical forces in internal columns are zero and in external columns are equal and opposite.

(2) That the points of contraflexure of each column is midway between the floor levels.

(3) That the point of contraflexure of each beam is at its centre.

(4) That the horizontal or shear force in each internal column at a given level is equal, and that in each external column is one-half that on each internal column at the same level.

Fig. 1 shows the forces (in thousands of pounds or kips) on and points of contraflexure of the columns on these assumptions, and also the points of contraflexure in the beams.

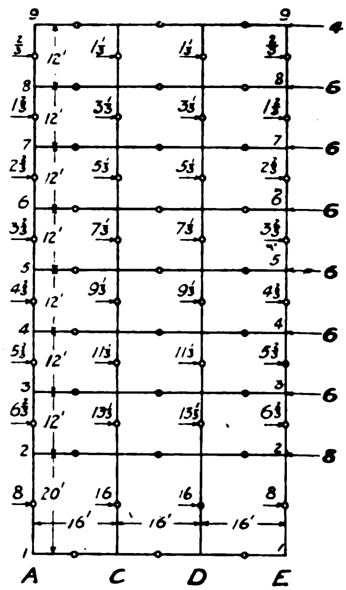


Fig. 1.

We will deal in order with the forces and bending-moments on the various members:—

Vertical Forces in Columns.—Taking moments about the intersection of the vertical centre line with the horizontal line through the points of contraflexure, we have for the top storey, since the vertical forces in the Columns *C* and *D* are zero,

$$E_{8,9} \times 24 - A_{8,9} \times 24 = 4 \times 6 = 24$$

but since the forces in the columns are equal and opposite, $E_{8,9} = -A_{8,9}$

$$\therefore E_{8,9} = \frac{24}{24 \times 2} = \cdot 5 \text{ kips (tension)}$$

$$A_{8,9} = \cdot 5 \text{ kips (compression)}$$

Similarly at the line through the points of contraflexure of the column 7,8, we shall have

$$48\ E_{7,8} = 4 \times 18 + 6 \times 16 = 108 \text{ ft.-kips}$$

$$\therefore E_{7,8} = \frac{108}{48} = 2{\cdot}25 \text{ kips (tension)}$$

$$A_{7,8} = 2{\cdot}25 \text{ kips (compression)}$$

and so as for succeeding columns the results coming as tabulated below in comparison with the results of the continuous portal method.

Column No.	Vertical Forces in Columns (Kips).			
	Inside Columns.		Outside Columns.	
	Smith's Method.	Continuous Portal Method.	Smith's Method.	Continuous Portal Method.
8,9	0	0·15	0·50	0·45
7,8	0	0·675	2·25	2·025
6,7	0	1·65	5·5	4·95
5,6	0	3·07	10·25	9·22
4,5	0	4·95	16·5	14·85
3,4	0	7·27	24·25	21·82
2,3	0	10·05	33·5	30·15
1,2	0	14·55	48·5	43·65

Horizontal or Shear Forces in Columns.—Taking the columns in the length 6, 7 as an example, the total horizontal or shear force above it is 16 kips. Each internal column takes twice as much horizontal force as an external column, so that the forces are in the order 1 : 2 : 2 : 1—*i.e.*, each external column takes one-sixth and each internal column one-third of the total horizontal or shear force in that length of column. In the length 6, 7, therefore, the force on each external column $= \frac{16}{6} = 2\frac{2}{3}$ kips, and that internal columns $= \frac{16}{3} = 5\frac{1}{3}$ kips. The values for the other columns are shown in *Fig.* 1.

Bending Moments in Columns.—The bending moments on the outside columns will be in this case one-half of those on the inside columns. As in the previous method, we obtain the bending moments by imagining the columns to be cut through at the points of contraflexure, at which act equal and opposite forces of magnitude equal to the shearing forces. The top half of the column A 8, 9, for instance, is regarded as a cantilever, having at its point of contraflexure an isolated load equal to two-thirds of a kip, so that the bending moment at the top is equal to $\frac{2}{3} \times 6 = 4$ ft.-kips. The corresponding bending moment in the interior columns will be twice this, the resulting bending moment diagrams then coming a number of triangles, as shown in *Fig.* 2, and the results as tabulated below:

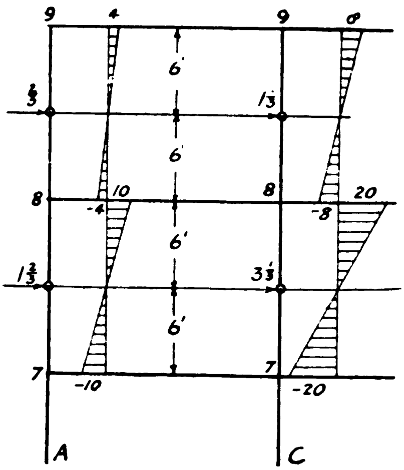


FIG. 2.

Column No.	Bending Moments in Columns in Ft.-Kips.			
	Inside Columns.		Outside Columns.	
	Smith's Method.	Continuous Portal Method.	Smith's Method.	Continuous Portal Method.
8,9	8	6	4	6
7,8	20	15	10	15
6,7	32	24	16	24
5,6	44	33	22	33
4,5	56	42	28	42
3,4	68	51	34	51
2,3	80	60	40	60
1,2	160	120	80	120

Bending Moments on Beams.—The forces and bending moment diagrams for the beams at the level 6-6 are shown on *Fig.* 3. The forces are shown in the reverse direction from those in the corresponding figure of the previous article; this is more accurate, but does not, of course, affect the numerical results.

Taking moments about the point A we have:

$B_A = 2\frac{2}{3} \times 6 + 3\frac{2}{3} \times 6 = 16 + 22$
$= 38$ ft. kips.

Next consider the point C; just to the left we have:

$B_{CL} = 2\frac{2}{3} \times 6 + 3\frac{2}{3} \times 6 + 5{\cdot}5 \times 16 - 10{\cdot}25 \times 16$
$= -38$ ft. kips.

This is the result we ought to obtain if, as in assumption (3) the point of contraflexure is to come at the centre of the beam. We see, therefore, that our assumptions are consistent with statical necessities.

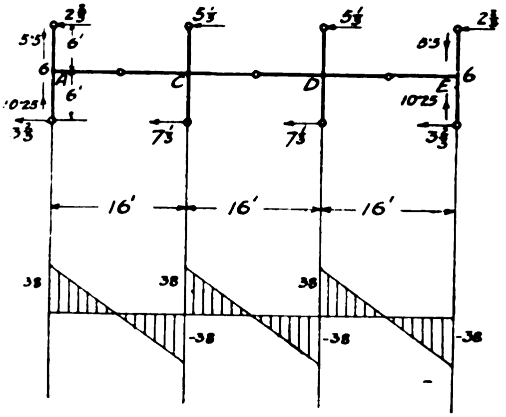


FIG. 3.

In all problems of this kind, when we attempt to find the stresses in statically indeterminate structures by approximate methods, it is essential that the assumptions shall be in accordance with primary statical conditions.

Just to the right of C we have:

$$B_{CR} = 2\tfrac{2}{3} \times 6 + 5\tfrac{1}{3} \times 6 + 3\tfrac{2}{3} \times 6 + 7\tfrac{1}{3} \times 6 + 5{\cdot}5 \times 16 - 10{\cdot}25 \times 16$$
$$= +38 \text{ ft. kips.}$$

and so on for the other points, the diagram coming as shown. The results for other floors are tabulated below.

We shall find, if we check the figures for any point of intersection of beams and columns, that the difference in bending moments (allowing for sign) of the bending moments in the columns above and below the point is equal to the difference in the bending moments in the beams to the right and left of the point.

Direct Forces or Thrusts in Beams.—The direct thrusts in the beams will be relatively small, and are calculated as follows:

Taking the top or roof-beam, 9-9, we have:

Thrust in $ED_9 = 4 - \frac{2}{3} = 3\frac{1}{3}$ kips
,, ,, $DC_9 = 3\frac{1}{3} - 1\frac{1}{3} = 2$ kips
,, ,, $CA_9 = 2 - 1\frac{1}{3} = \frac{2}{3}$ kips.

At the next beam, 8-8, we have:

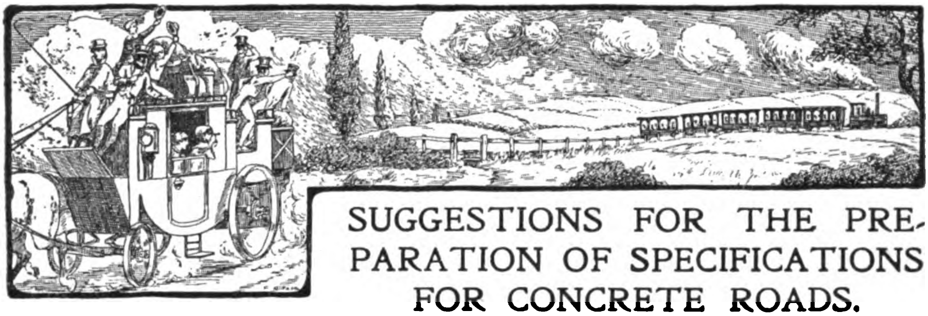
Thrust in $ED_8 = 6 + \frac{2}{3} - 1\frac{2}{3} = 5$ kips
,, ,, $DC_8 = 5 + 1\frac{1}{3} - 3\frac{1}{3} = 3$ kips
,, ,, $CA_8 = 3 + 1\frac{1}{3} - 3\frac{1}{3} = 1$ kip.

and so on for other floors, as tabulated below.

Floor Level.	Thrust in kips.		Bending Moment in Ft.-kips.			
	Smith's Method.	Continuous Portal Method.	Smith's Method.		Continuous Portal Method.	
			Left.	Right.	Left.	Right.
			Beam AC.			
9	3⅓	3	4	—4	6	—1·2
8	5	4·5	14	—14	21	—4·25
7	5	4·5	26	—26	39	—7·8
6	5	4·5	38	—38	57	—11·2
5	5	4·5	50	—50	75	—15
4	5	4·5	62	—62	93	—18·6
3	5	4·5	74	—74	111	—22·2
2	6⅔	6	108	—108	180	—36
			Beam CD.			
9	2	2	4	—4	4·8	—4·8
8	3	3	14	—14	16·8	—16·8
7	3	3	26	—26	31·2	—31·2
6	3	3	38	—38	45·6	—45·6
5	3	3	50	—50	60·0	—60·0
4	3	3	62	—62	74·4	—74·4
3	3	3	74	—74	88·8	—88·8
2	4	4	108	—108	441	—144
			Beam DE.			
9	0⅔	1	4	—4	1·2	—6
8	1	1·5	14	—14	4·25	—21
7	1	1·5	26	—26	7·8	—39
6	1	1·5	38	—38	11·2	—57
5	1	1·5	50	—50	15	—75
4	1	1·5	62	—62	18·6	—93
3	1	1·5	74	—74	22·2	—111
2	1⅓	2	108	—108	36	—180

We would suggest that for purposes of design Smith's method should be employed, and that in cases where the wind stresses form the greater portion of the total stresses, the calculations should be checked by the Wilson and Maney approximate method. In most cases, in practice, the wind stresses do not constitute a large proportion of the total stresses involved, and so great accuracy is not necessary. We may also draw attention to the fact that in accordance with the 1909 amendment of the London Building Acts (section 22, sub-section 21c), the working stresses adopted in the design of columns may be exceeded by 25 per cent. when such excess is due to wind pressure; this means that if the wind stresses in the columns are not more than one-fourth of the stresses due to the ordinary loading, no special provision to meet them will be insisted upon. The Act does not, however, appear to release the designer from allowing for the effect of the wind upon the design of the floor-beams, although the reason for this distinction is not by any means clear.

While the above is the law for buildings coming under the 1909 Act, it does not, of course, follow that wind stresses in columns are not important and should be neglected in design. The tall, narrow buildings in which these calculations became of greater importance are comparatively rare, so that high wind stresses do not often arise. Even then, the additional 25 per cent. allowed by the Act is not excessive, because the working stresses allowed in columns under the Act certainly err on the side of safety (one might even say waste of material) sufficiently to allow for this.



SUGGESTIONS FOR THE PREPARATION OF SPECIFICATIONS FOR CONCRETE ROADS.

In view of the increasing interest now being taken in the subject of concrete road-making in this country, we publish the following suggestions, which will undoubtedly be found useful. They are, however, purely suggestions, and must so be regarded. —ED.

MATERIALS.

1. Cement.—The cement shall be supplied by a British manufacturer of repute, and shall comply with the requirements of the British Standard Specification for Cement in force for the time being. It shall be of the "slow-setting" quality as defined in that specification. Conditions as to testing, delivery and storage shall be agreed between the vendor and purchaser.

2. Aggregates.—Great care shall be taken in the selection of the aggregates. The actual materials to be used must depend upon local circumstances, subject to the following limitations :—

No natural deposits of sand and gravel shall be used without washing, screening, and grading to comply with the conditions hereinafter laid down.

If crushed stone is used it shall be screened, graded, and, if necessary, washed, to comply with the conditions hereinafter laid down.

No aggregate shall be used which is not hard and tough, or which is laminated, and upon crushing breaks down into flat or elongated particles. Soft or porous materials, such as broken brick, breeze, etc., shall be prohibited.

All aggregates used shall be clean and free from clay, dust, vegetable and other foreign matter. Care shall be taken that the aggregate is not contaminated with mud, etc., after delivery to the site of the work.

Coarse Material.—For one-course roads no aggregate shall be used which will not pass through a screen having square openings of 1 in.; but for two-course roads the bottom course may contain aggregate the largest stones in which will pass through a 1½-in. square opening. None of the coarse material shall pass through a ¼-in. square opening. The grading from the maximum to the minimum sizes shall be regular, and no material shall be used which contains a large proportion of stones of approximately one size.

Sand or fine material shall all pass through a ¼-in. square opening, but not more than 10 per cent. by weight shall pass a sieve having 50 meshes per lineal inch. The grading from the maximum to the minimum sizes shall be regular, and no material shall be used which contains a large proportion of particles of approximately one size.

Representative samples of the approved coarse material and sand shall be retained by the Surveyor in charge of the work, and all deliveries shall be required to conform strictly to such samples.

3. Concrete.—The average compression resistance of not less than three test pieces of the concrete shall not be less than will comply with the following formulæ :—

When 4 weeks old :—$C.1 = 2{,}800 - 200\ V$, and

„ 13 „ „ $C.3 = 3{,}600 - 200\ V$, where

C.1 and C.3 = compression resistance in lbs. per sq. in.

V. = Volume of sand and coarse material per volume of cement.

For determining the compression resistance, tests shall be made on cubes or cylinders of not less than 6 in. each way. The preparation, setting and maturing of the test pieces shall, as far as possible, conform to the conditions that will obtain in the actual execution of the work, provided that care must be taken to see that the conditions for all test pieces are as uniform as practicable, and that none of them is exposed to frost during setting and maturing. The compression resistance of any test piece which gives such a low result as to indicate a faulty specimen shall be eliminated in arriving at the average of the results for any test.

4. Water. — The water shall be fresh and clean, and shall be taken from a public drinking water supply or from other source of known purity.

5. Reinforcement. — All metal for reinforcement shall be free from oil, paint, excessive rust, or coatings of any character which will tend to destroy the bond with the concrete. The metal shall develop an ultimate tensile strength of not less than 60,000 lbs. per sq. in., and withstand bending when cold 180 degrees around one diameter and straighten without fracture.

6. Joint Filler.—Joint filler must be an elastic water-proof material, which will not lose these properties under extremes of weather conditions.

PREPARATION OF THE EXISTING SURFACE.

7. Foundation. — The preparation of the foundation will necessarily vary with local conditions, and must be determined by the Surveyor in charge of the work. Any necessary embankments or fills shall be executed to the satisfaction of the Surveyor, and shall be thoroughly consolidated, so that there is no possibility of settlement at any point. Any soft or weak places must be excavated and filled up with hard stone or other suitable material, so as to obtain solidity equal to the remainder of the surface. The surface shall be finally rolled to the required contour with a roller of not less than 10 tons in weight. It should be noted that the use of concrete for the road cannot be assumed to do away with the necessity for a good and even foundation over the whole surface.

The surface thus prepared shall have a cross fall of one in 50.

When the road is not supported by curbing on either side, a channel not less than 6 in. wide and 4 in. deep shall be dug longitudinally immediately inside the edge of the prepared base, so that the concrete when placed has a cross section at this point, as shown in Fig. 1.

Immediately before the concrete is put into place, the prepared surface shall be swept clean of all dust and dirt and thoroughly watered.

8. Drainage. — Where local conditions require, a suitable drainage system shall be provided to the satisfaction of the Surveyor.

CONCRETE.

9. Proportions. —The coarse material and sand shall be used by volume in such proportions, one to the other, as are found by trial with several mixtures of the same total quantity measured separately, but of varying proportions, to give the least volume of concrete when mixed with the prescribed quantity of cement and tamped into a mould of known capacity.

For one-course roads not more than 5 parts of coarse and fine aggregate, mixed as provided, to one of cement, shall be used. For two-course roads not more than 8 parts of coarse and fine aggregate, mixed as provided, to one of cement, shall be used for the lower course, and not more than 3 parts of fine aggregate to one of cement for the upper or surface course. One-course roads shall only be laid in places where severe traffic conditions are not likely to be met with, unless made with concrete containing not more than 3 parts of aggregate to one of cement.

10. Measuring the Materials.—The method of measuring the materials for the concrete, including water, shall be one which will ensure uniform proportions at all times. The cement shall be taken by weight on the basis that 90 lb. is equivalent to a volume of one cu. ft.

11. Mixing. —The concrete shall be mixed in a batch concrete mixer of an approved type. The materials shall first be mixed dry, the mixing being continued until the materials are uniformly distributed, and the mass is uniform in colour. The water shall then be added and the ingredients again mixed until they are homogeneous and plastic throughout. The drum shall be completely emptied after mixing each batch.

12. Consistency.—The quantity of water to be added to the concrete shall be such as to secure a plastic mixture which can be easily worked, and so that only light tamping shall be necessary to consolidate when placed in position. Care shall be taken to prevent an excessive amount of water being used, and the concrete shall not be so sloppy as to cause a separation of the coarse aggregate from the mortar during handling and laying.

Any concrete which has partially set before being placed in position shall not be used. To avoid waste from this cause, all concrete which is mixed ready for placing in position immediately before the dinner hour or other stoppage of the work shall be placed and finished before stopping. Under all circumstances as little time as possible shall elapse between the mixing of the concrete and placing and finishing.

PLACING THE CONCRETE.

13. Weather Conditions.—So far as is practicable, all work shall be done during the summer months, but in no case shall concrete roads be laid in the winter months, except as a matter of urgency; and under no circumstances shall concrete be mixed and deposited when the thermometer is below 39 deg. F.

The concrete shall be deposited over the whole width of the road at one and the same time, except in cases where it is impossible to divert the traffic for the time being, and shall be deposited in alternate bays of not more than 50 ft. in length. The end of each bay shall be supported by a wooden or metal form sufficiently strong and properly supported to resist straining out of shape under the pressure of the concrete. All mortar and dirt shall be removed from forms which have been previously used, and the forms shall be wetted thoroughly before any concrete is deposited against them. The intervening bay shall be filled in when those on either side are set sufficiently hard to permit of the removal of the forms without damage to the edges. If desired, joints filled with material complying with paragraph 6 may be provided between the bays, but shall not exceed ½ in. in thickness. In the opinion of the writer, however, the value of these joints is not proved, and they undoubtedly introduce weak points into the road. Longitudinal joints similarly filled may also be provided alongside the kerb or channelling (if any) if desired.

14. Thickness.—The total thickness of concrete for both one and two-course roads shall not be less than 6 in. when tamped and struck off to the finished surface. The surface course of two-course roads shall be approximately 2 in. thick.

When a two-course road is being laid the upper course or wearing surface shall be spread on the lower course immediately after the latter is deposited and before it has begun to set.

15. Surface.—The wearing surface shall be struck off to the finished contour by means of a double template, constructed as shown in *Fig.* 2. This template shall be drawn over the concrete with a combined longitudinal and transverse motion, so as to produce a surface free from depressions or inequalities of any kind, and this surface shall not afterwards be disturbed by floating off or in any other way. The finished surface shall have a cross fall of 1 in 60 and shall not vary more than ¼ in. from the true shape.

No cessation of work of more than an hour's duration shall be permitted, except at the end of a completed bay.

In cases where it is impossible to divert the traffic and the concrete has to be laid on one half of the road at a time, the edge of the concrete in the centre of the road shall be left with a rough vertical edge, and immediately before filling in the concrete for the second half this edge shall be thoroughly swept, watered, and painted with a thin coat of neat cement and water in equal proportions. The concrete shall then be applied immediately.

16. Reinforcement.—The concrete shall be reinforced with steel mesh reinforcement of a type approved by the surveyor. The area of the reinforcing metal shall be equivalent to 0·05 square inch per foot of length or width of the concrete. In cases where joints as described in paragraph 6 are provided, the reinforcement shall be carried to within 2 in. of the joints, but shall not be carried across them, and all joints of the mesh reinforcement shall overlap at least 6 in.

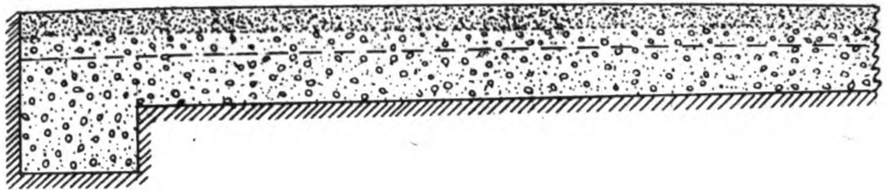


FIG. 1.

Cross-section of part of concrete road, showing suggested section of outside edge where not supported by kerbing.

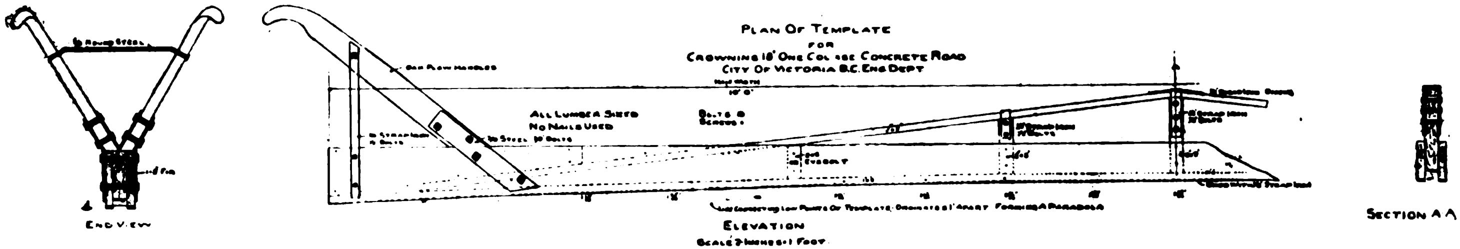


FIG. 2.

This drawing shows one half only of a template suitable for a road 20 ft. wide with a crown of about 1 in 45. It will be noted that the arrangement really comprises two templates and the first template should be just a little higher than the second so as to remove the bulk of the surplus concrete but leaving the latter to do the real finishing. The template should be drawn over the surface with a combined crosswise and longitudinal motion, making a longitudinal progress of about 2 inches for each transverse motion. Care must be exercised when approaching the end of a concrete bay to avoid damaging the edge and at the same time remove the surplus concrete. The second template must be set to the finished grade of the road and will give an excellent finish if the concrete is mixed to the right consistency.

The subsequent use of a wooden float is apt to produce flat or hollow places on the road surface and for this reason is not recommended,

CURING AND PROTECTION.

17. Watering Surface.—The surface of the concrete shall be sprayed with water as soon as it has sufficiently hardened to withstand pitting, and shall be kept wet until covered as hereinafter provided.

As soon afterwards as it can be done without damaging the surface, the pavement shall be covered with not less than 2 in. of wet sand or other material which will afford equally good protection. This shall be kept thoroughly wet during the whole time it remains on the concrete and shall not be removed until at least ten days after placing.

When sunshine, a drying wind, or other conditions make it desirable, in the opinion of the surveyor, the freshly laid concrete shall be protected by canvas laid on a wooden framing or other covering until set sufficiently to be watered and protected as prescribed.

18. Opening to Traffic.—Under the most favourable weather conditions the concrete road shall not be opened to traffic until at least twenty-one days after it is laid, and when the weather is cool or wet this period shall be increased for such additional time as may be necessary in the opinion of the surveyor.

Where the road is constructed in two halves owing to the impossibility of diverting the traffic, the traffic should not be concentrated on to the first half which has been concreted until at least thirty-five days after completion or longer where weather conditions make it desirable in the opinion of the surveyor.

Highway Construction: Toronto.—The Imperial Trade Correspondent at Toronto (Mr. F. W. Field) writes, under date October 31st, that a concrete highway has now been completed, with the exception of a few short gaps, between Toronto and Hamilton, a distance of about forty miles. This is the first important highway of this nature to be constructetd in Ontario.

The following table shows the number and types of vehicles which passed over the road between 7 a.m. and 10 p.m. on three recent days, the record being taken by officials of the Toronto-Hamilton Highway Commission :—

	September 29th.	October 1st.	October 9th.
Motor-cars	1,282	1,905	2,018
Motor-cycles	83	320	237
Bicycles	371	342	544
Horse-drawn vehicles	670	207	455
	2,406	2,774	3,254

As an example of the extraordinary developments in concrete road construction in America and Canada the following table speaks for itself :—

PORTLAND CEMENT CONCRETE HIGHWAYS LAID IN UNITED STATES AND CANADA.

Year laid.	Sq. yards.
Prior to 1909	799,390
1909	561,271
1910	1,313,449
1911	2,069,445
1912	5,295,447
1913	9,596,286
1914	14,815,034
1915	16,936,137
	51,386,459

In Western Washington, during 1916, there was laid in the counties, one-course 617,927, two-course 45,910. In the cities, one-course 172,045, two-course 12,180, or a total of 848,062 sq. yd.

The Carey Elastite.—In connection with concrete road making we draw attention to this preparation which is largely used in America for the expansion joints. It is claimed for this material that it will withstand pressure in summer time when expansion is going on, and gradually relaxes when colder weather sets in. We feel sure that a sample would be sent if application be made to Philip Carey Co., Lockland, Cincinnati, Ohio.

In our next issue we propose publishing an illustrated article on a reinforced concrete road in Dunfermline.

TURBINE HOUSE IN COURSE OF ERECTION.

THE SWEDISH STATE POWER STATION AT ALFKARLEBY.

The following interesting particulars of the application of reinforced concrete construction in Sweden have been summarised from the Official Report by

ALFRED B. SEARLE.

THE third of the large Swedish State stations for the production of electricity from waterfalls has recently been completed at Alfkarleby. It is situated about five miles from the mouth of the Dola River and includes the islands of Flakōn and Laxōn, with the Great Fall, the Central Fall, the Kingsadra Fall, and several other smaller falls.

The available head of water at the power station varies from 53 to 61 ft.

The difficulties of the scheme were increased by the provision necessary for great variations in the volume of water available and the violent spring floods. In normal years the volume of water ranges from 3,000 to 45,000 cu. ft. per second, but occasionally it rises to 70,000 cu. ft. per second. Provision for accumulating water being available. the station has been built to deal with rather less than 9,000 cu. ft. per second.

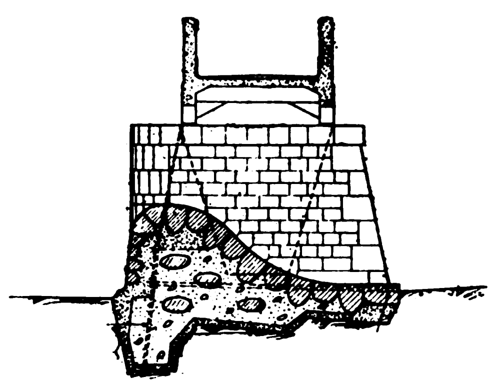


Fig. 1. Section of Dam at Central Falls.
REINFORCED CONCRETE CONSTRUCTION AT THE SWEDISH STATE POWER STATION AT ALFKARLEBY.

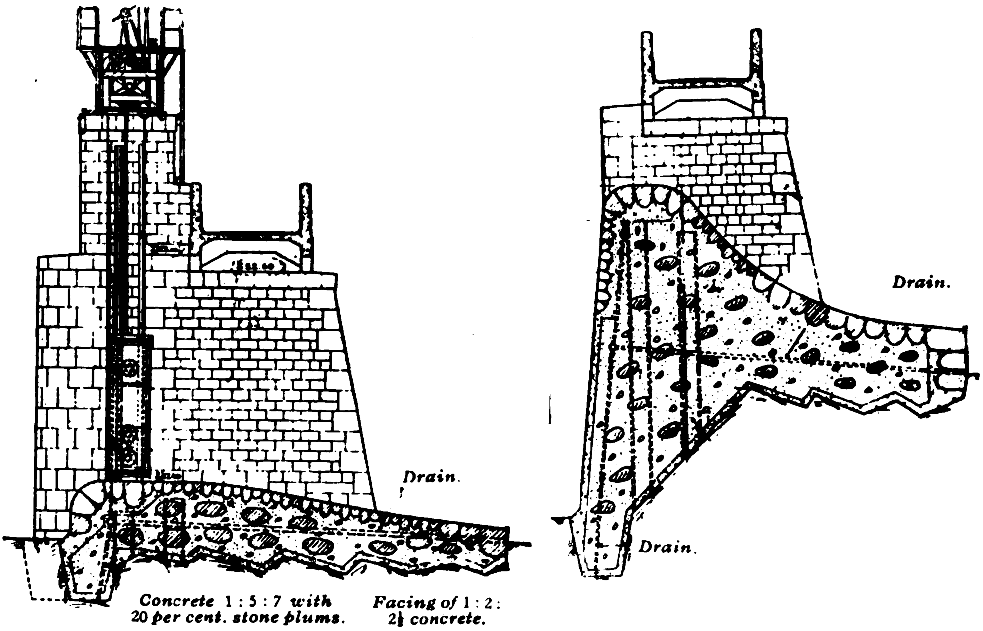
The ground on the right bank of the river is fine sand with solid rock at a slight depth, and all the structures are built on foundatons of solid rock.

The water level is controlled by various dams built across the river above the falls and is then led through an intake canal to the distribution basin, from which it flows into open concrete chambers containing the turbines. After passing through the latter it flows beneath the machine house into the outlet canal and then into the river.

The overflow water is delivered over fixed spillways at a level of 70 ft., so as to reduce the number of gates and rollers to seven.

The dam in the Great Fall extends from the right bank of the river to Flakön Island. It has wooden gates, for the purpose of passing any ice formed immediately in front of the intake. Next to these gates are two fixed spillways and four floating iron gateways for the passage of timber. The rest of this dam consists of six fixed spillways placed in a curve which is convex to the flow of the river.

The dam across the Central Fall joins the Flakön and Laxön Islands, has four fixed spillways on each side, and between them is an opening which allows



Figs. 2 and 3. Sections of Dam at the Great Fall.

REINFORCED CONCRETE CONSTRUCTION IN THE SWEDISH POWER STATION AT ALFKARLEBY.

ice formed above the fall to pass through it. This opening can be closed by a roller dam.

The southern end of Laxön Island has been protected by an earthern embankment.

In the Kingsadra Fall several salmon ladders are included in the dam. Near these is a small outlet with wooden gates and a floating opening with iron gates for passing timber. The rest of this dam consists of a fixed spillway connected by an earthen embankment to the left bank of the river.

Piers, 7 ft. wide, between the fixed spillways merely serve as supports for a reinforced concrete road running along the dams.

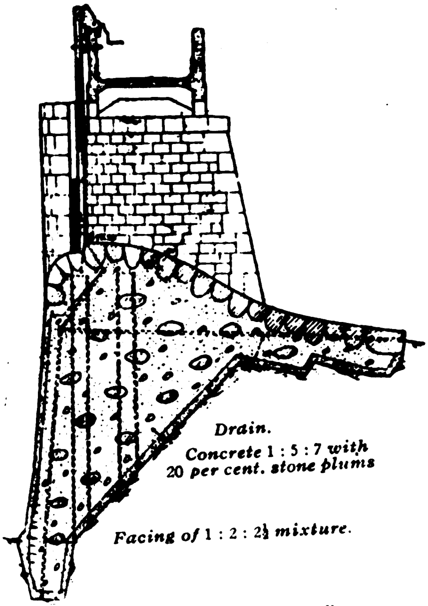


Fig. 4. Section of Dam at Great Fall

The dams are constructed of mass concrete, consisting of a mixture of 1 : 5 : 7, with 20 per cent. of stone plums, with stone facing on all surfaces likely to come in contact with ice. Water-tightness on the upstream side is secured by cutting into the rock and filling with a 6-in. layer of 1 : 2 : 2½ concrete, covered with a 1½-in. layer of 1 : 2 mixture. Some of the natural fissures in the rock were filled with 1 : 3 : 5 concrete. A dyke caulked with calendrite was formed around each pier, and the Kingsadra spillway was also divided by dykes, so as to prevent shrinkage cracks. The Kingsadra dam has been carried through a 20-ft. layer of sand to the rock beneath, and to reduce the cost the lower part of the spillway is constructed of arches filled with rubble. The bottom below this dam is covered with a thick layer of soft material and protected with timber cribs filled with stone. The lower part of the spillway is shaped so as to throw the water upwards.

The Central Fall and Kingsadra dams end in a slight slope or small terraces, but the edge of the Great Fall nearest Flakön Island follows the rock down into deep clefts on either side of a high rocky ridge. The down-stream side of the spillway on the Great Fall ends in a slope of 1 : 8.

The Central Dam is not immediately above the Fall, but has been set back so as to interfere as little as possible with the beauty of the

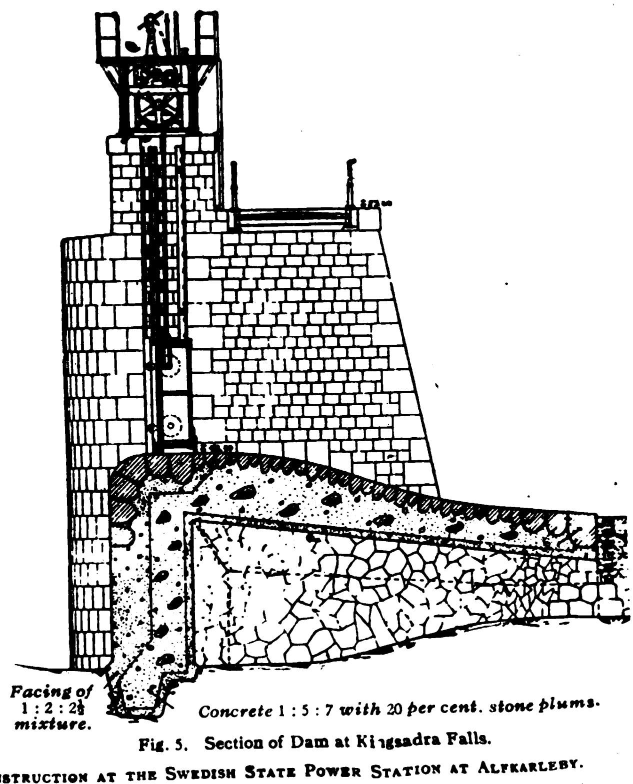
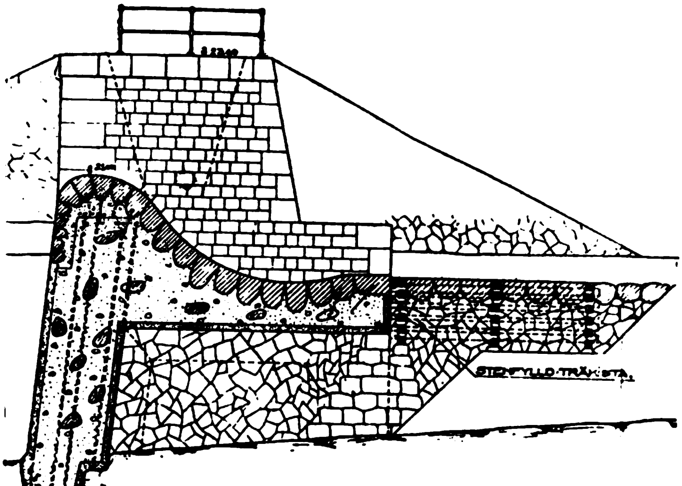


Fig. 5. Section of Dam at Kingsadra Falls.

REINFORCED CONCRETE CONSTRUCTION AT THE SWEDISH STATE POWER STATION AT ALFKARLEBY.

waterfall. In it, the space from the back of the dam to the rock bottom has been covered with an apron of rough stone laid in cement.



Facing of 1 : 2 : 2½ *mixture*

Concrete 1 : 5 : 7 *with* 20 *per cent. stone plums.*

Fig. 6. Section of Dam at Kingsadra Falls.

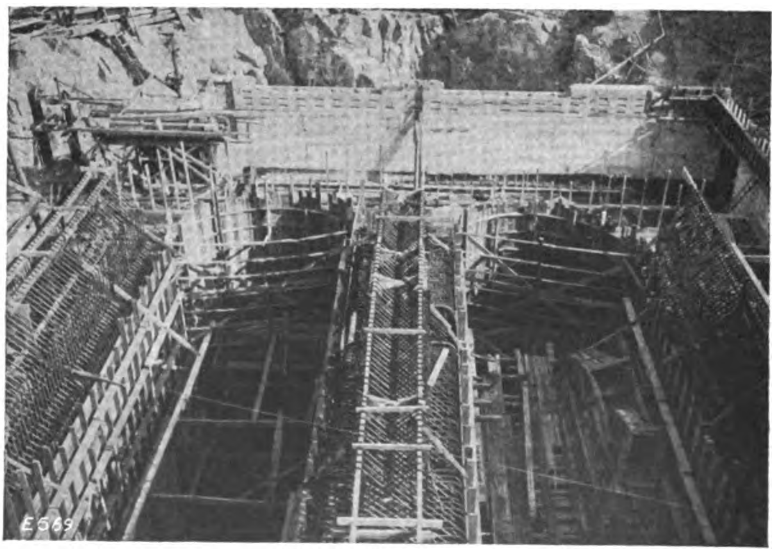


Fig. 7. Reinforcement in No. 2 Turbine House.

REINFORCED CONCRETE CONSTRUCTION AT THE SWEDISH STATE POWER STATION AT ALFKARLEBY.

The dams are connected with the shore by earthen embankments with water-tight cores. The crests of the earth dams are 79 ft. high and 10 ft. wide. The slopes are at a gradient of 1 : 1 : 5, and are pitched with stone.

The intake canal has a breadth of 52 ft. at the bottom and a depth of 39 ft. below normal water level, with an estimated current of 4 ft. per second. The canal walls are 65 ft. above datum, and have a batter of 7·5 : 1.

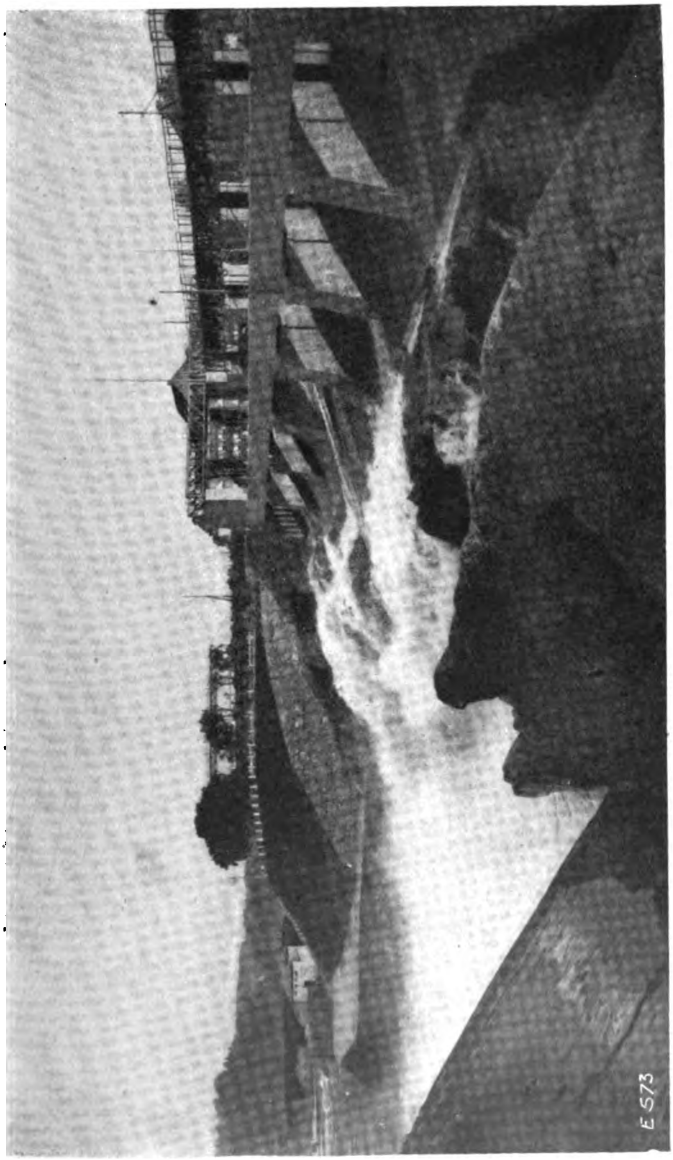


Fig. 8. The Dam at Great Falls as seen from Flakön Island.

REINFORCED CONCRETE CONSTRUCTION AT THE SWEDISH STATE POWER STATION AT ALFKARLEBY.

The concrete distribution basin has its bottom 30 ft. above datum. It has a bottom outlet of about 4 sq. ft. leading to the river. In the bottom of the basin a groove is cut in the rock and ends in the bottom outlet. Pipes lead from this groove to wells located in the walls of the basin, and any eels are sucked up into these wells and sent through wooden ducts at the water level of the river. The western wall of the distribution basin is a continuation of the canal wall; the eastern wall turns in a curve until almost parallel with

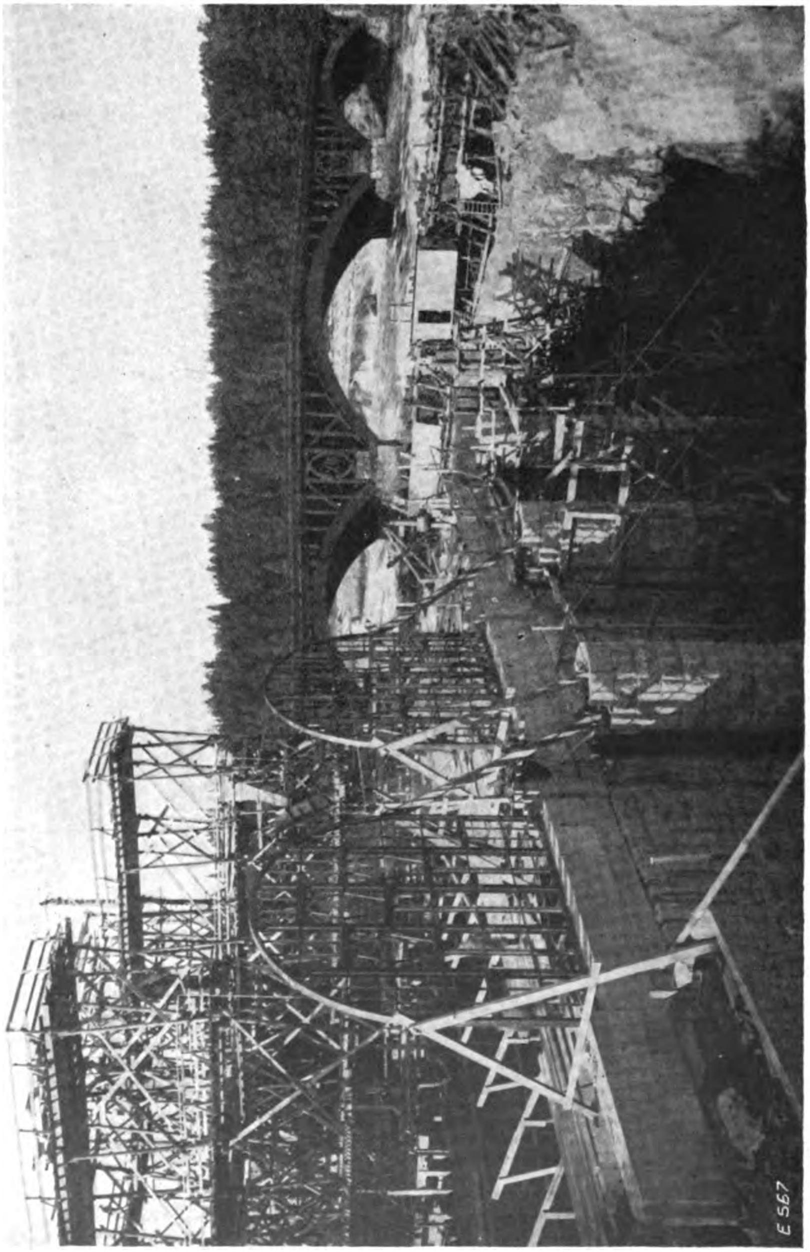


Fig. 9. Machine House in course of construction.
REINFORCED CONCRETE CONSTRUCTION AT THE SWEDISH STATE POWER STATION AT ALFKARLEBY.

the power station and about 50 ft. from it. The intervening space is closed by a reinforced-concrete screen.

The five turbine chambers are of reinforced concrete, about 10,000 cu. yds. of concrete and 800 tons of iron being used in their construction. Their crowns are 65 ft. and their bottoms 12 ft. above datum, the concrete walls being about 66 ft. high. The distance between the centres of the turbines is 34 ft.

The intermediate walls above the 60-ft. level are 3 ft. 6 in. thick; between this and the 30-ft. level the thickness of each wall in the pairs dividing the chamber is 5 ft. Below the 30-ft. level all the intermediate walls are 12 ft. thick. The breadth available for the water in the chambers is, therefore, 28 ft. in the upper part, 25 ft. in the intermediate, and 21 ft. in the lowest part of the chamber. The water enters the chambers over concrete sills 98 ft. long,

Fig. 10. The Interior of Turbine Chamber, as seen from the Machine House,
REINFORCED CONCRETE CONSTRUCTION AT THE SWEDISH STATE POWER STATION AT ALFKARLEBY.

the length of the chambers inside these sills being about 52 ft. To ensure adequate strength, the partitions of the chambers are let into the bottom and are further strengthened by two strong beams of reinforced concrete 5 ft. high and by a screen of reinforced concrete, which also separates the chambers from the distribution basin. The walls are doubly reinforced from below datum to their upper edges.

The walls near the machine house are built of reversed arches, strongly reinforced with steel bars and plates. The thickness of each arch above 66-ft. level is 1 ft., and between this and the 31-ft. level it is 2 ft. Below the latter level the arch forms part of the machine house wall.

The walls and bottom of the turbine chambers are finished with a coating of cement, water-proofed with ceresite, and 1½ in. thick near the bottom and 1 in. higher up. The chambers are provided with iron gates and wooden doors.

The machine house is 203 ft. by 45 ft. by 45 ft. high, the floor being about 3 ft. below the level of exceptionally high water in the outlet; hence special precautions have been necessary to keep out the water.

The building is of hard bricks lined with glazed tiles and plaster, vertical damp-proof asphalt slabs and reinforced concrete being used between the outer and inner facings to resist any likely water pressure.

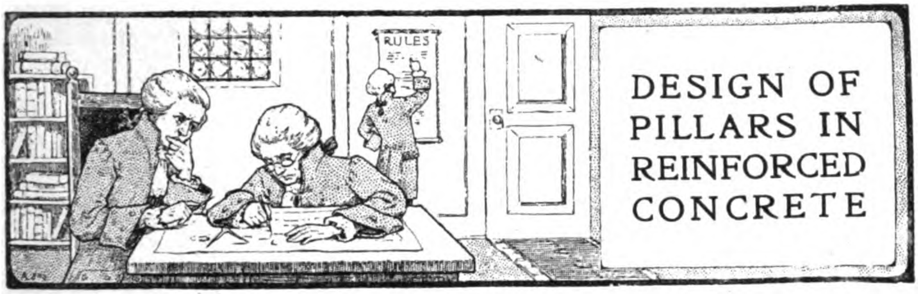
The foundation is of reinforced concrete, and in both walls and floor there is ample drainage in case of seepage.

The roof is supported on iron brackets, and consists of an inner roof of reinforced concrete and an outer one of tiles laid on wood.

The other buildings on the estate (including engineer's residence and workmen's dwellings) are built of concrete.

Fig. 11. The Dam at Kingsadra Falls.

REINFORCED CONCRETE CONSTRUCTION AT THE SWEDISH STATE POWER STATION AT ALFKARLEBY.



IN ACCORDANCE WITH THE L.C.C. REGULATIONS.

By F. E. DRURY, F.I.S.E., M.C.I.

Head of the Department of Building and Civil Engineering, Royal Technical Institute. Salford.

THE purpose of this article is to indicate methods of procedure in the design of pillars under axial loads and complying with the regulations of the London County Council.

Throughout the article we shall consider that standard concrete is adopted of Portland cement, sand and coarse material in the proportion of $1+2+4$, and that the material will safely bear 600 lbs. in.^{2} and fulfil the conditions required in the composition and testing of the concrete.

In assessing the load capacity of pillars the L.C.C. regulations adopt a straight line formula, in which the axial working load, (P), is proportionate to $\frac{v}{g}$, viz.:— $\frac{\text{virtual length}}{\text{radius of gyration}}$. As the unit working stress on the concrete (c) is proportionate to P for a constant ratio of vertical reinforcement, the tabulated working stresses for given values of $\frac{v}{g}$ may be graphed as shown in *Fig.* 1, condition 1, where, assuming as a standard, pillars with ends fixed in position and direction as per attached sketch, we find by analysis that the law of the graph is c (lbs. in.^{2}) $= 1200 - 13{\cdot}3\,\frac{l}{g}$, because l is to be taken as the unit virtual length for comparison with other conditions. In no case may $\frac{l}{g}$ for this case, or $\frac{v}{g}$ for other conditions, exceed 90, while if less than 45 the value of "c" must not exceed 600 lbs. in.^{2}

To assess the unit working stress (c), for any pillar, determine $\frac{l}{g}$ for the case and read off the value of c, then $P = c\,[A + (m-1)\,A_v]$ or $A.c.\,[1 + r\,(m-1)]$ where

A = area of pillar enclosed within lateral binding.

A_v = area of vertical reinforcement.

$r = \frac{A_v}{A}$. $\quad m$ = modular ratio.

Should the reader have difficulty in determining the value of "g" for a given section, reference may be made to a later diagram in this series, in which the average value of "g" is graphed for four forms of reinforced section used in pillars.

END CONDITIONS.

Suppose a change of condition occurs in the support or security of the ends, the virtual or comparative length is to be changed accordingly, and the graphs for conditions

2, 3 and 4 of the sketches on *Fig.* 1 (and in greater detail at *Fig.* 2) show the working stresses for each condition, still employing the ratio $\frac{l}{g}$ to avoid the trouble of conversion.

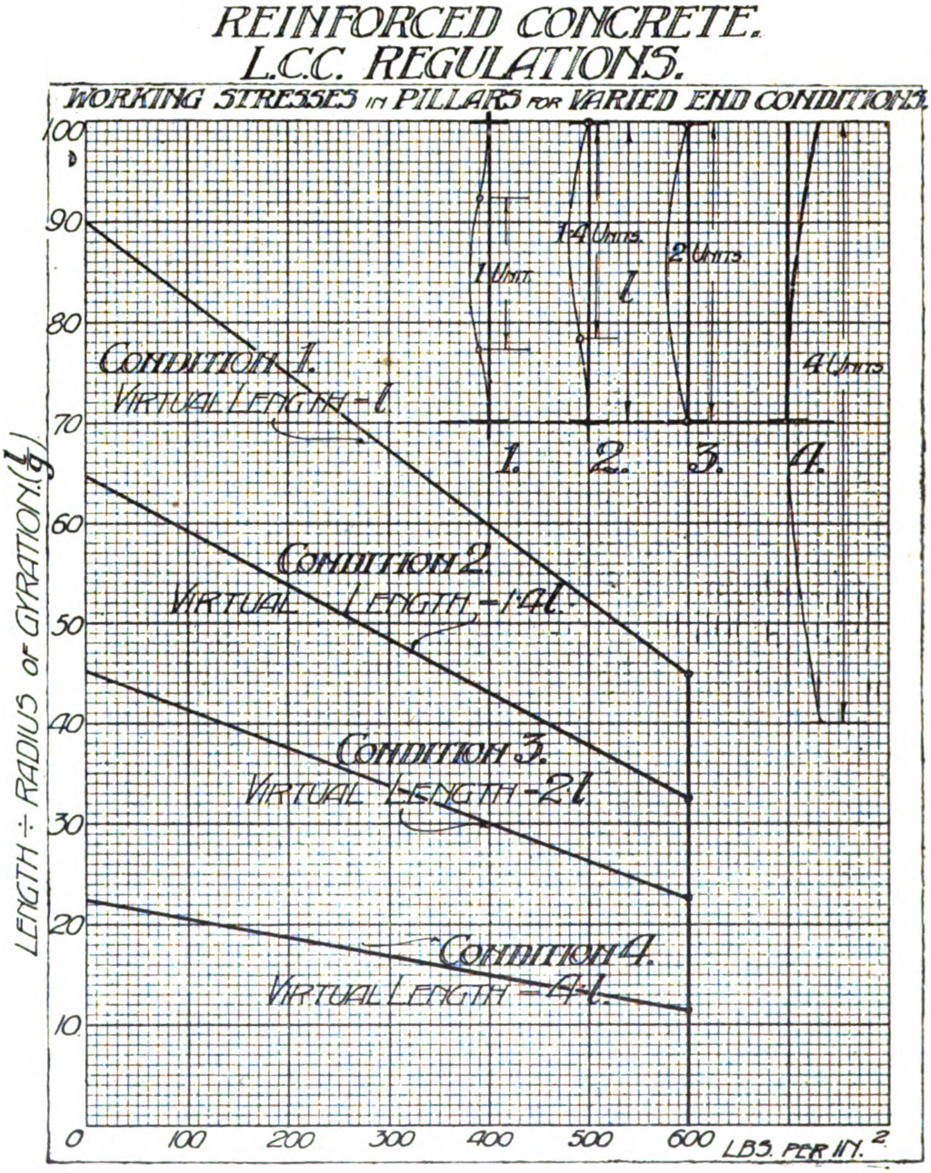


FIG. 1.

Thus if the ends are one fixed in position and direction, and the other in position only, the expression for unit working stress on the concrete would be:—

$$c = 1200 - \frac{13{\cdot}3\ (1{\cdot}4l)}{g}$$

because the virtual length of the deflected arc for comparison of "buckling lengths" is $\sqrt{2} \times$ length of arc in condition 1.

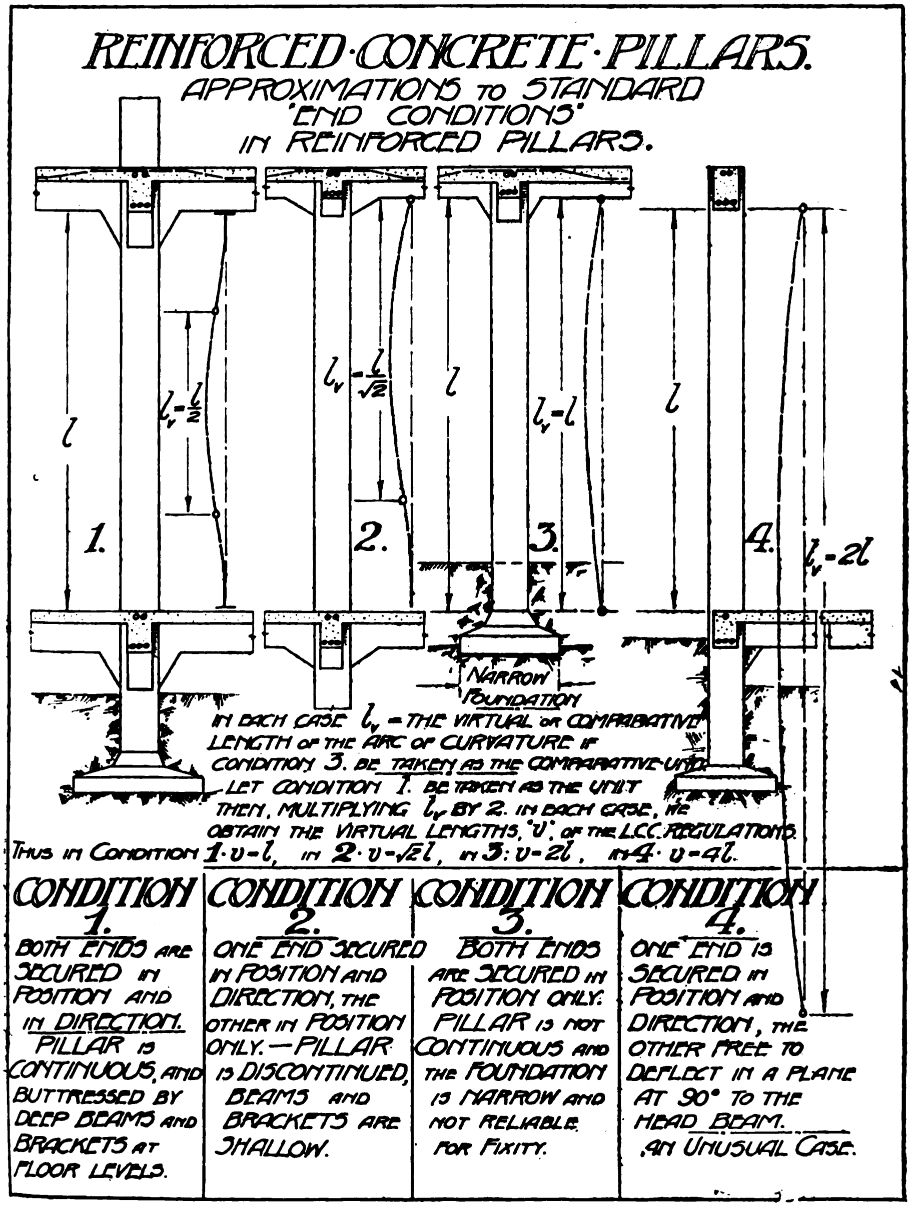


Fig. 2.

But, instead of calculating the stress by the formula, obtain the value of $\frac{l}{g}$ as before and read off the stress direct from the graph of condition 2. Proceed similarly for any condition of fixation and support agreeing with the sketches of *Fig.* 1.

D

ALTERNATIVE FORMULÆ.

In certain cases, especially in square pillars where the vertical reinforcement is less than 2%, it is more economical to adopt the alternative method of design allowed by the regulations.

Thus, for square and round pillars, two tables are given where P depends upon $\frac{l}{d}$, and when reduced to unit stress for the standard condition of end fixing gives:—

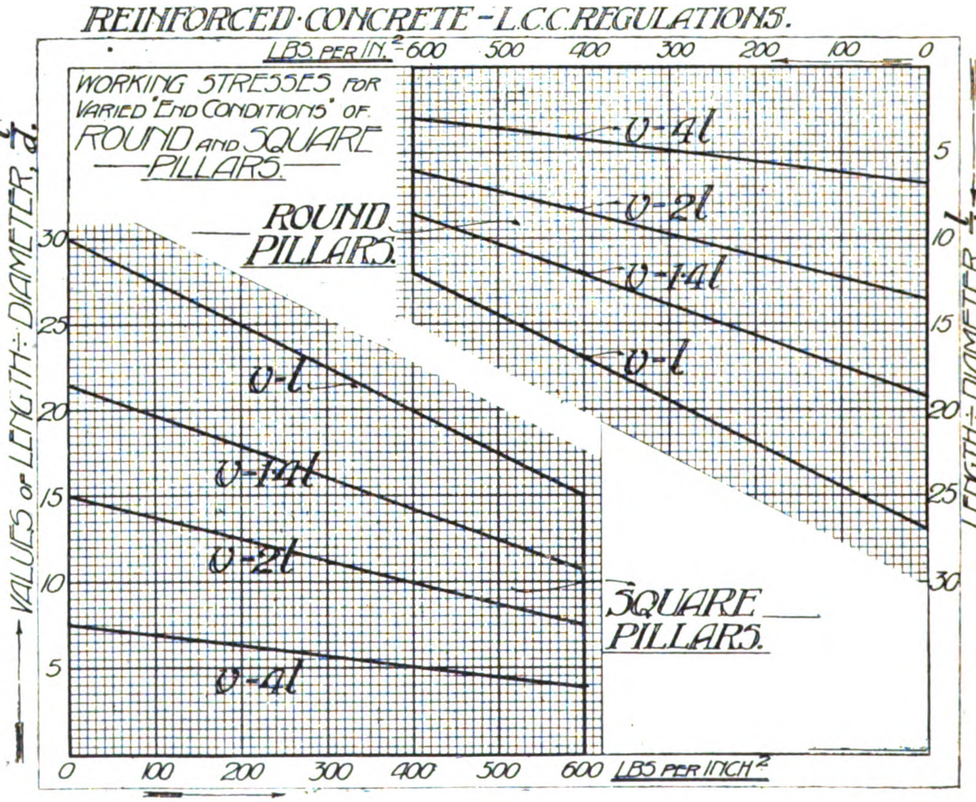


Fig. 3.

Square pillars:—

$$c = 1200 - 40\frac{l}{d}$$

where $\frac{l}{d}$ may not exceed 30, and if $\frac{l}{d}$ is 15 or less, the maximum stress is 600 lb. per in.^{2}

Round pillars:—

$$c = 1080 - 40\frac{l}{d},$$

where $\frac{l}{d}$ may not exceed 27, and if $\frac{l}{d}$ is 12 or less, the working stress is 600 lb. in.^{2}

These equations are graphed at *Fig.* 3 with modifications for the series of end conditions as in the general formulæ.

In all cases if concrete richer than 1+2+4 is employed the working stress is increased in proportion (see regulations).

SHORT PILLARS.

Figs. 4, 5 and 6 show by means of graphs the relation between "load and area," and "load and diameter" in the case of square, round and octagonal pillars, having

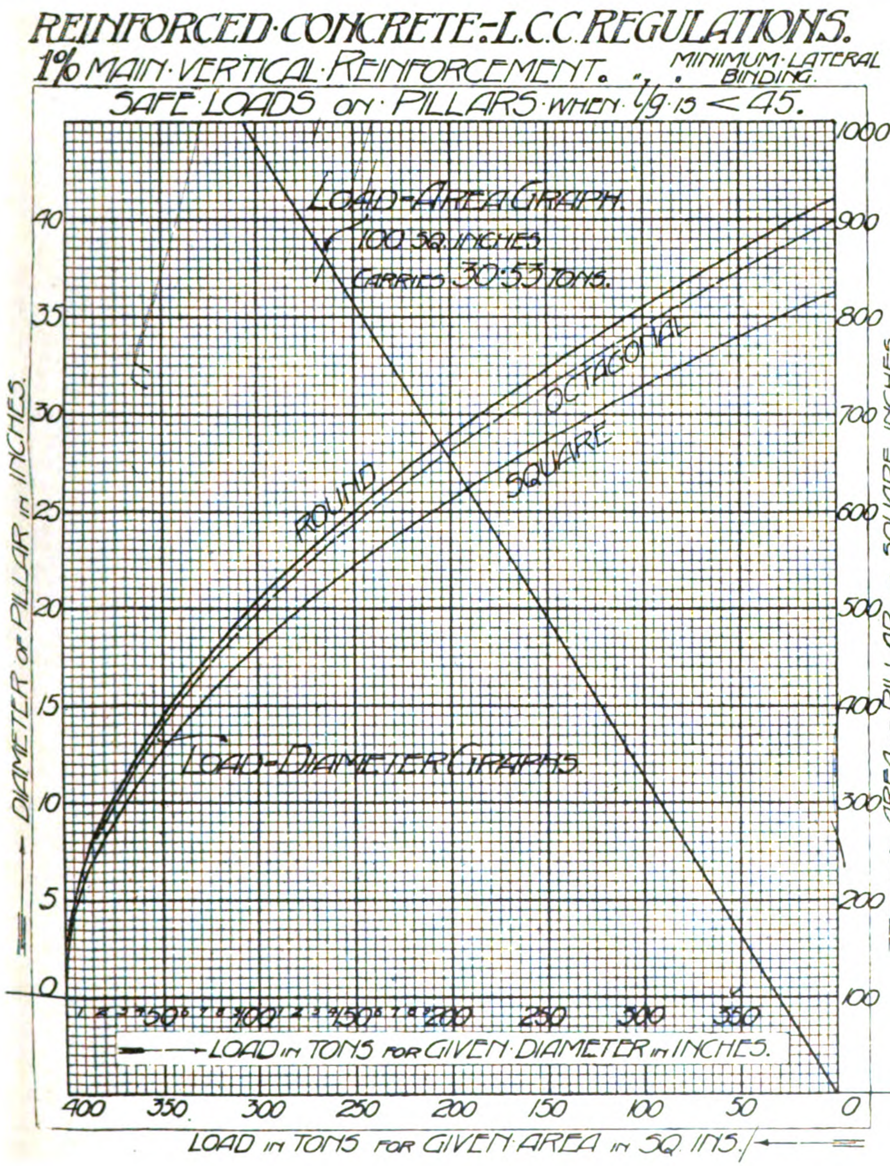


FIG. 4.

respectively 1, 2 and 3% of vertical reinforcement. These graphs apply only to pillars where $\frac{v}{g}$ is less than 45, or $\frac{v}{g}$ is less than 15 for square pillars and 12 for round ones.

Their purpose is to allow a speedy selection of trial dimensions in order to test whether $\frac{v}{g}$ exceeds 45, etc., if so the dimensions of the pillar may have to be obtained by an equation in which the equivalent value of c for the particular condition appears.

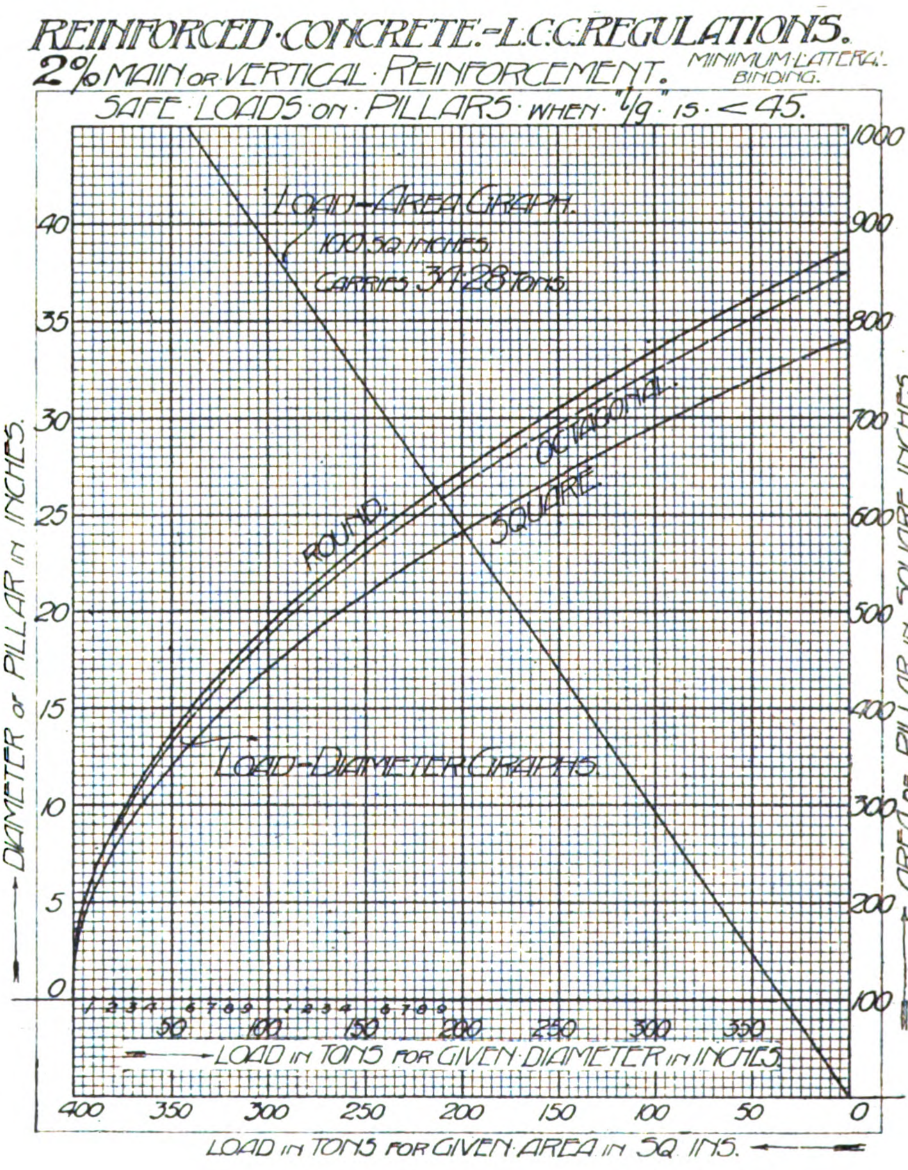


FIG. 5.

EXAMPLES.

I. "Let a square pillar be required to carry a load of 65 tons, length 21 ft., ends fixed in position and direction, main reinforcement 3%, and the lateral binding at a minimum. Using 1+2+4 concrete, determine the diameter and quantity of steel."

"From the 3% short pillar graph, *Fig.* 6, the diameter of a square pillar to support 65 tons is 13." For 3% of vertical reinforcement the value of g averages ·34 to ·345d (see later); using ·345d as the value we have $\frac{l}{g} = \frac{252}{\cdot 345 \times 13} = 56\cdot 2$: thus the pillar exceeds

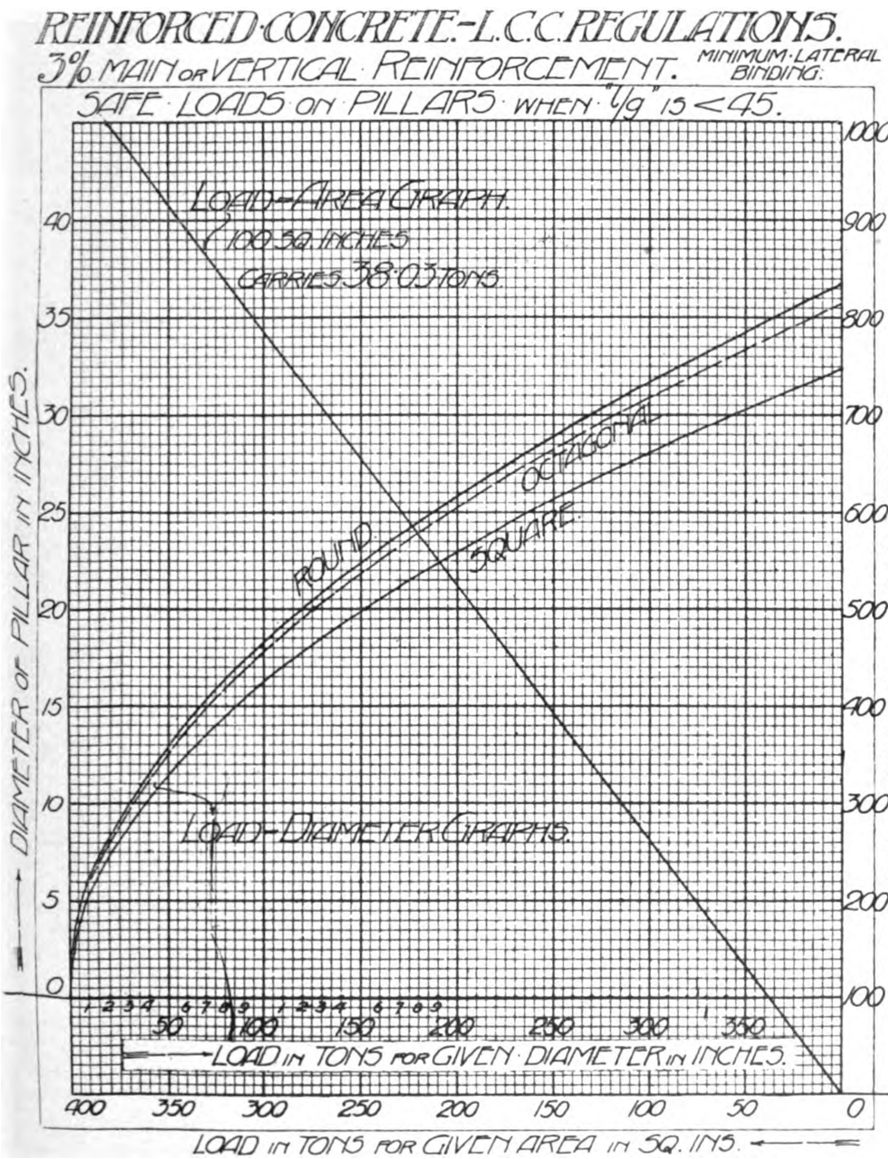


FIG. 6.

the length where 600 lb. in². is allowed. The working value of c is known, if within the limits of the graph of *Fig.* 1, and $c = 1200 - 13\cdot 3\,\frac{l}{g}$; thus the diameter of the pillar will increase as the working stress diminishes, leaving g an unknown quantity but capable of expression in terms of *d*. Insert the value as required and proceed thus :—

$$P=A.c.\ [1+r\ (m-1)] \qquad m=15$$

$$r='03\ (3\%)$$

$$A=d^2$$

$$c=1200-\frac{13'3\times252}{'345d}$$

$$\therefore 65\times2240=d^2\left(1200-\frac{9720}{d}\right)(1+'03\times14) \qquad =1200-\frac{9720}{d}$$

$$\frac{65\times2240}{1'42}=1200d^2-9720d$$

$$d^2-8'1d=85'5$$

$$\therefore d=4'05+\sqrt{85'5+16'4}=\underline{14'14\text{ in.}}$$

Now $\frac{l}{g}=\frac{252}{'345\times14'14}=51'6$, and referring to the graph of allowable stresses (*Fig.* 1, condition I), we find the corresponding value of $c=$about 510 lb. in². Checking the load capacity from the values we have obtained we get :—

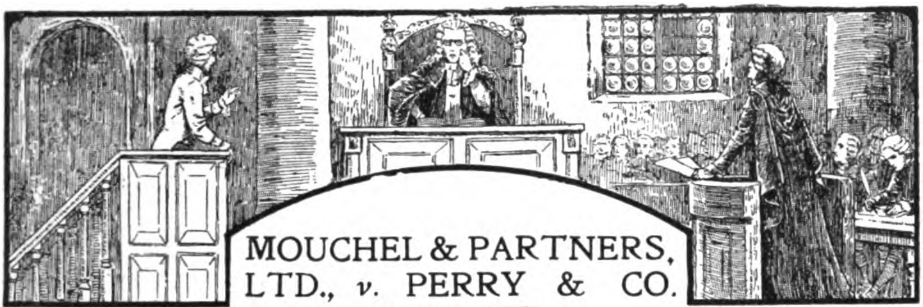
$$P=A.c.(1+r[m-1]=\frac{14'14^2\times510\times1'42}{2240}=64'6\text{ tons.}$$

Checking by calculation for *c* we have :—

$$c=1200-\frac{13'3\times252}{'345\times14'14}=1200-687=513\text{ lbs. in.}^2$$

and inserting this instead of the 510 lb. obtained from graph we find $P=65$ tons.

(*To be continued.*)



MOUCHEL & PARTNERS, LTD., v. PERRY & CO. (BOW), LTD.*

A legal case of considerable importance to reinforced concrete specialists and contractors was heard towards the end of last year, and we give below a short résumé of this case.—ED.

In this action the plaintiffs, Messrs. L. G. Mouchel and Partners, Ltd., claimed the sum of £1,920 4s. 11d. from Messrs. Perry and Co. (Bow), Ltd., who counterclaimed for £24,397 2s. 0d.

There being much detail and many documents to be dealt with, the case was tried by Mr. Muir Mackenzie, one of the Official Referees, and occupied about three weeks in the hearing.

By an agreement dated December 3rd, 1908, the plaintiffs licensed the defendants' predecessors (Messrs. Perry and Co.) to use certain patented inventions relating to reinforced concrete construction in carrying out plans and instructions supplied by the plaintiffs; and the defendants' predecessors agreed to employ the plaintiffs as their engineers surveyors, and technical advisers in connection with all reinforced concrete contracts during a period, and further to pay the plaintiffs a commission of 12 per cent. upon the gross contract price. The agreement was transferred to the defendants with the consent of the plaintiffs, and the defendants thereupon entered into contracts for reinforced concrete work in connection with, among other buildings, H.M. Stationery Office in Stamford Street, near Waterloo Station, London.

The defendants admitted that the plaintiffs' claim was payable by them subject to their counterclaim for damages for breach of contract to supply to defendants the necessary plans, calculations, instructions and quantities, and for indemnification against part of the loss they had sustained.

The defendants' tender of £47,838 for H.M. Stationery Office was accepted, and about the middle of 1912 a formal contract was made between them and the Office of Works. Thereunder the defendants were, as contractors, to comply with the requirements of the specification and general conditions and the drawings and plans supplied by the Office of Works' architect.

When the defendants became tendering contractors it was the plaintiffs' duty to prepare sufficient and adequate plans and quantities on which the defendants could safely make their tender, and, after the tender was accepted, to prepare working drawings for the necessary amounts and dimensions of steel reinforcement.

On October 3rd, 1911, the defendants sent the Office of Works' drawings and specification to the plaintiffs and asked them to proceed with the detail drawing of the reinforced concrete work and send them detail quantities. On the 6th of the same month the work commenced. The date for completion was December 9, 1912, though the plaintiffs alleged that they did not know that at the time.

On October 7th, 1911, the plaintiffs had written to the defendants asking what portion of the work was to be constructed first so that the plaintiffs could proceed with the working details of that part immediately; to which the defendants replied on October 9th that they would require the drawings for the basement columns and the retaining walls first, the first portion of all being the columns and walls next the underpinning. At this date the defendants had in their possession the Office of Works drawing No. 24, being the setting-out plan made by the architect and which had been sent

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* Reported by Douglas Leechman, Esq., A.I.M.E., Barrister-at-Law.

to them by the architect on October 5th. This setting-out plan, although necessary for the purpose of enabling the plaintiffs to prepare the detail drawings, was not sent to them by defendants till about November 4th. The plaintiffs proceeded with and at once prepared their first plan called No. 16.

On October 7th the defendants by letter asked the plaintiffs to tell them then approximately the quantities for the contract of the steel rods, hoop steel, and steel links which would be required for the contract, and these approximate quantities were sent on October 12th, and came to 1,009 tons.

Mr. Allison, the architect to the Office of Works, had the assistance of a distinguished ferro-concrete specialist, Mr. Dunn. The defendants had to obtain their steel for the reinforcement of the concrete from the makers, and required from the plaintiffs statements of the descriptions and quantities of steel required from time to time (called in the case steel orders and distribution and employment sheets) in good time to enable the defendants to give their orders to the makers.

The architect sent to the defendants such working drawings as he considered necessary from time to time. These it was the business of the defendants to send at once to the plaintiffs. The plaintiffs prepared and sent to the defendants these working drawings, each showing dimensions and design of the part to which it referred. Each drawing was sent on by the defendants to Mr. Allison, who made in it such alterations as he found necessary, and then the drawing went on to Mr. Dunn, who considered it and if necessary discussed it either with Mr. Allison or direct with the plaintiffs, and if he required amendments of design, dimensions, or construction, these had to be complied with. When, but not until the plaintiffs' drawing had been put into such shape that Mr. Dunn's and Mr. Allison's requirements were complied with, it became an approved drawing and the plaintiffs and defendants could proceed with it. It was then for the plaintiffs to prepare and send to the defendants the necessary steel order or steel orders and distribution and employment sheets for the defendants to obtain the steel bars or other steel with which to reinforce the concrete.

As regards the plans and quantities made by the plaintiffs for the defendants' tender, the plaintiffs were under obligation to use competent skill and take every care in the conditions in which the plans and quantities were to be prepared in the preparation of them so that they should be as far as possible accurate in the matters to which they related. As regards the preparation and supply of working drawings and steel orders during the progress of the work the plaintiffs were under obligation to use competent skill and exercise all reasonable care and diligence so that the working drawings and steel orders should be sufficient and adequate to enable the defendants to fulfil and complete their contract with the Office of Works and be supplied in reasonable time—that is to say, in sufficient time to enable the defendants to give their orders for steel and carry out their reinforced concrete without being delayed for want of working drawings or steel orders.

The work proceeded after its commencement in October, 1911, and progressed during 1912. In the first half of that year occurred the coal strike, followed after a short interval by the transport workers' strike. These caused considerable delay and interruption of the defendants' work owing to failure and difficulty to obtain execution of steel orders in time, and, in the case of the transport strike, owing to stoppage of delivery of materials, and the delivery of a large gantry and cranes for facilitating the work was greatly delayed.

Eventually, while the reinforced concrete work under the contract was still going on the Office of Works ordered a very considerable extension of the work, which was put in the hands of the defendants to carry out, and consequently came into the hands of the plaintiffs for making plans and quantities. This further work became, as it were, merged in the work of the main contract, and in consequence no claim was ever made by the Office of Works against defendants for penalties or damages for delay.

The plaintiffs did not know that the defendants had been supplied by the architect with Office of Works' plan 24 (the setting-out plan) and proceeded at once to prepare their first plan called 16. They considered that the defendants desired them to concentrate attention first on the warehouse block of the building, and they put aside plans of the office block on which they had been engaged and devoted themselves to the warehouse block. This plan 16, which deals with bases and columns, was sent to Sir Henry Tanner, then principal architect of the Office of Works. It was not sent to defendants. In the first days of November the setting-out plan reached the plaintiffs from defendants.

This necessitated the cancellation of plan 16 and the preparation and calculating for another to be sent for approval. This became plan 219.

On November 17th the plaintiffs sent forward to defendants their plan 217 showing columns. It went forward to Mr. Dunn. As it showed a variation from the original type drawing Mr. Dunn had a discussion with the plaintiffs about it, and in the result, though Mr. Dunn considered, as appears from his evidence, that plaintiffs' proposal was sound in principle as regards strength, it was not adopted. This, of course, led to some but not serious delay.

The next plan delivered out was called 218, and was of a retaining wall which had to be made to the satisfaction, not only of the Office of Works, but of the London County Council. It was duly prepared and sent by the plaintiffs to the defendants on November 23rd, and after examination by the architect and approval by Mr. Dunn, sent forward for examination by the London County Council. It was kept in the office of that department for a considerable time. In a letter dated December 18th from the architect to defendants, they were prohibited from proceeding with any work in connection with this retaining wall until the approval of the London County Council and the Office of Works' architect to it was obtained. The London County Council required modifications in this plan, and it did not become an approved plan so that orders could be given on it or for work connected with it till February 1st, 1912, or thereabouts.

The architect of the Office of Works in due course sent forward to defendants his detail drawings, which were sent on by defendants sometimes after a few days' delay to the plaintiffs. These drawings were necessary for the plaintiffs' work, and the plaintiffs could not safely proceed without having them and having regard to them.

Plan 219, which dealt with the parts originally dealt with by the cancelled plan 16, was sent to the defendants on November 28th. Plan 220 of underpinning was sent on November 30th, and the first steel order was sent by the plaintiffs on the 29th before and in anticipation of the formal approval of plan 219. The first consignment of steel came from the steel makers on January 13th, but the supply of the whole order was not completed till February. The steel makers were delayed in their work.

Plan 221 of bases and columns was sent on December 10th. It was approved almost at once and steel orders were sent almost at once.

On December 21st an advance copy of plan 223 was sent. This plan led to discussion, and its settlement occupied some time. It proposed a change of design from the Hennebique system to what was called a skeleton beam. The design was considered an improvement, and was ultimately accepted by both the Office of Works' expert and the defendants. It involved alteration in the quantities. On January 1st plans 222 and 223 were sent, the former also involving some alteration of construction. On January 24th plan 224 was sent. On January 19th plans 225 and 226 were sent, and No. 225 had to be altered to comply with an Office of Works' detail which came forward later.

Plan 227 was sent on January 22nd. It had to be altered afterwards to suit the Office of Works' detail 68, which was sent on February 7th.

Plan 228 was sent to defendants on February 6th. It was returned approved, and steel order sheets were sent for it on or about February 21st.

During the remainder of February, 1912, drawings 228 to 245 were sent by the plaintiffs fairly regularly.

Their drawings dealt first with the warehouse block, and at the commencement of April on the request of the defendants they began work on the office block.

The defendants made a strong point of the fact that the plan for the main beam of Stamford Street front was not approved until March 5th, 1912, but the learned Referee could not find that there was undue delay in the preparation of this plan in all the circumstances. In his opinion the situation at this point was accurately summed up in a letter written by the plaintiffs to Sir Henry Tanner.

New Stationery Office.

February 19th, 1912.

Sir H. Tanner.

Dear Sir,—In reply to your letter of the 14th inst., we were waiting for the setting-out plans, especially in connection with the Stamford Street wall, which the contractor asked us to proceed with first.

You may perhaps recollect that in the case of the General Post Office many of our plans had to be re-prepared because we made them before we had the setting-out plans. Slight alterations in the setting-out plan nullified our work, and we thought in this case it would be preferable to wait until we had definite information before commencing detail drawings.

We were able to send a number of further plans and sheets of calculation forward on Tuesday last, and as we have up to date, up to and including the ground floor, prepared 45 drawings, we certainly anticipate being able to expedite the work now.

The last plans forwarded, if approved, will give the contractor the whole of the main building up to and including the ground floor.

With reference to the vault wall, the contractor was anxious to make a start on this, and although we know now that nothing was altered, we could not make a start until we had a definite decision.

Yours faithfully,
For L. G. MOUCHEL AND PARTNERS,
(Signed) J. S. E. DE VESIAN.

After February the coal and transport workers' strikes seriously affected the defendants' ability to carry on the work, and it was on delays prior to the coal strike and consequent inability to get in their steel orders that the defendants strongly relied.

Having held the facts to be as above, the learned Referee found himself unable to accept the defendants' contentions that the complete plans for each floor should have been delivered within successive short periods, and that the plaintiffs had cut their quantities for the original tender in order that one of their contractors might secure the contract, and that delays arose by reason of their having to devise schemes to remedy the effects of the miscalculations.

The claim of the defendants so far as founded on the alleged delay therefore failed.

Turning next to the claim for damages because of inaccurate quantities supplied by the plaintiffs for the drawings and variations during the progress of the work, the learned Referee said :—

After the best consideration that I have been able to give of all that witnesses have said, and of all the documents and of the arguments so carefully and ably put before me on both sides, I am unable to find that the defendants have established that either in the preparation of the tender quantities or in the preparation of the subsequent working drawings, steel orders and distribution sheets, the plaintiffs were guilty of want of skill, of want of care and diligence, or any breach of their expressed or implied obligations to the defendants.

So much for that branch of the defendants' claim.

It remains to notice a claim by the defendants that the plaintiffs had by letters agreed to indemnify the defendants against any loss which the defendants should suffer by reason of variations during the construction of the structure in the plans and drawings, and warranted that the variations should not cause the defendants additional expense and damage. I do not read the letters of the plaintiffs on which this cause of action is pleaded as amounting to any such indemnity and warranty. But further, if they do, the circumstances in which the variations were made preclude any claim arising under such an indemnity or warranty, nor, as I have said, am I satisfied that any of the loss which the defendants have suffered is due to variations for which the plaintiffs are responsible.

The result is, in my opinion, that it is my duty to find that the liability of the plaintiffs to the defendants pleaded in the counter-claim has not been established, and therefore no inquiry as to amount and items is necessary.

It follows that there should be judgment for the plaintiffs for the amount claimed in the amended writ and dismissing the counter-claim with costs of the action and counter-claim.

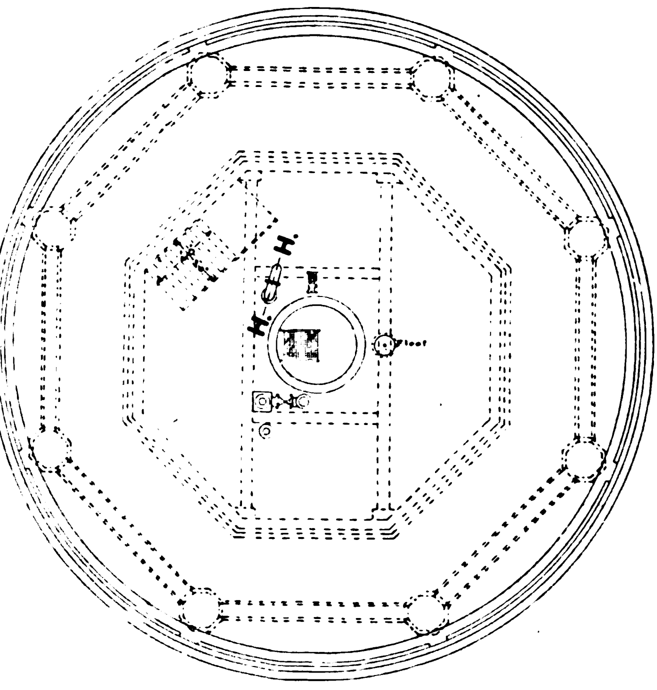
NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

REINFORCED CONCRETE WATER TOWER AT TOPSHAM, DEVON.

THE economy and adaptability of reinforced concrete over steel and cast iron tanks is so appreciable that practically all modern water towers are now constructed in reinforced concrete. The illustration which we herewith reproduce shows one of the latest works of this kind recently erected in this country at Topsham, near Exeter. The water tower is in connection with a scheme for the supply of water to the rural district council of St. Thomas.



Section.

REINFORCED CONCRETE WATER TOWER, TOPSHAM, DEVON.

The construction of the water tower, pump house, and, in fact, the entire scheme, was elaborated in accordance with the plans and under the supervision of Mr. Sidney R. Lowcock, M.Inst.C.E., M.Inst.M.E., on the Coignet System of reinforced concrete, and plans for the reinforced concrete were prepared in accordance with this method by Messrs. Edmond Coignet, Ltd., of 20, Victoria Street, S.W.

The total capacity of the water tower is 50,000 gallons, and, as shown in the illustration, the tank is supported by an octagonal tower surrounded by pillars.

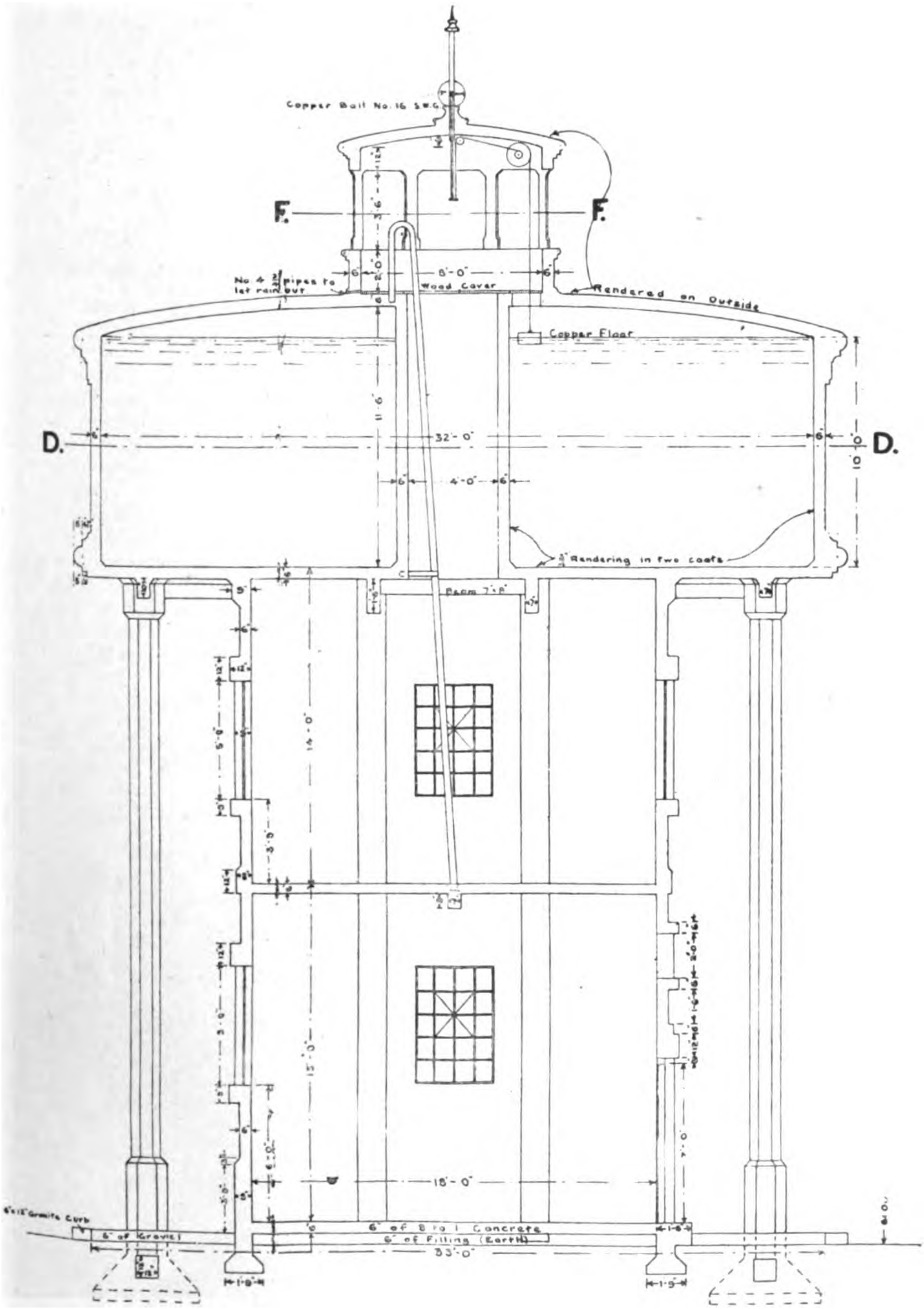
The tower contains a ground floor and first floor suitable for storage purposes and also for the accommodation of the various pipes and valves. A circular access well through the centre of the tank leads to the top by means of a spiral staircase. The upper turret contains a suitable manhole and an iron ladder to enable the occasional inspection of the inside of the tank to be carried out.

The mouldings surrounding the tank at the top and bottom, and various other decorative features, have been introduced in order to give the work a pleasing appearance

Finished View of Structure.
Reinforced Concrete Water Tower, Topsham, Devon.

The tank stands at a height of 30 ft. above the level of the ground. The height of the tank itself is 10 ft. with an inside diameter of 32 ft. The total height of the structure, however, is, approximately, 50 ft. from the ground level to the top of the turret. The tank is covered by means of a reinforced concrete dome, and an ingenious apparatus fitted to the top of the turret indicates the level of the water in the tank by means of a copper ball rising and falling along a shaft, the copper ball being connected by means of pulleys to a float.

The entire reinforcement was composed of round bars of mild steel. The pillars,



Section.

REINFORCED CONCRETE WATER TOWER, TOPSHAM, DEVON.

which are octagonal, contain eight vertical bars surrounded by spiral ties of small diameter.

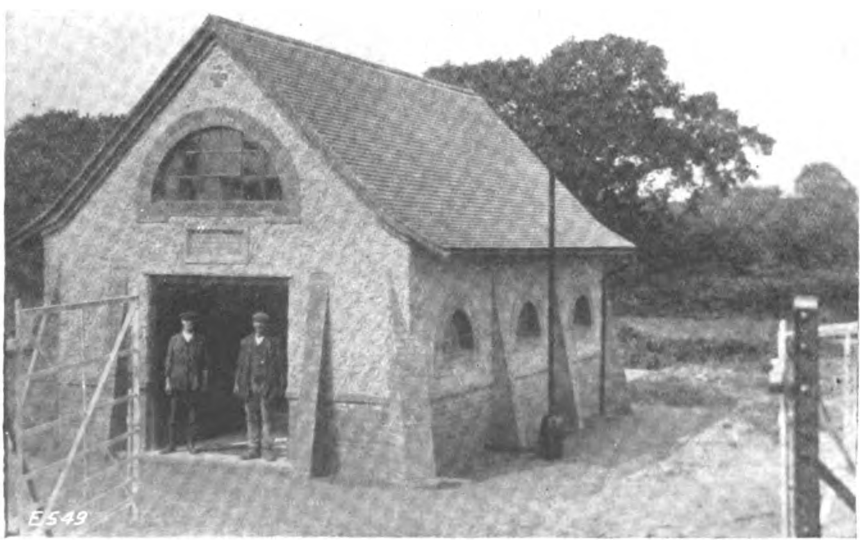
The loads are transmitted to the ground by means of footings in the shape of a pyramid, also reinforced by bars of small diameter. The various footings are braced together by means of beams, and the walls of the tower, which have a thickness of only 6 in., are simply reinforced by means of a meshwork of small bars. The bottom of the tank is 5 in. thick and the walls 6 in. thick. The thickness of the dome is 6 in. The reinforcement of the bottom is composed of slabs and beams distributing the weight evenly on the pillars and walls of the tower, the reinforcement of the slabs being composed of principal and secondary bars as usual, and the reinforcement of the beams being composed of groups of straight bars top and bottom, linked together by means of stirrups. The walls are reinforced by means of circular bars varying between ½ in. and ⅜ in. in diameter and spaced 3½ in. centres along the height, in order to evenly resist the water pressure. A circular beam around the bottom of the tank is calculated to form a connection between the walls, and the floor of the tank should also absorb a certain amount of the pressure. A circular beam at the top of the tank is calculated to absorb the outward thrust of the dome. The reinforcement of the latter is composed of a meshwork of small bars radiating from the centre. The inner circular access well has walls of a thickness of 6 in., the inside diameter of the well being 4 ft. The reinforcement of these walls is similar to that of the outside walls.

The whole of the inside of the tank was made thoroughly water-tight by means of ¾ in. of rendering applied in two coats.

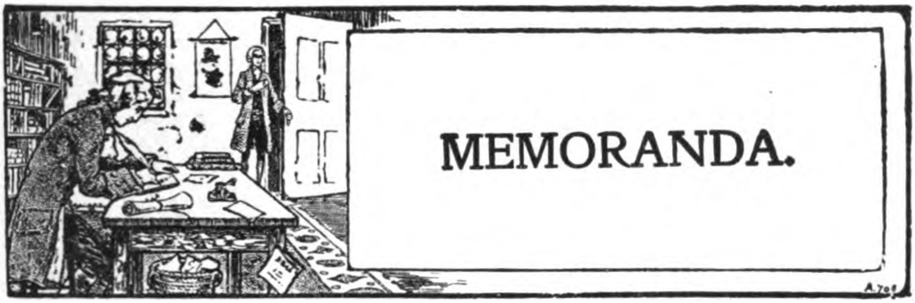
After a suitable length of time the tank was filled with water, and it was found to be absolutely water-tight, no leakage appearing anywhere.

A pump house with oil engines has been constructed in brickwork with a tiled roof about three-quarters of a mile from the water tower in order to pump the water from the well into the tank.

The work was carried out by Mr. John K. Harris, contractor, of Clyst Hydon, near Exeter. The contractor's agent supervising the construction was Mr. V. D. Lake.



REINFORCED CONCRETE PUMP HOUSE, TOPSHAM, DEVON.



Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Concrete Institute.—The next meeting of the Institute will take place on January 25th, at 5.30 p.m., when Mr. C. R. Peers, Chief Inspector of Ancient Monuments, H.M. Office of Works, will read a paper on "The Care of Ancient Monuments."

Keadby Bridge.—At a recent meeting of the Institution of Civil Engineers an interesting paper was read by Mr. J. B. Ball, M.Inst.C.E., on this bridge. We give the following abstract from the paper:—

The Great Central Railway Company have recently completed an important bridge over the River Trent at Keadby, about fourteen miles north of Gainsborough, of which the chief feature is a lifting span, built on the Scherzer principle, which claims the distinction of being the heaviest lifting bridge yet constructed in Europe. The new bridge replaces the old swing bridge at Keadby which has carried the railway for over sixty years, and, in addition, carries a public highway in satisfaction of a long-felt want.

The new structure consists of a combined railway and roadway bridge of five spans of the following dimensions:—Two fixed river spans of 135 ft. each; a lifting span of 160 ft., giving a clear waterway of 150 ft.; a track span of 40 ft., on which the lifting span rolls, and an approach span of 70 ft. on the east bank of the river.

The bridge has a width of 53 ft. 6 in. between the centres of the outside girders, of which 29 ft. 3 in. is occupied by the railway and 24 ft. 3 in. by the roadway; each span consisting of three main girders, the centre one dividing the roadway from the railway.

The river piers, of which there are four, are faced with granite and founded on rectangular steel caissons filled with concrete and sunk under compressed air to a depth of 50 ft. below low water. The largest of these caissons has an overall length of 94 ft., a width over cutting edges of 20 ft., and a permanent height of 32 ft.

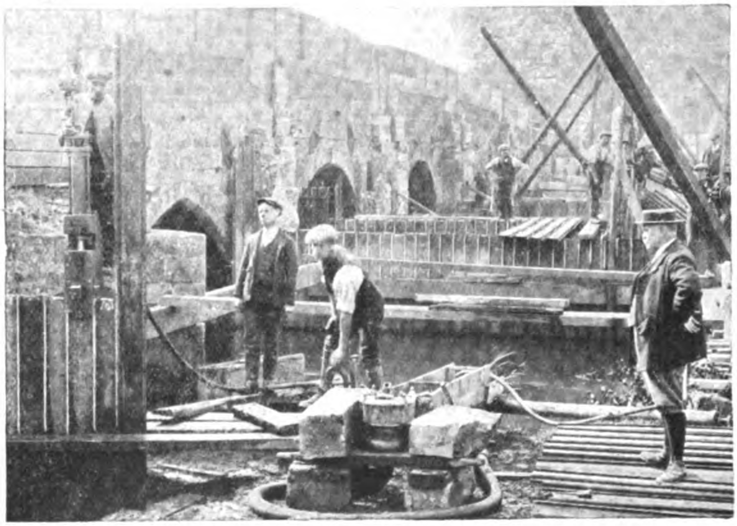
Difficulty was encountered in the early stages of sinking through one of the caissons tilting forward and moving bodily towards the river, which threatened serious results, but steps were taken which proved effective in arresting any further movement, and the caisson was finally righted during sinking in the new position it had taken up.

The two fixed river spans are similar in design, the main girders being of the ordinary N type, 17 ft. in depth, divided into ten panels and counterbraced in the two centre bays. The cross girders are suspended from the vertical posts below the bottom booms and spaced 13 ft. 6 in. apart; between them ordinary roadway and railway stringers carry the deck plating.

The top booms are connected by portal bracings at each vertical post, intersected by diagonal wind-bracing, and provision for longitudinal expansion is made at the junction of the spans by means of cast-steel bearings mounted on groups of rollers. The total weight of steelwork in each of these spans is 540 tons.

The three main girders of the track span form a path on which the lifting span rolls, and together have to sustain the weight of the lifting span, which is nearly 3,000 tons. These girders, which are of very heavy construction, have an effective length of 40 ft. and a depth of 10 ft., and carry on their upper flanges cast-steel plates,

The BRITISH STEEL PILING Co



Widening Dove Bridge, Uttoxeter.

The contractor who used the piling wrote :—"I have been well satisfied with the piling."

The Piling used was our "SIMPLEX," in 18 ft. lengths, 22 lbs. per sq. ft. Sufficient was supplied to do half the work : the piles were driven through the timber foundation grillage of old work with a No. 3 McKieman-Terry Hammer, and withdrawn with one of our "GRIPS": then we repurchased the materials from the contractor.

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$3\frac{1}{2}$ in. thick, on which the teeth are formed, engaging with corresponding slots in the segmental girders of the lifting span.

Considerable attention was given in the design of the bridge to the question of the contact pressures obtaining between the segmental girders and the track plates upon which they roll, and for the purpose of determining the probable arc of contact, careful experiments were made, particulars of which are recorded in the paper.

The lifting span consists of three main trusses spaced at the same distances from one another as the main girders in the fixed spans, and taper from a depth of 36 ft. at the rear end to 18 ft. at the fore end. Cross girders, spaced 19 ft. $8\frac{3}{4}$ in. apart, with longitudinal stringers between them, carry the deck plating of the road and railway respectively, whilst the upper booms of the trusses are connected together by substantial overhead portal bracing on each of the vertical posts, which, together with the wind-bracing above and the floor members below, tie the trusses together, thus securing rigidity in the span as a whole.

The lifting span is counterweighted at the rear end in order to secure balance at all angles of lift, the counterweight consisting of a rectangular steel shell extending across the full width of the bridge, and heavily braced internally by lattice frames and strengthening girders. Its internal capacity is 24,780 cu. ft., and it contains 1,800 tons of concrete.

The total weight of steelwork in the lifting span is 987 tons, exclusive of the machinery and gearing, and the total weight of the moving span, together with its counterweight, is approximately 2,920 tons.

Concrete Wine Vats.—The following is taken from *Il Cemento* :—Concrete wine vats were introduced by Borsar in 1873, and for ten years they were constructed without any special lining. In course of time, however, it was observed that the flavour of the wine was spoiled by the action of the vinous acids on the cement, and for some years concrete vats lined with plate glass about $\frac{1}{4}$ in. thick have been used with complete satisfaction.

The vats may be of any shape, this being a great advantage where space is limited, as the use of vessels of circular section is often inconvenient. Wooden vats must always be kept in good order, whereas damp does not harm concrete.

The vats are usually built in batteries in order to utilise the common walls. Below each is a small outlet, towards which the bottom of the vat converges, so that it may be completely and rapidly drained.

Vats made of concrete—even when lined with glass—cost much less than wooden ones, a saving of 10 to 20 per cent. being readily effected. Concrete vessels are much cleaner than those of wood, as they can be washed and purified perfectly and used to keep different wines—either white or red—without the flavour of these being influenced by the vats. This is impossible with wooden vats.

Another advantage is that concrete vessels may be made much larger than wooden ones, so that the temperature is more constant and there is much less evaporation; in closed cement vats, lined with glass, the loss by evaporation is about one part per thousand against sixty to seventy parts per thousand in the wooden vats. Whilst this difference is important in the case of wines, it is still more so in that of liqueurs.

When grapes are scarce and some vessels must, therefore, be left empty, those made of concrete do not deteriorate at all, whereas wooden ones must be heated with sulphur. If a concrete vat is to remain inactive for a short time it is sufficient to wash it clean and leave it open, but if it is to remain for a long period it is better to wash it, wipe it dry, then wash it with a mixture of alcohol and water in equal parts, and to close it completely.

The substitution of tiles for glass in lining the vats is not desirable, as wine may percolate through the joints of the tiles and into the concrete and may eventually spoil the wine in the vats.

The expectation that concrete vats would be too cold for effective fermentation has proved to be incorrect, and in any case they can be maintained at any desired temperature by means of suitable heating appliances.

In some cases it has been found necessary to aerate the liquid very slightly, as the glass lining is not porous like wood and may delay the fermentation because it allows less oxygen to enter the vessel.

The fears that the conductivity of the concrete may interrupt the fermentation by allowing too much heat to pass away is also unfounded. Even in Algeria, where there are many concrete wine vats, this fact has never been noticed. In the hotter countries the manufacturers water the outer walls of the vats during the fermentation; this can be done equally readily with concrete vats.

Experience has shown that glass-lined concrete vats may be used with complete satisfaction for both cheap and costly wines; even vermouth is stored in them in large quantities. For the cheaper wines the lining of glass is often omitted without any serious consequences being observed, provided the inner surface of the vats has been well grouted and waterproofed.

CHANGE OF ADDRESS.

Messrs. Henry Faija Co. again call attention to the fact that they have secured larger and more convenient laboratories at 6, Earl Street, Westminster, S.W., and all communications should be sent there and not to the old address in Old Queen Street.

PUBLICATIONS RECEIVED.

A useful little booklet for students has been published, dealing with the "Slide Rule: Its Operations and Digit Rules," by A. Lovat Higgins, Demonstrator of Engineering at Queen's University, Belfast. The booklet deals with the use of the slide rule and the methods of operating the rule in various computations. Price 4d.

TRADE NOTES.

The British Reinforced Concrete Engineering Co., Ltd., Manchester, have issued another of their booklets dealing with "Road Reinforcement," and it contains interesting particulars and illustrations showing the difference in character between English and French roads.

CONCRETE
THE
MONEY
SAVER

SMALL CONCRETE GARAGES.

By ALBERT LAKEMAN, M.S.A.

In the articles here presented it is intended to give information on the construction of small garages only. In the concluding article some notes will be added on the important questions of the storage of petrol, lighting, ventilation, etc. Our illustrations have been reproduced from a pamphlet issued by The Portland Cement Association of U.S.A. on the subject of concrete garages.—ED.

INTRODUCTION.

THERE are many points to consider in the design and construction of small motor garages, and this type of building is probably the most important of any of the out-buildings erected in connection with ordinary domestic usage, on account of the value of the contents stored therein. In spite of the latter fact, however, it will often be found that an expensive car is housed in a cheap and unsuitable building, and in many cases this is due to the lack of foresight and experience on the part of the owner rather than to any deliberate attempt to save a few pounds to the detriment of the building itself. If the obvious advantage of a suitable structure, which need not necessarily be expensive, were clearly set down before the average motor-car owner, it is quite certain that he would not be prepared to run the risks of a combustible or temporary building, and the result would be that garages would be built on better lines.

The chief points to consider in connection with every garage may be stated as follows:—(1) Site; (2) Dimensions; (3) Materials of construction and finishing; (4) Storage of petrol; (5) Lighting and heating; (6) Ventilation.

SITE.

The first point will naturally be much governed by the circumstances which obtain in each particular case, and it is quite unlikely that identical conditions will be met with in any two cases.

There are, however, some considerations which should be borne in mind when planning the position of the structure, such as the accessibility from the road, the space for turning the car, the space for outside washing, and the distance from the water, gas, and electric light mains. The garage should also, preferably, be kept away from the dwelling house, even when the regulations of the district do not insist on such a condition, and it is also a very bad policy to house the car in any garage which is adjoining wooden sheds or other combustible erections.

DIMENSIONS.

With regard to the dimensions, it may be sufficient to provide for a particular car which it has been definitely decided to house, but if this is a small car it may not prove economical to build the garage to suit this only, as in the event of the owner acquiring a slightly larger car, the building may be useless. It is a wise policy to make the garage of such dimensions that it will accommodate any ordinary size car, and thus a standard type can easily be evolved. The general tendency is to make the garage so small that there is a difficulty in passing the car, and all inside repairs are impossible. To allow a clearance on each side of about 2 ft. necessitates a width of 10 ft. to 12 ft., and the latter dimension is often adopted. The length will be influenced by the question as to whether an engineer's bench is to be provided at one end. If this is required it should be about 2 ft. wide, and there should be 3 ft. for working at the end of the car, necessitating a total length of about 21 ft. in the garage. If no bench is to be installed, then the length may be reduced to 18 ft. or even 16 ft. For a small car, where the cost is to be reduced to the minimum, the size can be taken as 10 ft. by 16 ft., and for a moderate size car, with a bench, the dimensions should be 12 ft. by 21 ft.

MATERIAL OF CONSTRUCTION.

The selection of the materials used in the construction and finishing of a motor garage is one of great importance, and too much care and consideration cannot be exercised in this direction. The primary points to be kept in view are (1) fire resistance, (2) durability, (3) appearance, (4) economy. The materials in common use are concrete, bricks, stone, timber, and galvanised iron, and some of these are very unsuitable, while there is no doubt that concrete takes first place as a good material which meets all the conditions imposed under the four primary points as stated above. Concrete has the valuable characteristic that it can be used for the floor, walls, and roof, and thus it is the one material that will provide a homogeneous structure. If brick or stone is used, then the floor and roof will require to be of some other material, and although satisfactory buildings are erected with these materials, they do not combine the maximum of fire resistance with economy and durability, and thus concrete is daily becoming more universal for garage construction. Concrete is eminently fire-resisting, as has been proved by actual fires in buildings; it is the most durable material in existence; a very pleasing appearance can be obtained, and it is more economical, as regards initial outlay, than either brick or stone. The material has been successfully used in numerous garages, and some of these are illustrated in this article, where the satisfactory appearance can be seen.

FLOOR.

The floor should be constructed with 5 in. or 6 in. of plain concrete, laid to fall slightly from the two side walls to the centre, where a channel for drainage is formed, but the floor should be level across the longitudinal section. This concrete should be composed of 4 parts suitable aggregate, 2 parts clean sharp sand, and 1 part of Portland cement. In the majority of cases no hard core is necessary under this concrete which can be laid directly on to the ground when the top spit has been removed. The channel formed in the centre of the floor should be carried the full length of the building and discharge into an open gulley outside. The surface of the concrete should be finished with a non-absorbent material, to prevent oil soaking in, as the latter is very destructive to the tyres, and good materials for this purpose are granolithic, composed of granite dust and cement, or cement and well washed sand.

When the ground is suitable it is an economical method to carry the concrete forming the floor over the site to the outside line of the walls in the nature of a raft, and upon this the walls are built direct. This will obviate any trenches for the wall foundations, and thus both digging and material are saved. It may be considered by some that it is absolutely essential to carry the wall foundations down to a point below the level of atmospheric influence, to avoid settlement; but in small light buildings, such as are here dealt with, it is rarely necessary, and the writer has constructed many buildings on the economical principle above mentioned without having a single failure. If the ground is very poor and unreliable it will be necessary to increase the thickness of the concrete under the walls accordingly, and the bottom of the building will then be in the nature of a large slab with plain concrete beams projecting on the underside, and it is advisable to lay the whole of the concrete as one process and form the floor and foundations as a complete unit.

WALLS.

With regard to the walls there are various methods of concrete construction, each of which has its particular advantages according to the circumstances of the case. It must be borne in mind that the walls do not need to be carried up to a great height, 8 ft. 6 in. or 9 ft. being sufficient in all cases, and therefore a heavy type of construction is not essential. The concrete may be used either in the form of blocks, or to give a monolithic structure by being cast between vertical shuttering, or, again, the garage may be built with light steel uprights covered with metal lathing to serve as a ground for stucco or cement plaster.

Some idea of the pleasing effect that can be obtained by the use of the concrete blocks is seen in *Fig.* 1, which is a photograph of a garage built for one car. The design is very effective as regards appearance, and although the dormer window

Fig. 1. A One-Car Concrete Block Garage.
SMALL CONCRETE GARAGES.

in the roof could be omitted, and the doors and windows simplified to reduce the cost, it affords a good example of concrete block walling. The drawings for a simple garage with alternate elevations for monolithic or block construction are illustrated in *Fig.* 2, and the general arrangement of a cheap structure for one car is shown. Other examples of the application of block construction are given in *Figs.* 3 and 4. The first of these two illustrations is interesting as showing the effect of using blocks of varying sizes. Although not commonly adopted this method should remove the prejudice that exists in the opinions of many persons that concrete block construction is monotonous on account of the units being uniform in size and colour. The second illustration indicates some originality on the part of the designer and shows the possibility of concrete work.

Concrete Blocks.—In the case of block construction for the walls it will be realised that the conditions which have to be met in domestic buildings will not be applicable to garages, and the arbitrary bye-laws which exist in many districts for cottage work will not be enforced in the case of structures which are not built for habitation. As an example, in some districts hollow blocks for domestic work are only allowed on condition that each part of the wall is at least 4½ in. thick. As the average hollow blocks are made with two 2¼ in. leaves with a 4½ in. space between, they will not comply with the bye-law, and thus, although eminently suitable for cheap cottage work, they are often prohibited through ignorance on the part of those responsible for the drawing up of such bye-laws. In consequence of this prohibition much work is executed with 4½ in. solid blocks built in two leaves with a cavity between, but in small garage work this is not essential, and economy can be effected by the use of one thickness of walling. The blocks should be of the hollow type 18 in. long, 9 in. wide, and 6 or 9 in. high, and the cavities in the block should not exceed one-third of the total bearing surface. Larger blocks may be obtained, but the units of construction should bear some proportion to the size of the structure in order to maintain the scale and provide a satisfactory appearance, and if large blocks are used they are likely to affect adversely the appearance of the building unless they are to be rendered with some material on the outside. The latter is not necessary

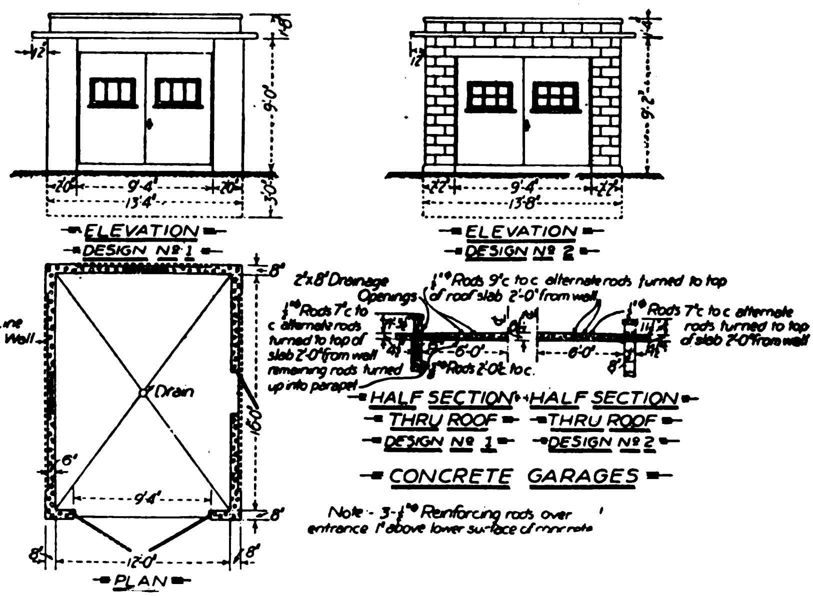
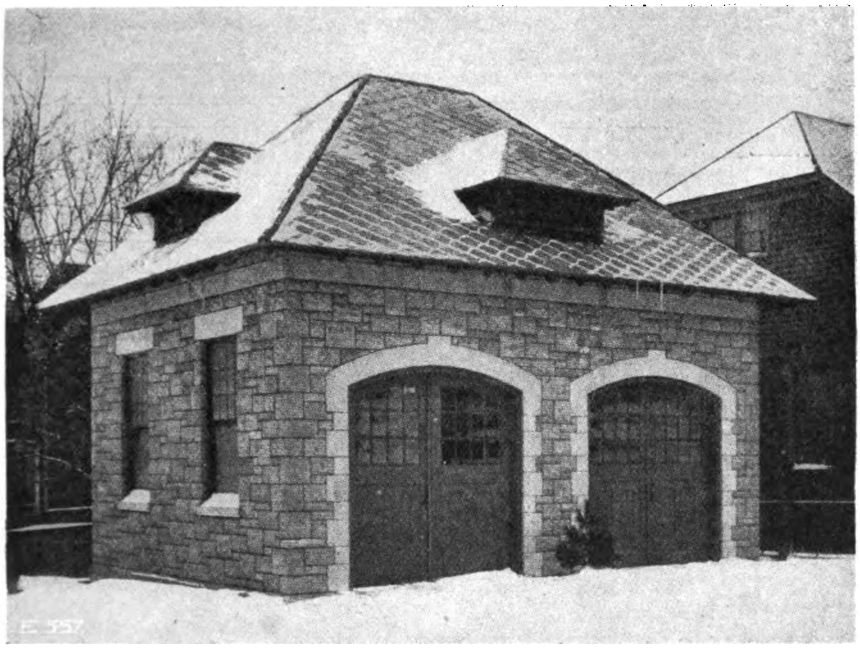
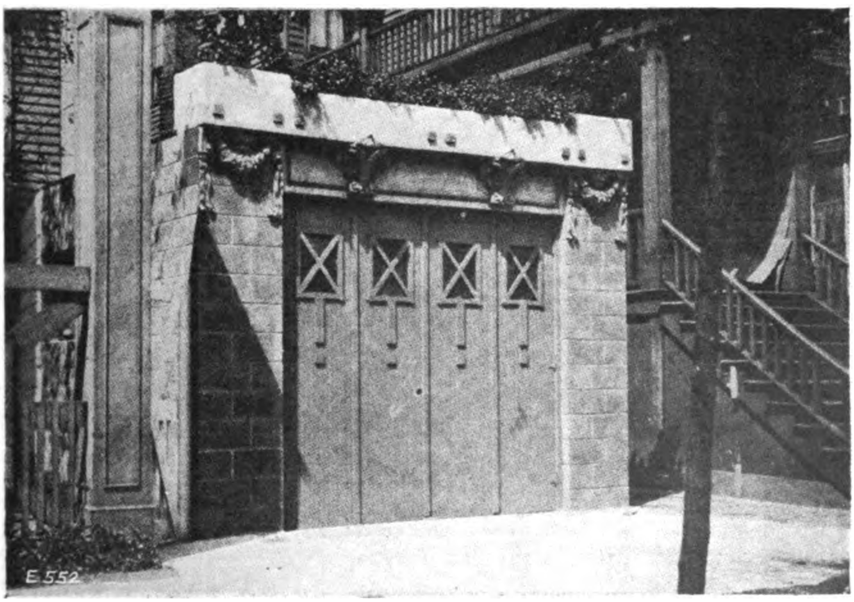


Fig. 2. Design for Small Monolithic Concrete Garage, showing alternative construction by using Concrete Blocks.

SMALL CONCRETE GARAGES.

from the practical point of view and the cost will be unnecessarily increased. The use of ordinary hollow blocks will give a thickness of wall of 9 in. and this will be satisfactory for all ordinary cases without any outside rendering or rough cast, and no plaster will be required on the inside. If the building is at all exposed to adverse weather conditions the blocks should be made with a face consisting of two parts of sand and one part of Portland cement, as this will render them more impervious to rain. The face may be moulded with a rustication or left plain as may be desired, or rock-faced blocks may be used for the quoins only, but care should be taken to keep the work simple and not too heavy in such small buildings. A damp proof course should be inserted at the base of the walls to prevent damp rising, and the joints between the blocks should be well flushed up with mortar, while all cavities are kept clear. Where windows occur they should have a width equal to some multiple of the length of block used to prevent cutting and ensure good work, and the lintels over windows and doors should be of concrete cast *in situ*, with a little reinforcement in the case of the latter on account of the span.





Figs. 3 and 4. Examples of Concrete Block Garages.

SMALL CONCRETE GARAGES.

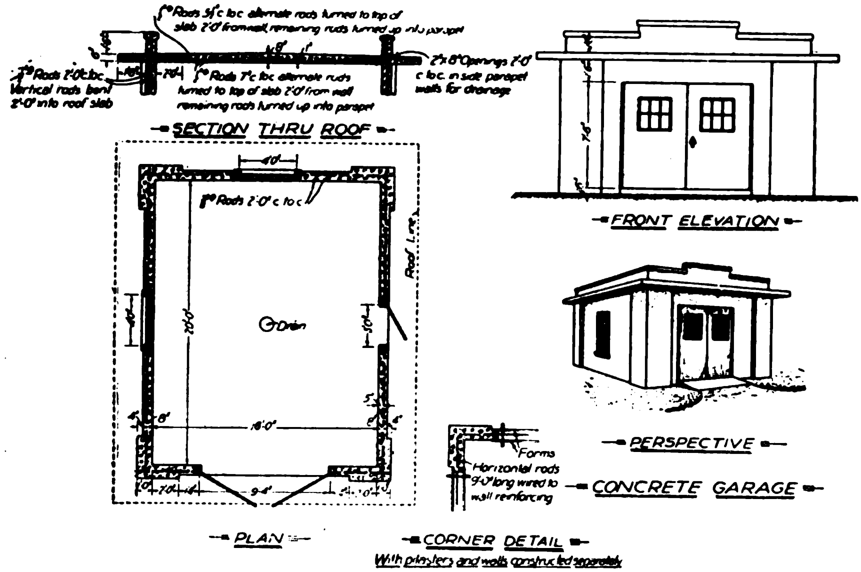


Fig. 5. Another Plan for Monolithic Construction with Pilaster Effect at Corners.

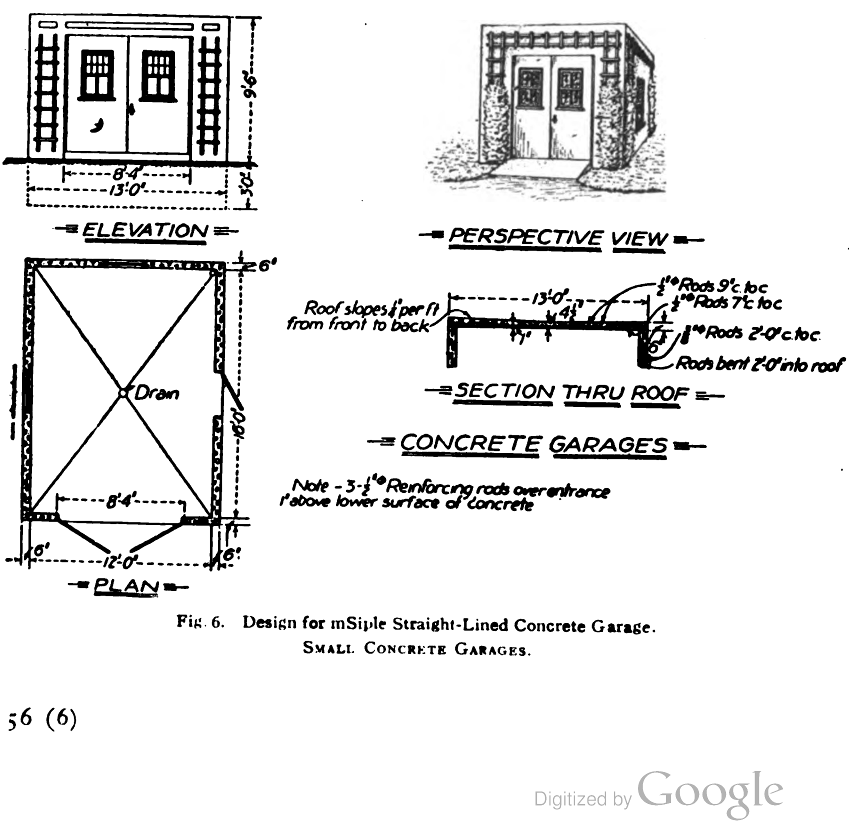


Fig. 6. Design for mSiple Straight-Lined Concrete Garage.

SMALL CONCRETE GARAGES.

Monolithic Walls.—When the walls are constructed with monolithic concrete the thickness usually employed is 5 in. or 6 in., and a little reinforcement is added in the nature of small rods spaced at 18 in. or 2 ft. centres to prevent cracks. These rods should be carried down into the concrete at the bottom and into the roof at the top when the latter is of concrete, and additional steel is provided over the openings and at the corners. The drawings of a slightly larger garage than that usually employed for one car is illustrated in *Fig.* 5, where monolithic construction is indicated. The walls are here given as 8 in. thick reinforced with ⅜-in. diam. rods at 2 ft. centres, and the corners are stiffened by piers 3 ft. wide on face and 12 in. thick. This construction would be quite effective but it would prove more expensive than the use of concrete blocks, and the outside surface of the walls would require some form of treatment, either rendering or rough cast, to produce a pleasing appearance. Another suggestion for a monolithic structure is given in *Fig.* 6, where the most simple type possible is illustrated. A building of this kind is practically a concrete box, and

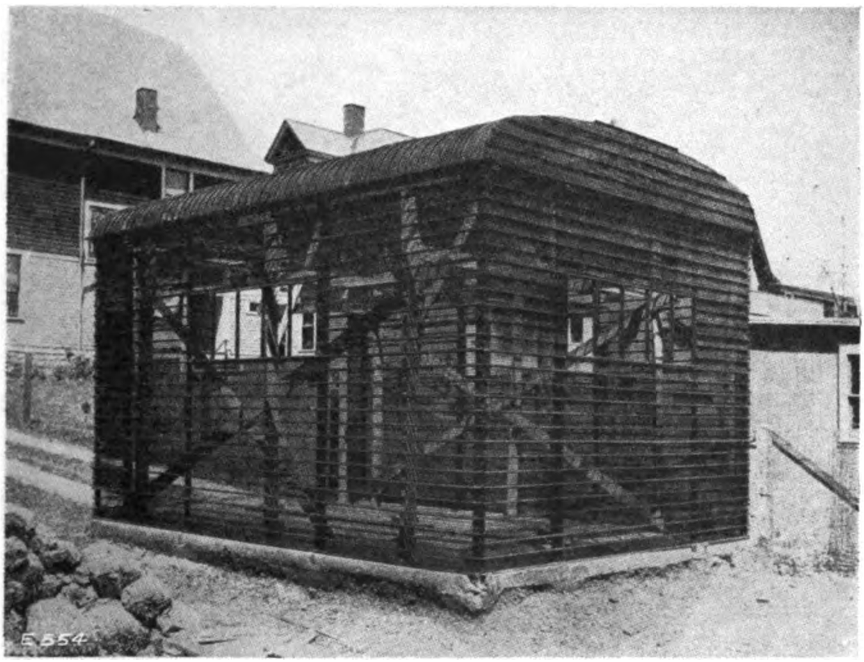


Fig. 7. Metal Lath Framework to be covered with Stucco or Cement Plaster.
SMALL CONCRETE GARAGES.

apart from its appearance it is cheap and eminently suitable for housing a small car where fire resistance is desired, and the maintenance is practically nil. The walls are given as 6 in. thick, reinforced with ⅜-in. diam. rods at 2 ft. centres, and three ½-in. diam. rods over the entrance doors. Although small monolithic structures have been built with some success they will not usually be found so economical as those built with separate units because the shuttering is expensive, especially with timber at its present high price, and a certain amount of skilled labour is necessary in its erection, and it is only when the shuttering can be repeatedly used in repetition work that the outlay will be refunded to the builder. Garage work does not usually provide much scope for such repetition work, and thus the use of concrete blocks is likely to prove more economical and be more generally adopted than the monolithic type. It is highly important, however, that the blocks be well seasoned before being used to prevent cracks occurring, and too much stress cannot be laid upon this point, because many a building which is admirably designed and well constructed in all other respects develops defects from this cause alone, and clients become dissatisfied, when the cause of the complaint could have been prevented by a little care in the right direction. The cheapest possible form of construction for small buildings, which are to be weatherproof and lasting, is provided by the use of well-made, seasoned concrete blocks, and it has a great future before it if its reputation is not damaged by careless work.

Metal Lathing with Stucco, etc.—Mention was made in the earlier notes of walls constructed with metal lathing and covered with stucco or cement plaster, and an excellent example of this class of work is illustrated in *Figs.* 7 and 8, where two photographs are given, one showing the framework and lathing as fixed in position and the other giving the finished building. The appearance of the structure certainly leaves much to be desired, but it is a cheap and efficient covering for a car, and far preferable to the wooden and temporary buildings that are so often seen. In some cases this type of building is erected with small reinforced concrete columns at the corners with wires passing through the concrete for the attachment of the metal lathing which is used for the filling. Wherever metal lathing is adopted the vertical members to which it is attached should be well secured at the foot to the floor concrete or concrete foundations in order to provide efficient anchorage.

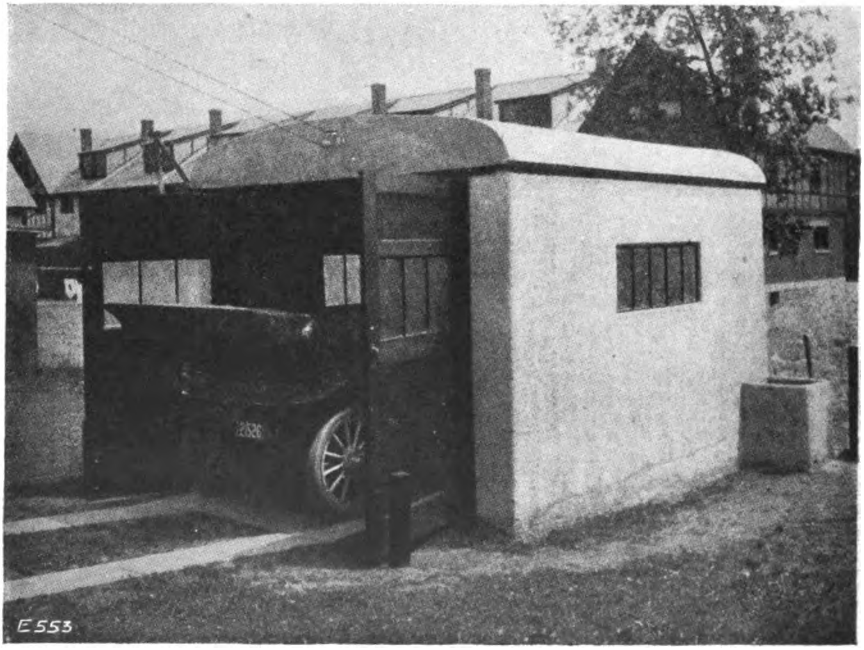


Fig. 8. View of Metal Lath Structure when completed.
SMALL CONCRETE GARAGES.

(To be concluded.)

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CONCRETE AND CONSTRUCTIONAL ENGINEERING

FEBRUARY 1917. VOL. XII. No. 2.

A MONTHLY JOURNAL FOR ENGINEERS, ARCHITECTS, SURVEYORS & CONTRACTORS and all interested in CEMENT, CONCRETE, REINFORCED CONCRETE, FIRE-RESISTING CONSTRUCTION and STRUCTURAL STEEL.

ISSUED MONTHLY

CONTENTS.

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(Editorial Offices at 8 Waterloo Place, London, S.W.)

Reinforced Concrete Construction in the New Cotton Warehouses and Terminals of the Port of New Orleans.
(*For description see page* 61.)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XII., No. 2. LONDON, FEBRUARY, 1917.

EDITORIAL NOTES.

CONCRETE AND RESEARCH.

ONE of the last announcements made on behalf of the Coalition Government was Earl Crewe's intimation that a proper place was to be given in Whitehall to the consideration of problems of scientific and technical research. What had been originally initiated in the form of a Committee of the Privy Council was to become a proper department having funds at its disposal, and, apparently, it was to be so organised that it would not only be able to accept and administer funds put at its disposal by His Majesty's Treasury, but also all moneys received by donation or bequest. The outgoing Government were to be congratulated upon following the advice they had received from the old Committee of the Privy Council, and the chairman and officers engaged on the technical work of that Committee have deserved well of the nation in pressing the claims of scientific and technical research, and in pressing for the establishment of a suitable department to deal with the problems that require elucidation and advancement.

Given the new Department of Scientific and Technical Research, it behoves this journal to press the claims of concrete and reinforced concrete. It is not properly understood by building owners, as a whole, that economy in building construction will be very much the order of the day after the conclusion of the present war. It is still less understood by them that for a considerable period there will be a dearth of steel for steel frame buildings and similar constructions, and that for all building purposes nothing can be devised that is more practical and more economical than structures of concrete and reinforced concrete to meet the demands that will arise.

The very essence of concrete and reinforced concrete is economy and adaptability, and its great feature is that a comparatively small quantity of Portland cement and of steel in the form of bars has to be transported in order to produce, with the aid of local aggregates, the necessary substance for any building under consideration; whether the aggregate be local gravel, ballast, clinker or burnt clay is immaterial given a proper and suitable application of these aggregates. The great feature is that more than three-fourths of the bulk of the material to be utilised can, as a rule, be obtained locally with the least possible amount of cartage and at the least possible expense, and that the cement and the steel bars that are required will not make heavy calls upon railway or shipping facilities.

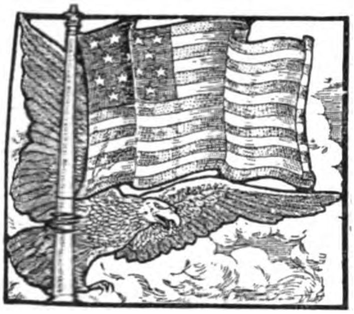
A certain amount of research work has been done in this country as far as concrete and reinforced concrete are concerned. We are indebted to individual manufacturers, to the Institution of Civil Engineers, and to one or two individual investigators for British data as far as stresses, strains, etc., are concerned. We are further indebted to the British Fire Prevention Committee for certain valuable investigations as to the fire rsistance of concrete and reinforced concrete, in which department research in this country takes the lead; and we have to thank various cement chemists and Portland cement undertakings for inquiries into the various advantages of applying cement under various conditions and under varying circumstances. Except on the fire question, in which this country has led, the net amount of information obtained in this somewhat haphazard manner has been useful, but very limited in extent. We have had to rely chiefly on the investigations of the United States and to a certain extent on the investigations conducted in France, Germany, and Austria. In all these countries conditions are somewhat different to those met with here; the cements vary somewhat, the aggregates vary materially, and the practice also differs in many respects. It is, accordingly, high time that systematic research work should be undertaken in the United Kingdom as far as concrete and reinforced concrete are concerned, and if, as we anticipate, this research work can be conducted with the aid, under the guidance, and, to a certain extent, under the control of the new Department of Scientific and Technical Research set up in Whitehall, we shall indeed be taking a step forward.

In the first instance, a piece of research work in the matter of the relation of concrete and cement to sea water is, we believe, being undertaken on the South Coast, with the aid of an investigation grant. Next we hear that some questions relating to the investigation of the different concrete aggregates is under contemplation. There are several spheres in which research would be useful, notably, for instance, in the matter of the resistance of concrete and reinforced concrete to high temperature fires, in respect to which question the existing data are not yet sufficiently complete, and, further, its resistance to shock or impact. It would lead too far to dwell on other aspects of the problems that have to be considered; but those mentioned above as being either started or under contemplation are essential, and they are certainly those that claim the more immediate attention.

The demands upon the Research Department are sure to be great, and it will be difficult indeed to weigh the importance of the different claims for assistance where so much has been neglected in the past. We, however, sincerely trust that concrete and reinforced concrete will receive their due share of consideration and assistance, for the proper application of these materials will be of the utmost importance in the future economy of the nation's building operations.

CONCRETE AND THE GREAT EXPLOSION.

As we go to press some short particulars reach us as to the technical aspects of the great disaster that occurred in the form of an explosion on Friday night, January 19th. To all those concerned in concrete and reinforced concrete it may be a matter of interest to know that certain buildings erected in reinforced concrete during the past decade in or near the area affected have made a remarkably good showing under strains and conditions that have been unequalled during the period that reinforced concrete has been utilised in this country for industrial buildings.



THE NEW COTTON WAREHOUSES AND TERMINALS OF THE PORT OF NEW ORLEANS.

Some interesting reinforced concrete construction work has been carried out in connection with the erection of the new cotton warehouses and terminals of the Port of New Orleans, and the general development of that port, and by the courtesy of the engineers, Messrs. Ford, Bacon & Davis, we are able to publish the following details and illustrations.—ED.

Introduction.—New Orleans, as is well known, is the centre of the raw cotton trade in the U.S.A., and for many years it was realised that a large central cotton warehouse was required, as much time and money were lost in hauling cotton from railway depôts and steamboat landings to yards and thence again to the ocean-going steamers. Grain silos and plant, etc., for dealing with bananas, coffee and other products became an urgent necessity, and in 1896 a Board of Commissioners for the Port of New Orleans was appointed to deal with the whole matter.

In 1914 this Board appointed Messrs. Ford, Bacon, and Davis, Engineers of New Orleans, New York, and San Francisco, to prepare designs for warehouses to co-ordinate river, rail and ocean transportation so that low storage and insurance rates could be operative with rapid and efficient methods of handling the goods.

The accompanying illustrations and description show how well they have succeeded, and the direct connections thus established are causing a revival of river transportation and will lead to comparative lower freight rates not only on local cotton but on through cotton *via* New Orleans.

The Port, about 100 miles from the Gulf of Mexico, extends for nearly fifteen miles along the Mississippi River. The principal commercial development is on the east bank, but on the western bank there are also wharves and landings. The river is from one-half to three-quarters of a mile in width and the depth to within 10 ft. of the wharves ranges from 70 to 30 ft. Unloading can be done in midstream, but most of the vessels land broadside along the wharves, which extend out from 50 to 100 ft. from the bank. Easy access to this whole wharfage front is afforded by city streets and by railway tracks in the rear of and upon the wharves.

The works here considered are located on the east bank and possess a river frontage of over a mile with a depth of about 1,600 ft., and comprise warehouses, grain elevator, railway yards, etc.

The special features of interest in the plant are almost too numerous to mention. It is of permanent construction, being of concrete and steel throughout.

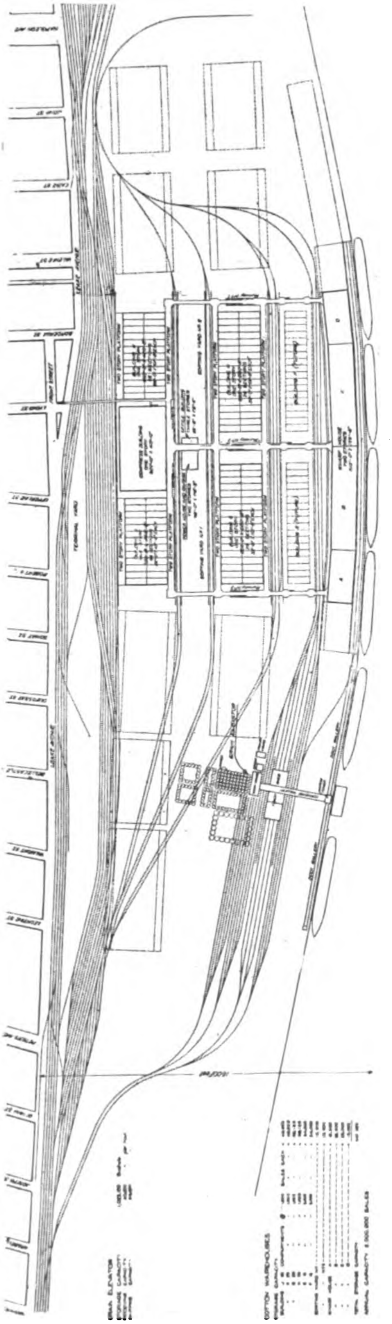


Fig. 1 Key Plan to General Scheme.

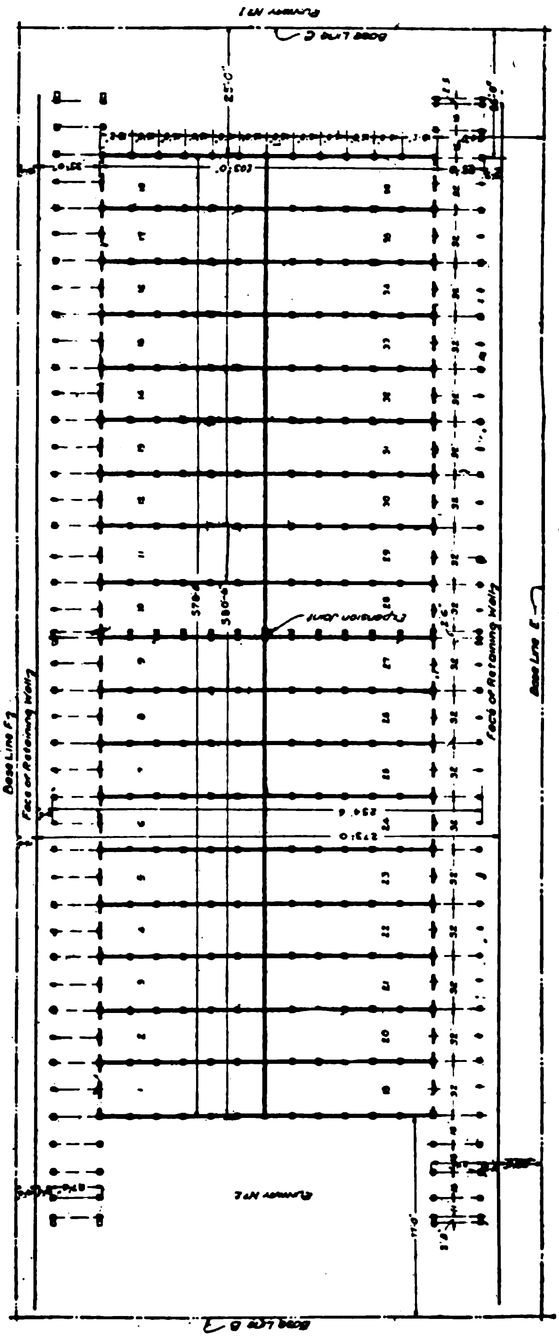


Fig. 2. Key Plan to one of the Warehouses.

REINFORCED CONCRETE CONSTRUCTION IN THE NEW COTTON WAREHOUSES AND TERMINALS OF THE PORT OF NEW ORLEANS.

The cotton warehouse buildings are only one storey in height, affording simplicity of design, greater flexibility for mechanical handling, less lost space, consequently greater capacity for a building of given cubical content, and, therefore, low first cost per bale of storage capacity. Elevated runways 18 ft. above floor of buildings, and entirely surrounding and connecting them, assure freedom from ground surface interruptions or interferences with the free movement of traffic about the plant or shipments moving from warehouses to shipside. Runways are sufficiently wide to permit two way operations on the same runway as well as loop and shuttle operation of trucks and tractors with trailers. Overhead travelling cranes which can reach every part and compartment of all buildings are provided.

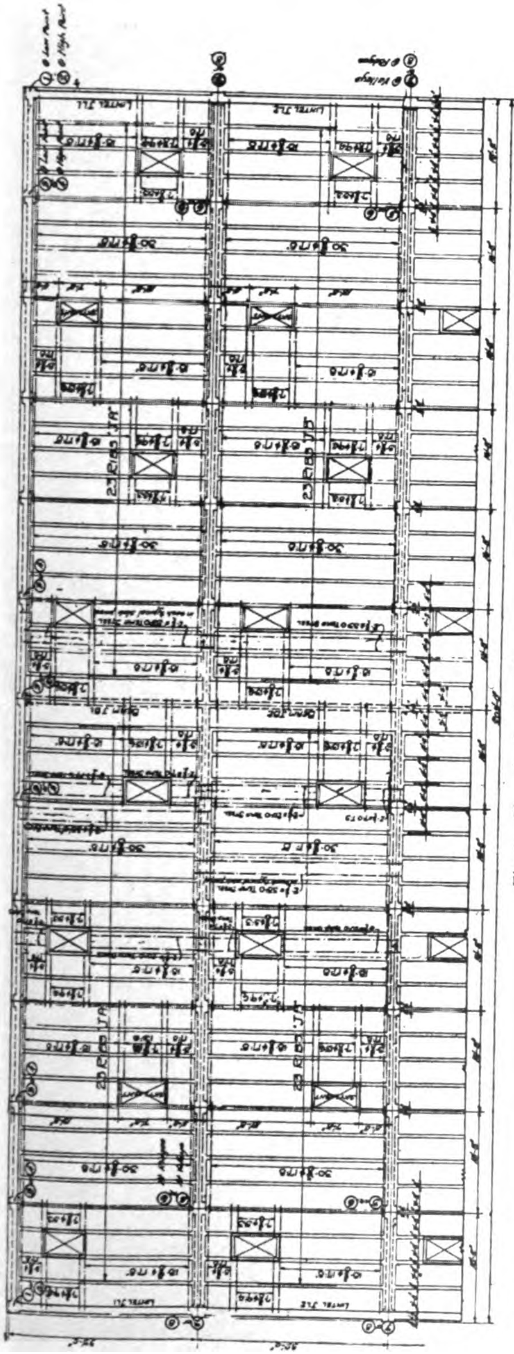


Fig. 3. Plan of a Portion of the Warehouse Roofs.

Reinforced Concrete Construction in the New Cotton Warehouses and Terminals of the Port of New Orleans.

The whole undertaking is structurally a large reinforced concrete project. In the completed plant there will be six large single-storey warehouses, a compress building, and a two-storey wharf house, all connected by a system of overhead runways or bridges. In addition to these main buildings there will be a two-storey power house and a three-storey office building, as well as numerous small transformer and machinery houses.

In the design of this large plant, involving over a hundred thousand cubic yards of concrete and some twelve million pounds of reinforcing steel, many interesting problems were encountered, the first of which was the selection of the most suitable building materials. It was early seen that the choice lay between brick and steel structures and buildings of reinforced concrete, and after a careful study of their relative merits it was decided to use the latter.

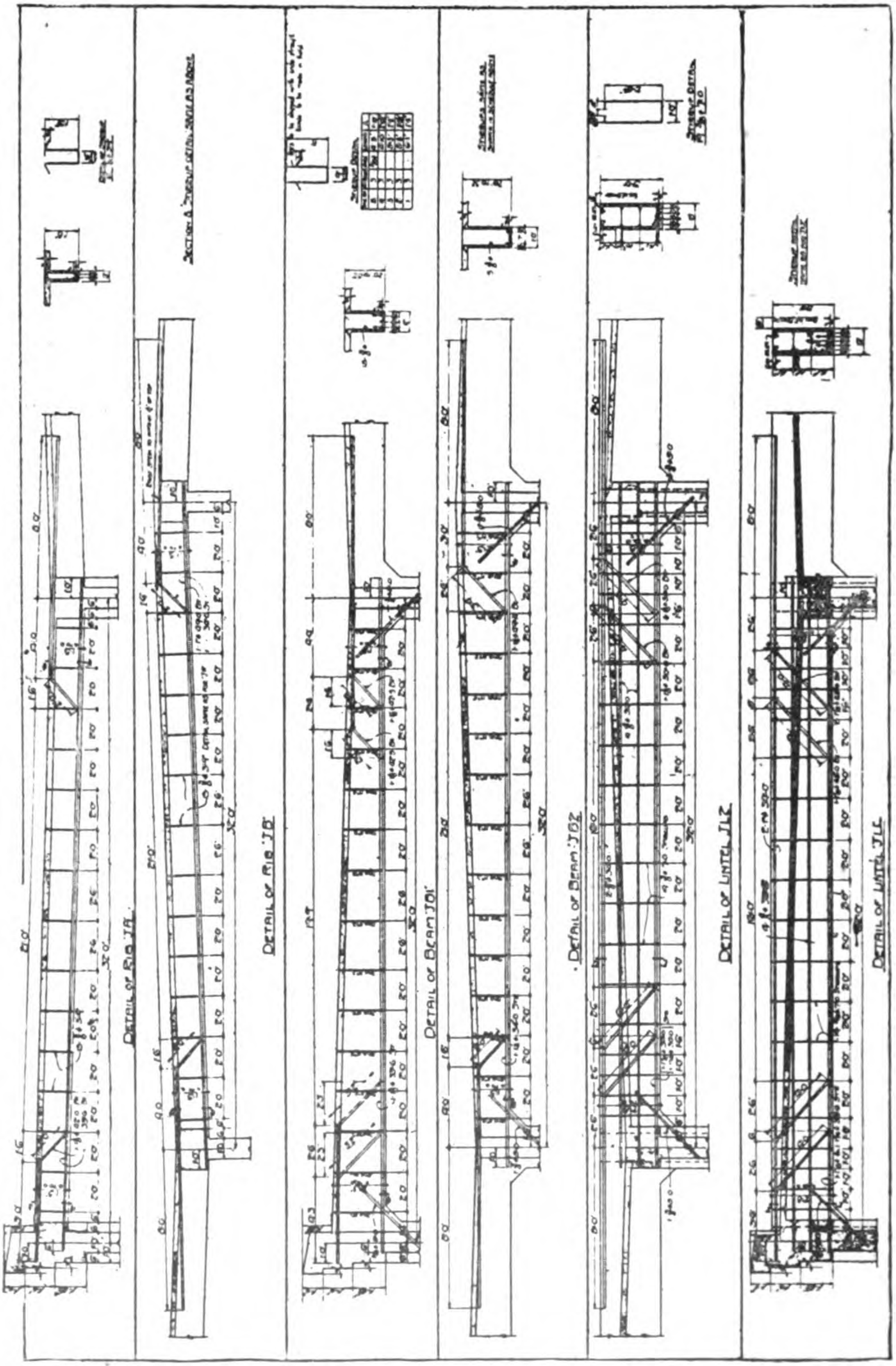


Fig. 4. Details of Ribs of Roofs.
REINFORCED CONCRETE CONSTRUCTION IN THE NEW COTTON WAREHOUSES AND TERMINALS OF THE PORT OF NEW ORLEANS.

For the runways it would have been impossible to use brick and steel, except in the form of a steel supporting structure carrying a series of brick

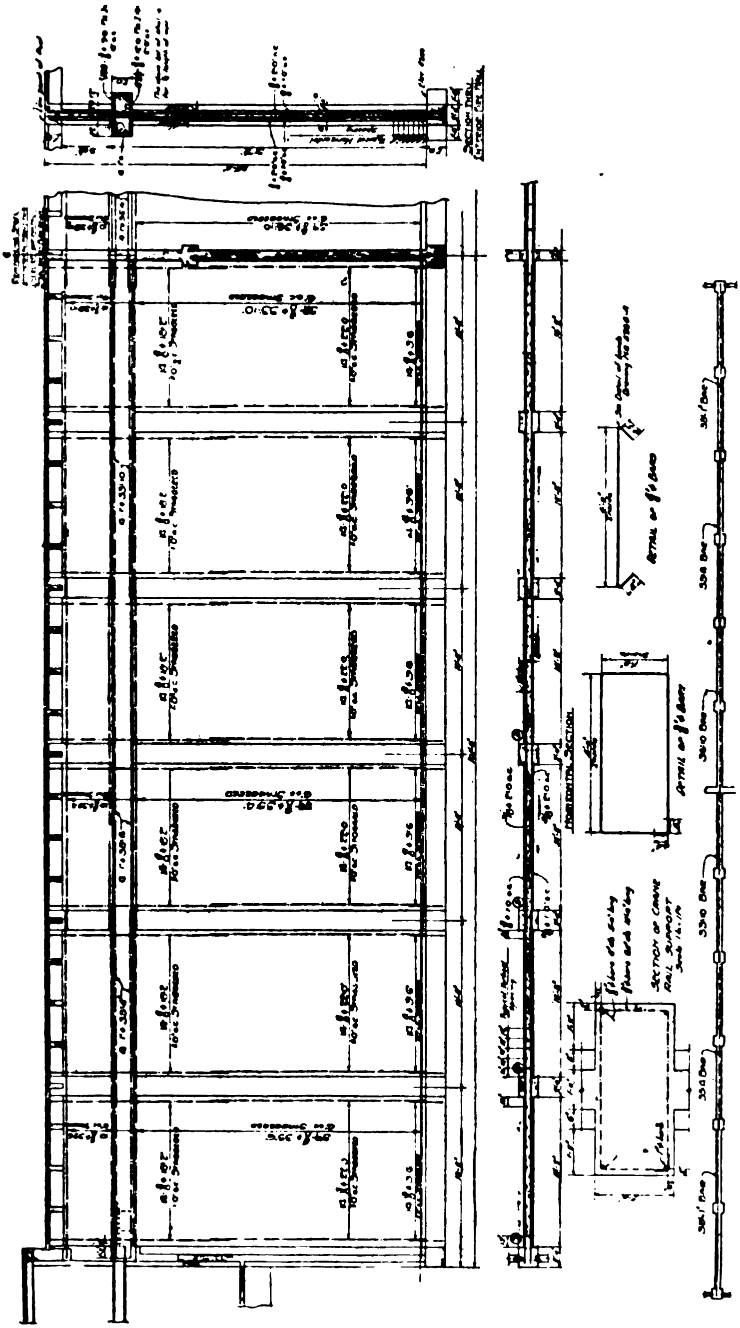


Fig 5. Details of Fire Walls.

Reinforced Concrete Construction in the New Cotton Warehouses and Terminals of the Port of New Orleans.

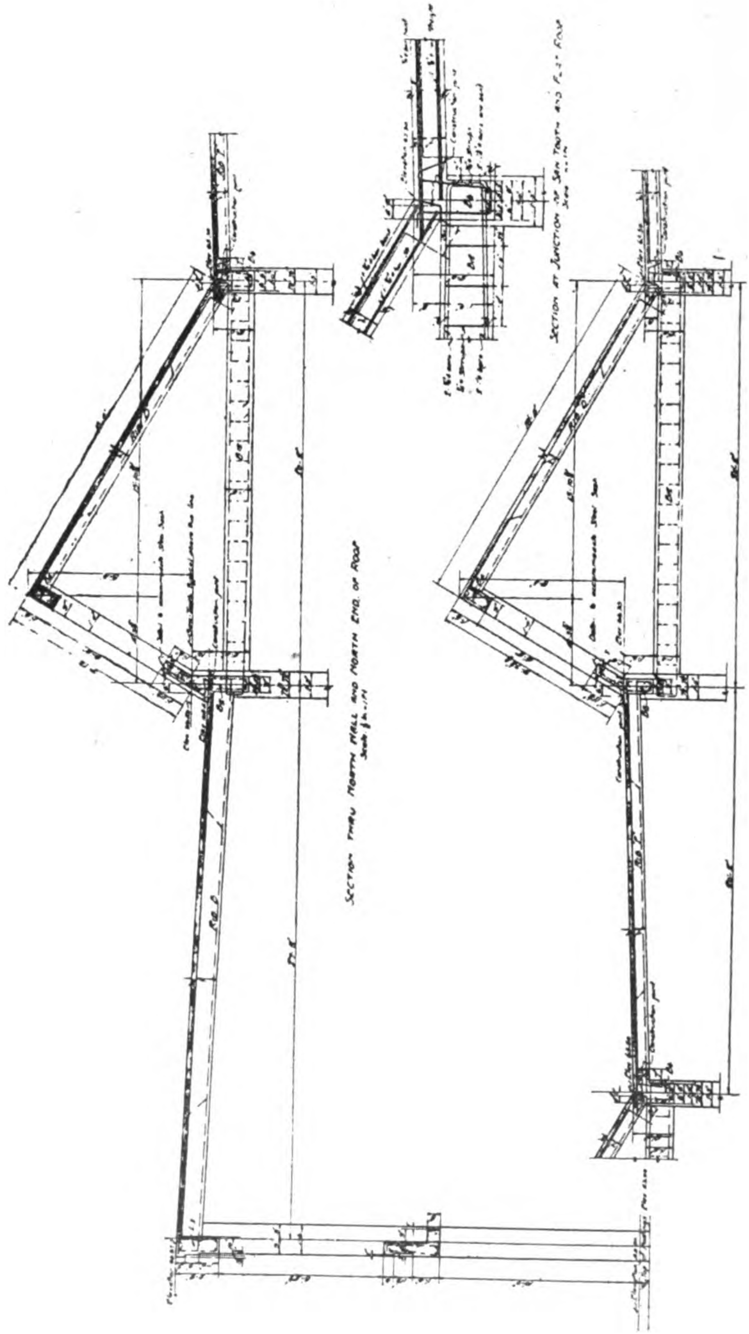
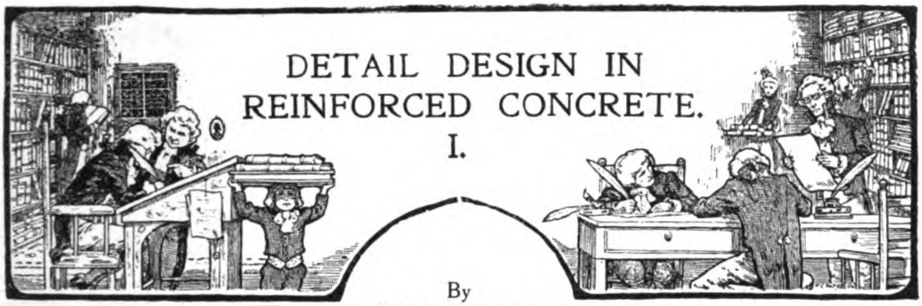


Fig. 6. Section through Typical Roof Panels.

REINFORCED CONCRETE CONSTRUCTION IN THE NEW COTTON WAREHOUSES AND TERMINALS OF THE PORT OF NEW ORLEANS.

arches, and for the runways, therefore, reinforced concrete was undoubtedly the most suitable and economical material.

(To be continued.)



EWART S. ANDREWS, B.Sc.Eng., M.C.I.

We are publishing this series of articles to meet a long-felt want amongst students and others, and at the request of some of our readers.—ED.

Introductory.—In the present series of articles we propose to attempt to fill a gap which many students, as well as practising engineers and architects, have noticed in the literature of the subject—viz., the explanation of the application of the scientific principles of reinforced concrete construction to the detail design of the structures. Although there are now a number of colleges where the theory of the subject is dealt with in a more or less exhaustive manner, it is very difficult for a student to obtain experience in the actual design of reinforced concrete structures and in the preparation of working drawings.

One of the difficulties in dealing with the subject in article form lies in the necessary lack of space, seeing that the detail calculations, irrespective of the working drawings, of one typical structure run to a very large number of pages, even when set out in a fairly concise form, without the explanations which are essential in the present case. We will therefore not attempt to give the complete calculations of a whole structure, but will choose typical details of each kind of calculation and the corresponding working drawings, and will explain the design at length.

The reader will be assumed to have sufficient knowledge of the theory to enable him to follow calculations of bending moments, continuous beam effects, etc., and will introduce, at the points where they become relevant, special constructions and diagrams for enabling the calculations and design to be expedited.

Except where otherwise stated, the calculations will be made only to the degree of accuracy obtainable by an ordinary slide-rule.

EXAMPLE I.—DESIGN OF FLOOR OF A WORKSHOP BUILDING.

It will be assumed that the building has to be designed in accordance with the Reinforced Concrete Regulations * of the London County Council.

The numbers printed in heavy type are the numbers of the relevant clauses of these regulations.

The floor slab is 5 in. thick, weighing 60 lb. per sq. ft. The superload will be taken at the specified figure of 112 lb. per sq. ft. (**10**).

All calculations will be made in units of thousands of pounds (kips.), and inches unless otherwise stated.

The concrete is to be 1 : 2 : 4 mixture, for which the specified stresses are 600 lb. per sq. in. in compression, and 60 lb. per sq. in for shear (**42a**).

We will take the portion of floor illustrated in *Fig.* 1—viz., that included between interior pillars *A*, *B*, *C*, *D*. The slabs are of 9-ft. span, and transmit their loads to

* A convenient pocket form of these regulations, with notes by the author, is published by B. T. Batsford, Ltd., price 2s. 6d.

secondary beams *A B*, *AD—BE*, and *DE* of 25-ft. span, the loads of the first and last being transmitted to the pillars direct, and the load from the middle one being carried

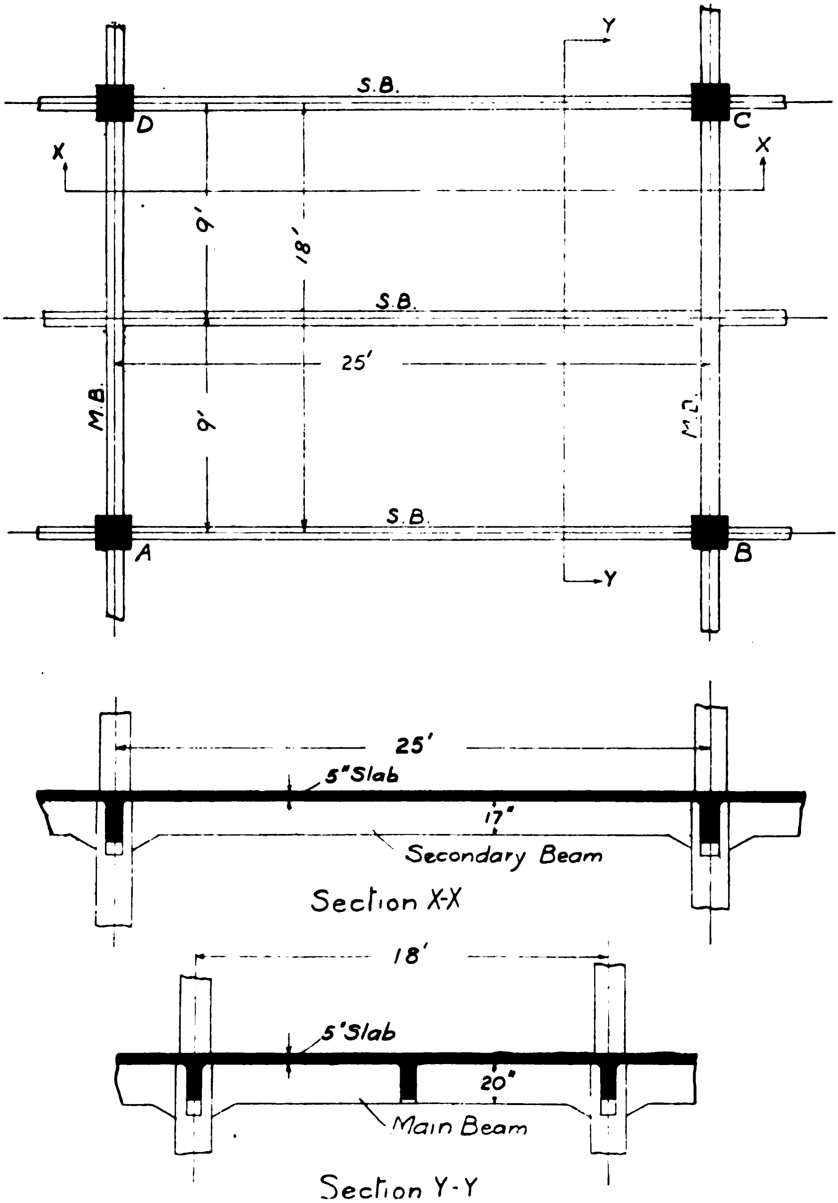


Fig. 1.
DETAIL DESIGN IN REINFORCED CONCRETE.

by the main beams *AD* and *BE*. All the beams are continuous, and for the portion considered constitute interior spans, but the pillars *A*, *B* and *D* will be taken as the first pillars from the walls of the building.

Design of Slab.—

Super load per sq. ft. = 112 lb.
Slab weight per sq. ft. = 60 lb.

Design load per sq. ft. = 172 lb.

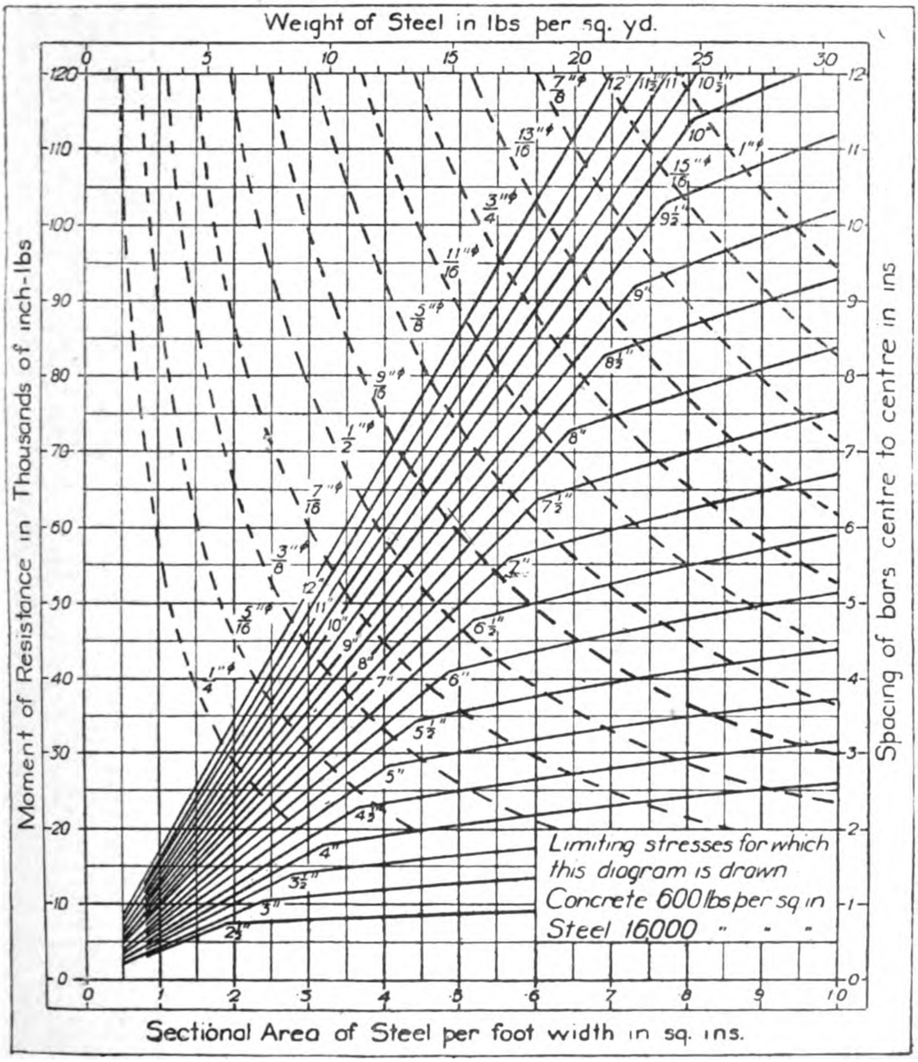


Fig. 2. **Diagram for Slab Design.**
Detail Design in Reinforced Concrete.

Considering a foot width of slab, the span being 9 ft., we have

$$W = \frac{172 \times 9}{1000} = 1 \cdot 55 \text{ kips.}$$

$$\text{Centre B.M.} = \frac{Wl}{12} = \frac{1 \cdot 55 \times 9 \times 12}{12} = 13 \cdot 9 \text{ kip.-in.}$$

$$\text{Support B.M.} = \frac{Wl}{10} = \frac{1 \cdot 55 \times 9 \times 12}{10} = 16 \cdot 7 \text{ kip.-in.}$$

Fig. 2 gives a very convenient diagram for readily deciding upon a suitable spacing of round rods for slab reinforcement for various effective depths of slab.*

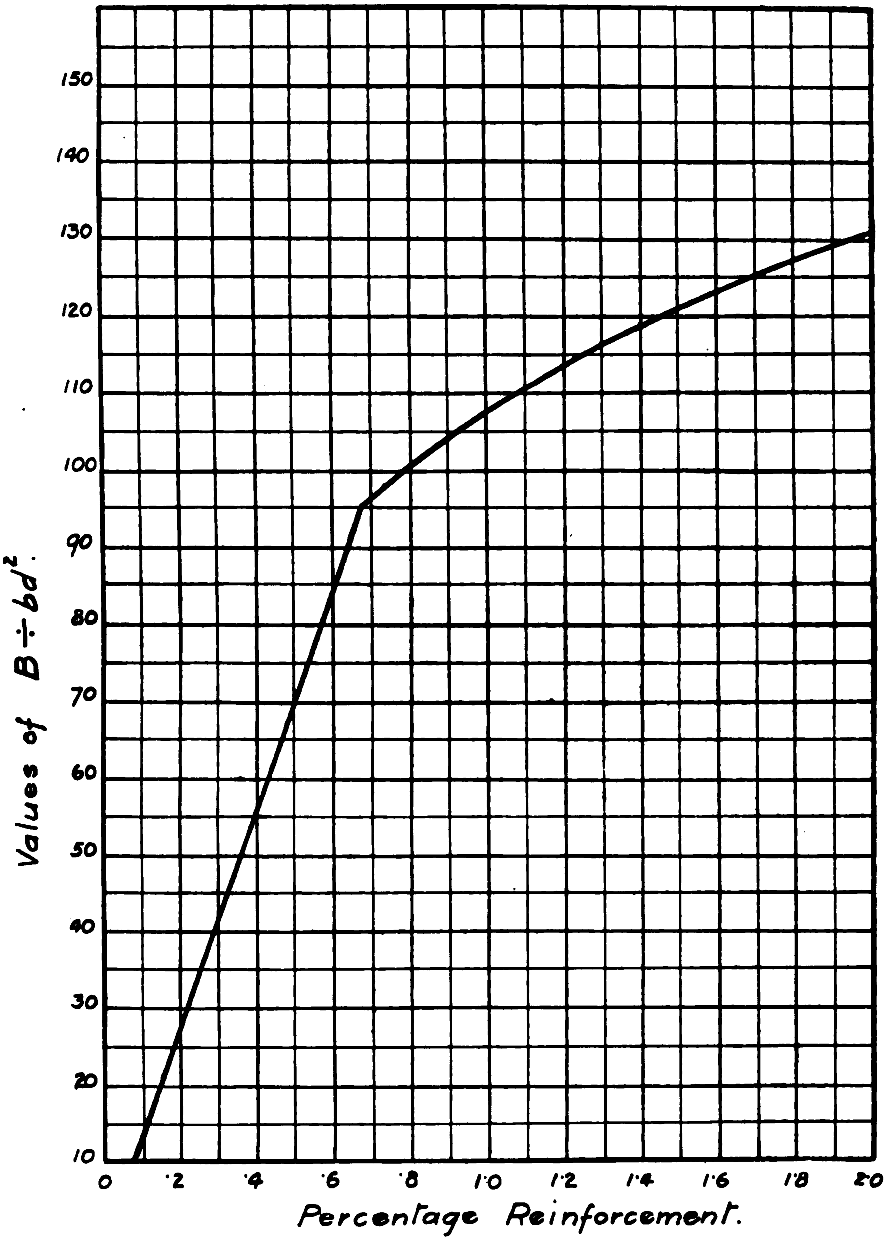


Fig. 3. Diagram for design of rectangular Beams of 1 : 2 : 4 concrete with tension reinforcement only.
DETAIL DESIGN IN REINFORCED CONCRETE.

The cover required by slab reinforcement (**142**) must be not less than ½ in., and not less than the diameter of the bar to be covered.

* This diagram and *Fig.* 7 are reproduced by permission of the Associated Portland Cement Manufacturers from their publication *Everyday Uses of Portland Cement.*

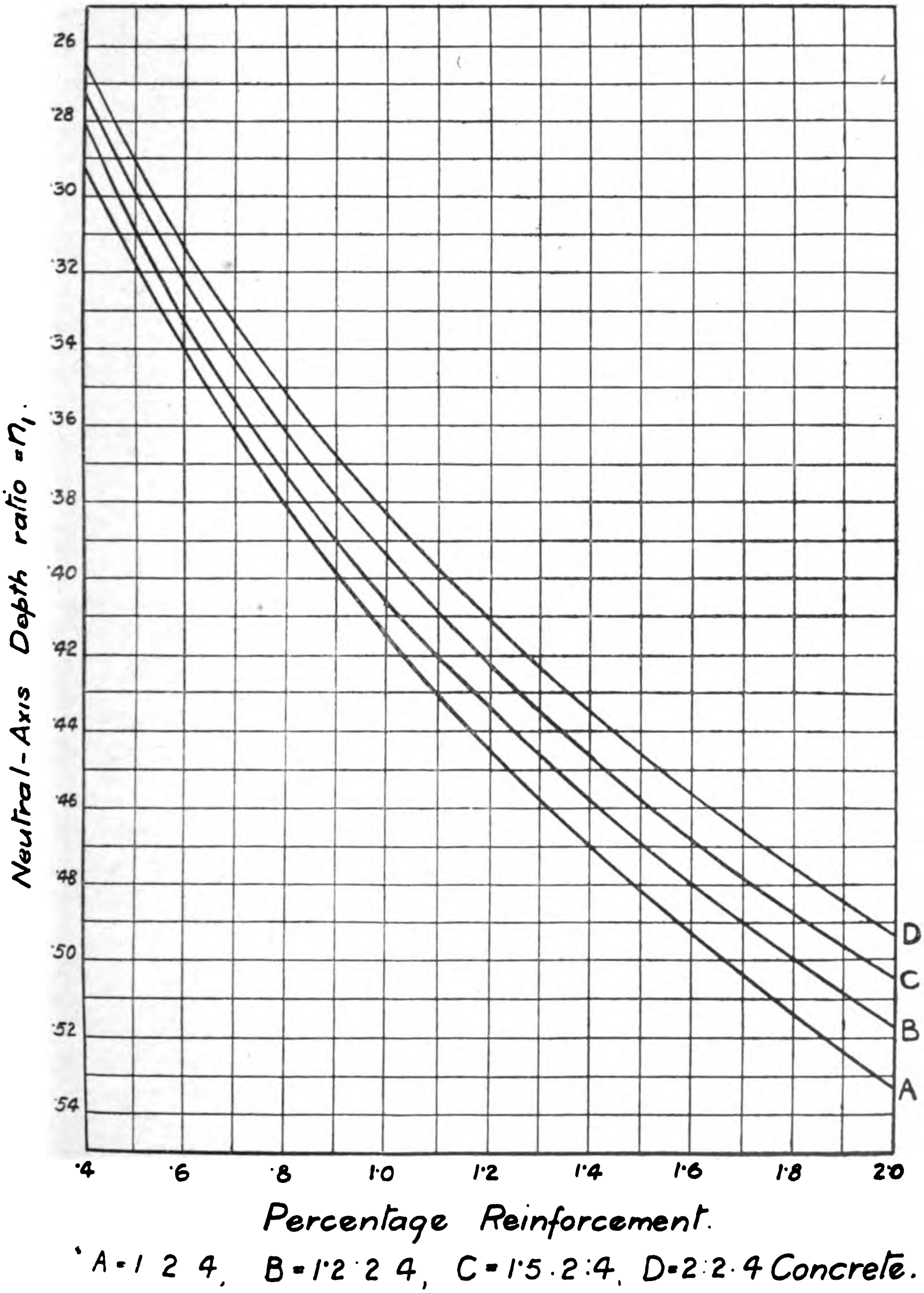


Fig. 4. Neutral Axis Depth for rectangular Beams with tension reinforcement only.

DETAIL DESIGN IN REINFORCED CONCRETE.

Taking, therefore, ½ in. round bars (written ½φ), we see that the effective depth
(72) $d = 5 - \frac{1}{2} - \frac{1}{4} = 4\frac{1}{4}$ in.

We have to design the slab to carry 16·7 kip.-in. at the supports, so we mark on our diagram, *Fig.* 2, 16·7 on the left-hand scale, and run in horizontally until we come midway between the full lines marked 4 in. and 4½ in.; we then run vertically until we come to the dotted line marked ½ φ, and then run horizontally, and read the

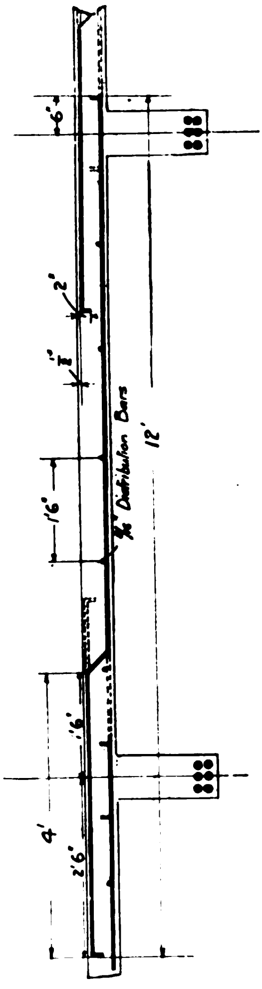


Fig. 5. Section showing slab reinforcement.

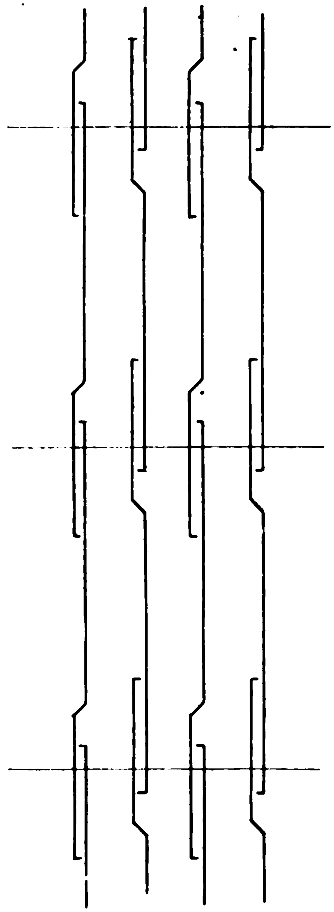


Fig. 6. Bar bending diagram.

DETAIL DESIGN IN REINFORCED CONCRETE.

requisite pitch of bars on the right-hand scale. This gives 8 in. as a suitable pitch (8½ in. would be nearer, but 8 in. is preferable). An alternative procedure which takes a little more time, but which is applicable to rectangular beams of all depths, is to use the "Qualifier" or resistance modulus diagram given in *Fig.* 3, in conjunction with Table I. of areas grouped bars, which we shall find useful in a large number of other calculations.

In one case $\frac{B}{bd^2}=\frac{16\cdot7\times1000}{12\times4\cdot25^2}=76\cdot9$

$\therefore$ From *Fig.* 3 per cent. reinforcement required $=0\cdot54$

Number of Bars.						Diameter of Bars (inches).	Number of Bars.					
1	2	3	4	5	6		7	8	9	10	11	12
0·110	0·220	0·331	0·441	0·552	0·662	$\frac{3}{8}$	0·772	0·883	0·993	1·10	1·21	1·32
0·196	0·392	0·588	0·785	0·981	1·18	$\frac{1}{2}$	1·37	1·57	1·77	1·96	2·16	2·35
0·306	0·613	0·920	1·23	1·53	1·84	$\frac{5}{8}$	2·15	2·45	2·76	3·07	3·37	3·68
0·441	0·883	1·32	1·77	2·21	2·65	$\frac{3}{4}$	3·09	3·53	3·98	4·42	4·86	5·30
0·601	1·20	1·80	2·40	3·01	3·61	$\frac{7}{8}$	4·21	4·81	5·41	6·01	6·61	7·21
0·785	1·57	2·36	3·14	3·93	4·71	1	5·50	6·28	7·07	7·85	8·64	9·42
0·994	1·99	2·98	3·98	4·97	5·96	$1\frac{1}{8}$	6·96	7·95	8·95	9·94	10·9	11·9
1·23	2·45	3·68	4·91	6·14	7·36	$1\frac{1}{4}$	8·59	9·82	11·0	12·3	13·5	14·7

TABLE I.—AREAS OF GROUPED BARS.

$\therefore$ area A of steel required per in. width $=\frac{0\cdot54\times4\cdot25}{100}=0\cdot0229$ sq. in. but area of each $\frac{1}{2}\phi=0\cdot196$

$$\therefore \text{pitch required}=\frac{0\cdot196}{0\cdot0229}=8\cdot5 \text{ in. nearly.}$$

This complies with regulation **77**, which states that the maximum distance between bars of the tensile reinforcement shall not be greater than 12 in., and not more than twice the effective depth of the slab.

Distributing Bars (**78**).—These have to be placed at the top of the lower tensile bars at right angles thereto; they must not be further than 18 in. apart, and must have an aggregate cross-sectional area of at least 0·08 per cent. of the effective cross-sectional area of the slab; or their diameter shall be not less than $\frac{d}{16}$, and their pitch shall not be greater than $4d$.

$\frac{5}{16}$ in. bars at 17 in. centres would satisfy the second condition, and for the first condition at 18 in. centres, we should require a cross-sectional area $=\frac{0\cdot08\times18\times4\cdot25}{100}=$ 0·0612; $\frac{5}{16}$ in. bars have a cross-sectional area $=0\cdot076$.

$\therefore$ adopt $\frac{5}{16}$ in. bars at 18 in. centres.

Shear.—Regulation **64** specifies that the shear stress carried by concrete only shall be considered on the compressed area of the web, or on the web area for a depth equal to the arm of the resistance moment.

These alternatives do not give anything like the same result, and the regulation is unsatisfactory, since, if the calculations are made by the less severe or second method, they are certain to be unsatisfactory by the first. We will follow the usual method of using the " arm of the resistance moment " (a).

$$a=d-\frac{n}{3}=d\left(1-\frac{n_1}{3}\right)$$

The values of the neutral-axis depth ratio n_1 for various percentages of reinforcement and various mixtures of concrete are given in *Fig.* 4. For approximate working a may be taken $=0\cdot9d$. The diagram gives $n=0\cdot33d$. approximately for our case of 0·54 per cent. reinforcement $\therefore a=1-0\cdot11d=0\cdot89d$.

Maximum shearing force on 12 in. breadth of slab $=\frac{W}{2}=\frac{1\cdot55}{2}$ kips.

$$\therefore \text{ shear stress in concrete in lb. per sq. in.} = \frac{1 \cdot 55 \times 1000}{2 \times 0 \cdot 89 \times 4 \cdot 25 \times 12}$$

$$= 17 \cdot 1 \text{ lb. per sq. in.}$$

This is much less than the permissible 60 lb. per sq. in., and so shear reinforcement need not be considered. Except for their slabs carrying very heavy loads on short spans, shear on slabs does not usually have to be considered.

Slab Bar-bending Diagram.—We come next to the actual arrangement of the bars of the slab reinforcement, it having been decided to employ $\frac{1}{2}\phi$ bars at 8-in. pitch. The bending moment is reversed over the supports, and so the bars are bent up over the supports, as shown in *Fig.* 5. There are several ways adopted in practice for doing this; that shown in *Fig.* 6 is a very good one. In this figure a "bar-bending diagram" is shown of the reinforcement for the slab; in this diagram, bars which are in reality placed at the same level at distances apart (8 in. in our case) are shown vertically below each other for the sake of clearness.

In the arrangement shown there is a continuous reinforcement right along the bottom of the slab, although when all the spans are loaded no reinforcement is necessary at the bottom of the slabs near to the supports. It may, however, often happen in practice that some spans will be loaded and some unloaded in such a way that there will be tensile stress on the bottom of the slab over the whole span; in this case the continuous bottom reinforcement is desirable.

In the form of reinforcement shown each bar is of the same shape, thus facilitating manufacture, and one end only of each is bent up. They are placed in a "heads and tails" manner, and in successive rows they face in opposite directions.

Before leaving the question of slab design we will consider the other regulations governing the bars.

In the first place we have the anchorage or bent-up portion of the bars; by regulation **48**c "the anchorage shall be bent up to a right angle from the centre line of the bar, and the width across such anchorage shall be at least three times the normal diameter of the anchored bar." By adopting a bent-up portion of 2 in. we have complied with the regulation.

Next there is the overlap or grip length of the bar, which by regulations **50** and **42**a must be sufficient to keep the grip stress within 60 lb. per sq. in.; this corresponds to a grip length of 67 diameters if the steel is stressed to its full permissible value. The overlap of the bars should therefore be at least 34 in. if this regulation is applied. But in beam reinforcement the stress in the bars is varying constantly, and at the junction of the lower bars is very small, so that the overlap shown there is sufficient.

(*To be continued.*)

REINFORCED CONCRETE ROAD WORK IN CANMORE STREET, DUNFERMLINE.

For the following interesting particulars of Reinforced Concrete Road Construction in Scotland we are indebted to the Burgh Engineer of Dunfermline, Mr. P. C. Smith. — ED.

CANMORE Street, Dunfermline, is one of the few "level" streets found in the south side of a city where hills and steep gradients predominate. Connecting, as it does, with the centre of the town at its west end and with New Row at its east end—the latter being the principal route to the lower railway station, and

Fig. 1. Road Prior to Reconstruction.
REINFORCED CONCRETE STREET WORK IN CANMORE STREET, DUNFERMLINE.

very steep in that portion which lies between Canmore Street and High Street—it has to carry a very heavy traffic. During the summer of last year a motor-'bus service was inaugurated between the city and the dockyard at Rosyth, with its starting point at the west end of Canmore Street. The roadway, which averages 15 ft. 6 in. wide between the kerbs, was constructed of whinstone setts

Fig. 2. Road during construction.

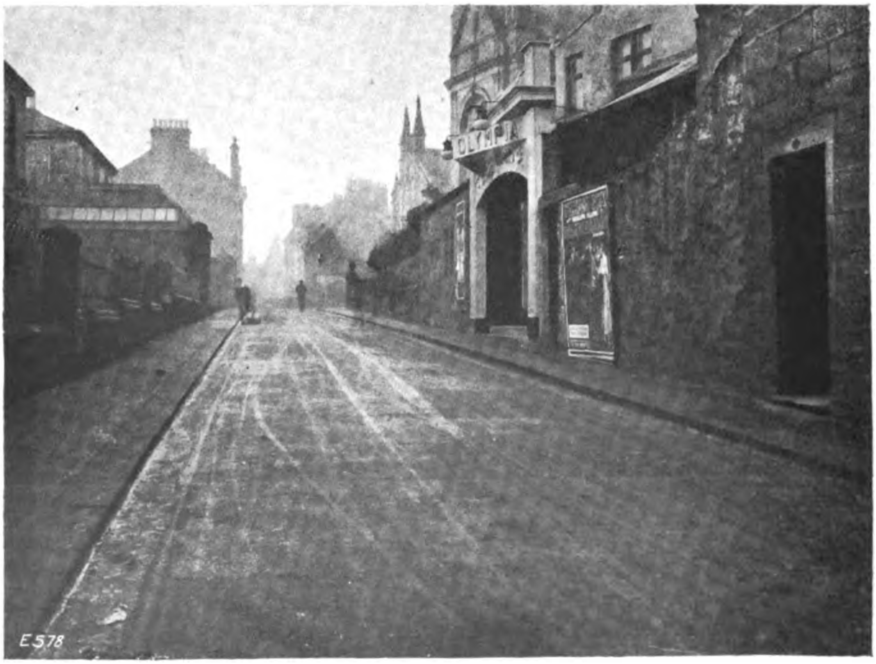


Fig. 3. View of Finished Road.

REINFORCED CONCRETE STREET WORK IN CANMORE STREET, DUNFERMLINE.

7 in. deep laid on the clay, and this soon gave way under the 'bus traffic, so much so that within a very few months it became dangerous. Repairs were at first resorted to, but this was soon seen to be unsatisfactory and unremunerative. The Burgh Engineer laid two schemes before the Town Council: No. 1, to lift the setts, lay a concrete foundation, and relay the setts, grouting the same with pitch; and No. 2, to discard the setts and lay the roadway with 6 in. of concrete reinforced with steel wire and surface sprayed with tar and chipped. After full discussion No. 2 scheme was adopted, and the work has now been satisfactorily completed. A description of the work may be of interest. The reinforcement used was supplied by the British Reinforced Concrete Engineering Co., Ltd., and known as B.R.C. Fabric, No. 9.

The old setts having been removed and the surface brought to the proper contour and level, 2 in. of concrete was laid down; on this was spread the reinforcement. Two widths were required to cover the roadway, and an overlap, averaging 8 in., was allowed; on top of this another 2 in. of concrete of the same proportions as the bottom layer was laid, while on top of this again was laid the finishing coat, 2 in. thick. The work was so carried on that no layer was "set" before the other was superimposed on it.

The two bottom layers consisted of 3 parts 1½ in. machine broken whinstone metal, 2 parts sharp sand, and 1 part cement, while the finishing coat was of 2 parts ½ to 1 in. whinstone metal chips, 2 parts granite ¼ in. to dust, and 1 part cement.

At the start of operations an attempt was made to use 2 parts 1½ in. metal, 2 parts ½ in. whin chips, and 1 part cement for the finishing coat, but this was found unsatisfactory, too much time being required to work up a smooth surface.

The surface contour was maintained by the putting in of pegs every 4 ft. along the kerb line and at the crown of the roadway; on these were laid 1 in. laths from kerb to kerb, these being taken up as the work proceeded.

When the surface was about three-quarters "set" it was gone over lightly with a bass broom, thus securing a "key" for the tar spray; it was thereafter covered over with fine sand which was kept moist for seven days and removed at the end of fourteen days.

On the work being completed the surface—with the exception of 12 in. at the sides which was finished smooth—was tar sprayed with No. 2 Tar (Road Board Specification) and chipped with ⅜ to ¼ in. whinstone chips. No expansion joints were put in transversely, but along both kerbs were laid ½ in. white pine boards the depth of the concrete. It was intended to remove these and fill the cavity with pitch, but wet weather has interfered and it is feared the wood will require to remain in meantime. When operations were suspended at night a piece of reinforcement was inserted 2 in. below the finished surface with 1 ft. grip into the finished work and 1 foot left projecting to form a "grip" for the succeeding day's work. Now that the work is completed it presents a remarkably fine surface, is practically noiseless, but experience alone will tell as to its lasting powers.

Before the work was undertaken all gas, water, electric and sewer connections were examined with a view to reducing to a minimum the necessity of breaking the surface. The upper 6 in. of the openings made for this purpose were filled with concrete, the cost of which is included in the cost of the work

The cost of the works, which includes the removal of the old setts, excavation, filling gas, water, etc., trenches with 6 to 1 concrete, the concrete in the roadway, the fabric and the wood slips along kerbs, is 10s. 4d. per super yd. and the tar spraying 1¾d. per super yd. Comparing this with the pre-war prices for whinstone or granite setts on 6 in. concrete foundations—6 to 1—the author had the following works executed in—

1912.—6 in. granite setts on 6 in. concrete foundation grouted with pitch at 13s. 1½d. per super yd. (This was within thirty miles of the quarries, for Dunfermline add, say, 7d. per yd.)

1913.—Whin. setts ditto 11s. 3d. per super yd.

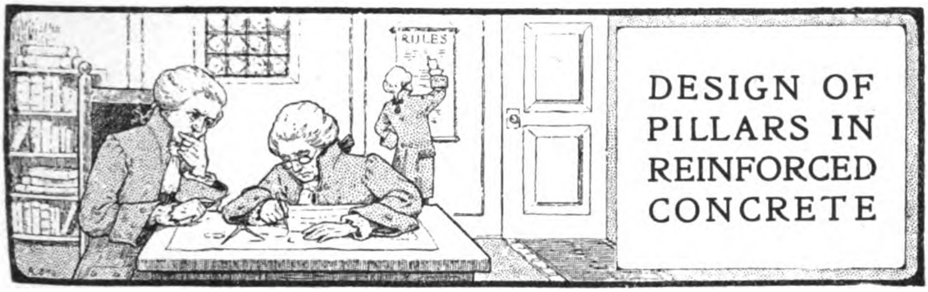
1914.—Whin. setts ditto 11s. 2d. per super yd.

Taking present-day prices, the author questions if setts could be laid at an additional 3s. per super yd. on the above prices. The advantage as to price is therefore very much with the reinforced concrete, while for smoothness, the want of noise, ease in cleaning, and appearance the setts cannot stand to be compared.

Concrete Roads and the Question of Expansion Joints.—It is interesting to note that on a road put down over a year ago by the Illinois State Highway Department, described as Jericho Road, Aurora, there was a stretch of 1,000 ft. laid *without an expansion joint.*

The report states that an examination after twelve months showed eleven small transverse cracks and no longitudinal cracks in the monolithic section of 1,000 ft. In the other 4,000 ft., where joints were spaced at 100-ft. intervals, the transverse cracks were more frequent and several longitudinal cracks had developed.

The monolithic section proved so entirely satisfactory that the Aurora Township Commissioners have just completed 1½ miles of another road in which the entire length was built without any expansion joint.



IN ACCORDANCE WITH THE L.C.C. REGULATIONS.

By F. E. DRURY, F.I.S.E., M.C.I.

Head of the Department of Building and Civil Engineering, Royal Technical Institute, Salford.

(*Continued.*)

Figs. 4, 5, and 6 referred to in the text were included in our January issue.—ED.

II. "Let a square pillar 12 ft. long be required to have 2% of reinforcement and to support an axial load of 130 tons. Find its dimensions to comply with the L.C.C. regulations if the ends are secured in position but not in direction."

Determine whether $\frac{v}{g}$ is beyond the short pillar limit of 45. Referring to the 2% short pillar graph *Fig.* 5, the required diameter as a short pillar is 19·5 in. and "g" = ·33d for this percentage. Then $\frac{v}{g} = \frac{2l}{\cdot 33d} = \frac{2 \times 144}{6\cdot 5} = 44\cdot 3$, and the pillar may therefore be worked at the maximum stress of 600 lbs. sq. in. *with an effective* diameter of, say, 20 in.

III. "A square pillar is required to support an axial load of 80 tons. Its length between supports is 18 ft. and the ends are fixed in position only. Determine the diameter for 3% of vertical reinforcement."

Using the 3% short pillar graph. *Fig.* 6, the necessary diameter for the maximum stress would be 14·5 in. and with this condition $\frac{v}{g}$ would $= \frac{2l}{\cdot 345d} = \frac{216 \times 2}{\cdot 345 \times 14\cdot 5} = 86\cdot 3$, which lies much outside the short pillar ratio. The example must therefore be treated as a long pillar and

$$c = 1200 - 2 \times 13\cdot 3\frac{l}{g}$$
$$= 1200 - \frac{26\cdot 6 \times 216}{\cdot 345d}$$

As in all pillars with axial loads

$$P = A.c.\ [1 + r\ (m-1)\ ]$$
$$\therefore\ 80 \times 2240 = d^2\left(1200 - \frac{26\cdot 6 \times 216}{\cdot 345d}\right)(1 + \cdot 03 \times 14)$$
$$\frac{80 \times 2240}{1\cdot 42} = 1200d^2 - 16640d$$
$$\therefore\ d^2 - 13\cdot 86d = 105$$
$$d = 6\cdot 93 \pm \sqrt{105 + (6\cdot 93)^2}$$
$$\therefore\ d = 19\cdot 31 \text{ in.}$$

The working stress for this pillar would be :—

$$c = 1200 - \frac{13\cdot 3 \times 2l}{\cdot 345d} = 1200 - \frac{26\cdot 6 \times 216}{\cdot 345 \times 19\cdot 31} = 335 \text{ lbs. in}^2\text{. (say), and checking}$$

the load capacity from known values we get :—

$$P = A.c.\ [1 + r(m-1)]$$

$$P = \frac{19{\cdot}31^2 \times 335}{2240} \times 1{\cdot}42 = 80 \text{ tons (approx.)}$$

This pillar would be made 20 in. sq. with a slight reduction of steel, or 19 in sq. with the necessary increase. It is seldom possible to select market sizes of bars giving exact percentages and no practical advantage would be gained thereby.

IV. "A cylindrical pillar 15 ft. long, one end fixed in position and direction and the other in position only, is to carry a load of 43 tons; determine the size of the pillar

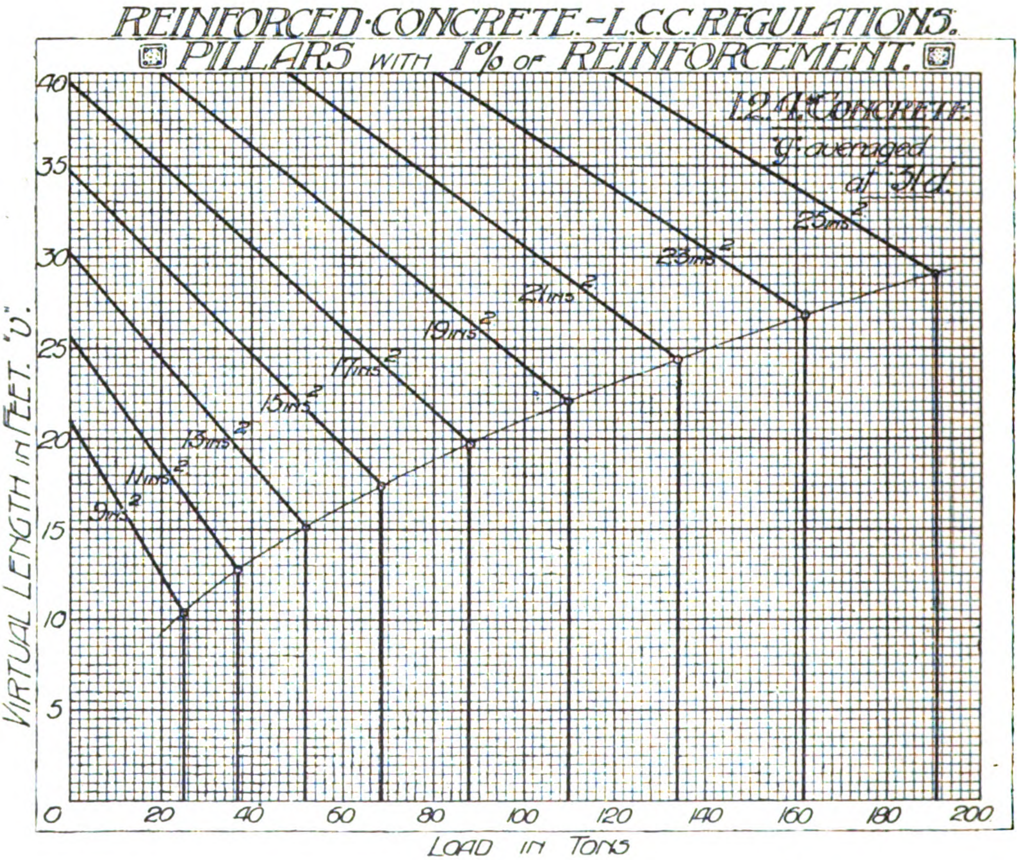


FIG. 7.

with 1 per cent. of vertical reinforcement, using the minimum amount of lateral reinforcement to comply with the regulations."

In this case $v = 1{\cdot}4l$, and testing for condition of length by reference to 1 per cent. short pillar graph, *Fig.* 4, we find that a diameter of 13·5 in. is required to support 43 tons.

Then $\frac{v}{g} = \frac{1{\cdot}4l}{{\cdot}261d} = \frac{1{\cdot}4 \times 180}{{\cdot}261 \times 13{\cdot}5} = 71{\cdot}5$, which, being in excess of 45, shows that we must calculate as a long pillar, and that $c = 1200 - \frac{13{\cdot}3 \times 1{\cdot}4l}{{\cdot}261d}$ will express the working stress on the concrete.

Then, as before:—$P=A.c.\ [1+r\ (m-1)]$

$$43\times2240=\frac{\pi}{4}d^2\left(1200-\frac{13{\cdot}3\times1{\cdot}4\times180}{{\cdot}261d}\right)(1+{\cdot}01\times14)$$

$$\frac{43\times2240}{{\cdot}785\times1{\cdot}14}=1200d^2-12840d$$

$$d^2-10{\cdot}7d=89{\cdot}7$$

$$\text{and } d=5{\cdot}35\pm10{\cdot}86=16{\cdot}21 \text{ in.}$$

This example should also be tested by using the formula for the tabulated values of load depending on the ratio $\frac{v}{d}$, in lieu of $\frac{v}{g}$. Thus the law of the circular pillar

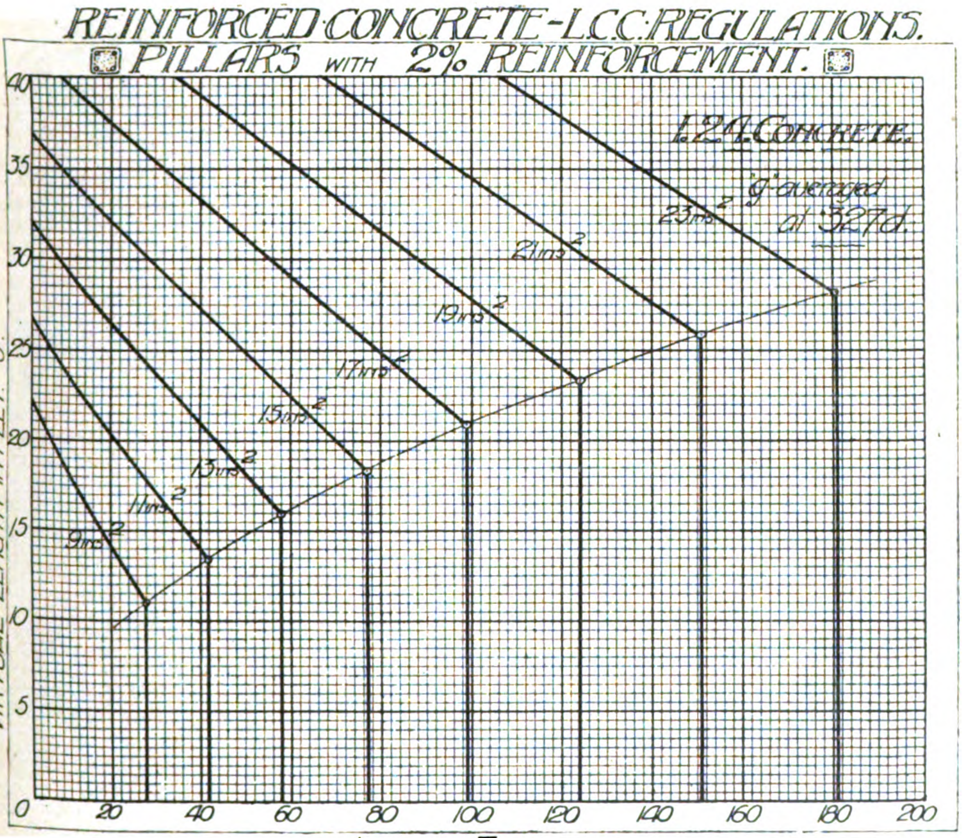


Fig. 8.

graph on *Fig.* 3 is, $c=1080-40\frac{v}{d}$, and for the end conditions of this case $c=1080-\frac{40\times1{\cdot}4l}{d}$. Being a long pillar we have:—

$$P=A.c\ [1+r\ (m-1)]$$

$$43\times2240=\frac{\pi}{4}d^2\left(1080-\frac{40\times1{\cdot}4\times180}{d}\right)(1+{\cdot}01\times14)$$

and on solving $d=15{\cdot}66$ in., which is less than the first result.

For low percentages of reinforcement—generally less than 2%—the advantage of design lies with computation on the basis of $\frac{v}{d}$, but with higher percentages, especially with square pillars, the basis $\frac{v}{g}$ is the more economical.

The latter is the preferable method of procedure for all cases, ensuring uniformity of practice under varying conditions. By using the graphs of *Fig.* 12 (*see succeeding article*) there is no need to calculate the exact value of g for every case; a very close approximation is obtainable by reading off the value of $\frac{g}{d}$ for any given or proposed ratio of reinforcement and multiplying the ratio by the diameter.

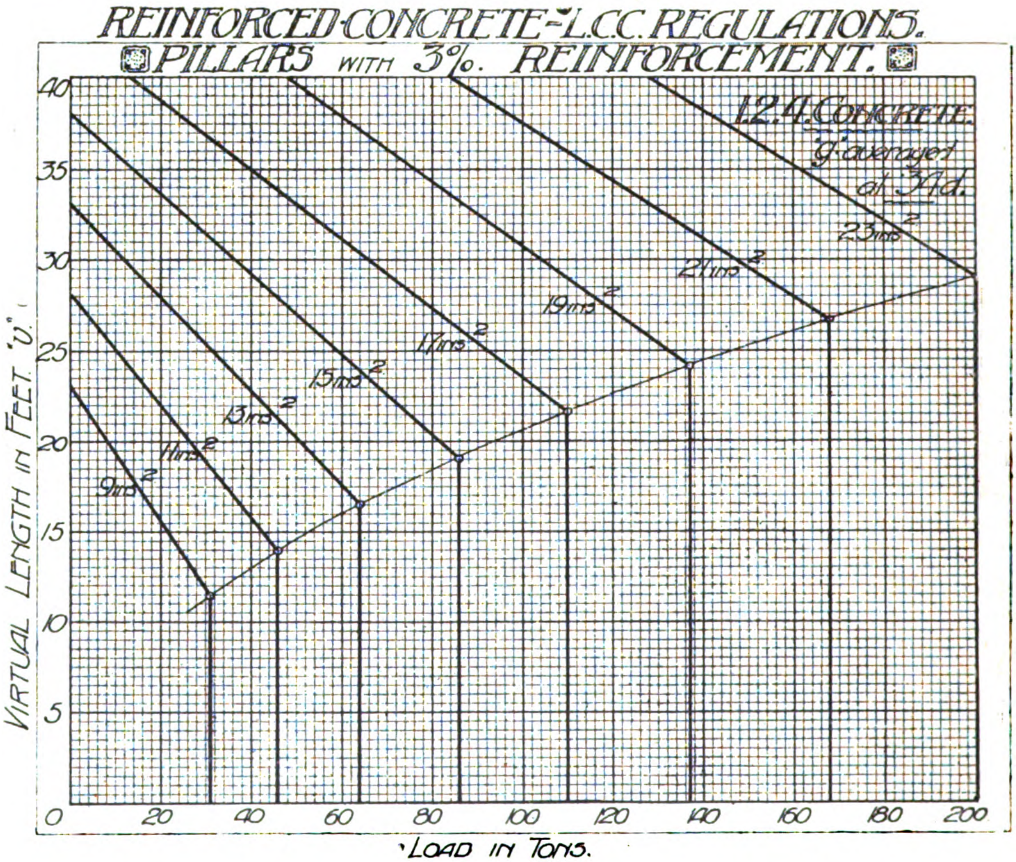
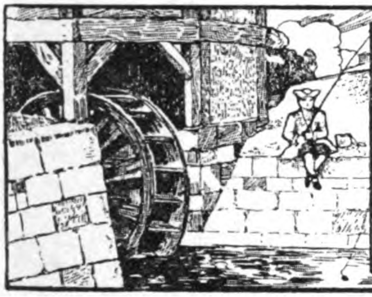


FIG. 9.

To save the large amount of labour in calculating the dimensions of pillars under varying conditions, the graphs of *Figs.* 7, 8 and 9 may be employed to select the approximate dimensions of any pillar of square section, with 1, 2 or 3 per cent. of vertical reinforcement, the minimum amount of lateral binding and 1+2+4 concrete to standard specification. The assumed value of g in plotting these graphs is stated in each case and is purposely kept slightly below the average value. The graphs show the safe loads in tons on pillars from 9 in. to 23 in. sq. for any virtual length up to 40 ft., and by interpolation between the graphs the nearest effective dimension is easily obtained. If the ends of a pillar vary in condition from the standard, the actual length must be converted into the virtual or comparative length v.



SOME NOTES ON THE CONSTRUCTION OF CURVED DAMS IN NEW SOUTH WALES.

By E. M. de BURGH, M.Inst.C.E.,
Chief Engineer for Water Supply and Sewerage, Department of Public Works, N.S.W.

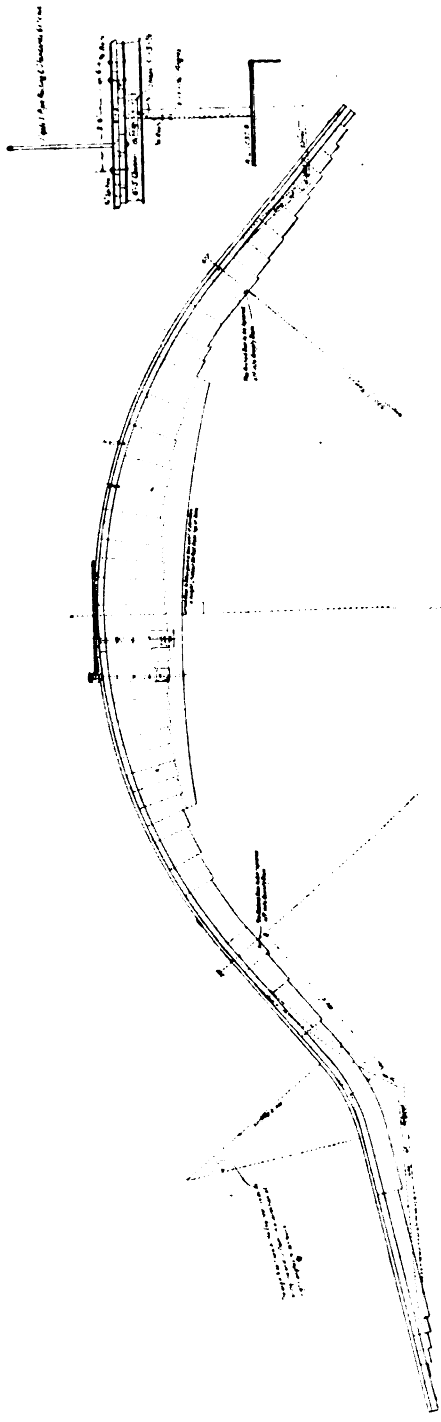
The following notes on some Dam construction work in New South Wales may be of interest.—ED.

Reservoir dams constructed of concrete which rely for stability on the stresses in the structure being conveyed to the abutments by the arched form adopted in plan are not novel, but it is doubtful if this form of construction has been more frequently adopted anywhere than in the State of New South Wales, Australia, where there are at the present time seventeen dams of this class completed and two in course of construction.

This method of design was adopted in the State of New South Wales in the first instance by Mr. Cecil West Darley, M.Inst.C.E., who was Chief Engineer of the Public Works Department up to April, 1901, and was continued by the late Mr. L. A. B. Wade, who was Chief Engineer for Water Supply and Sewerage up to April 16th, 1909, and since that date by the writer.

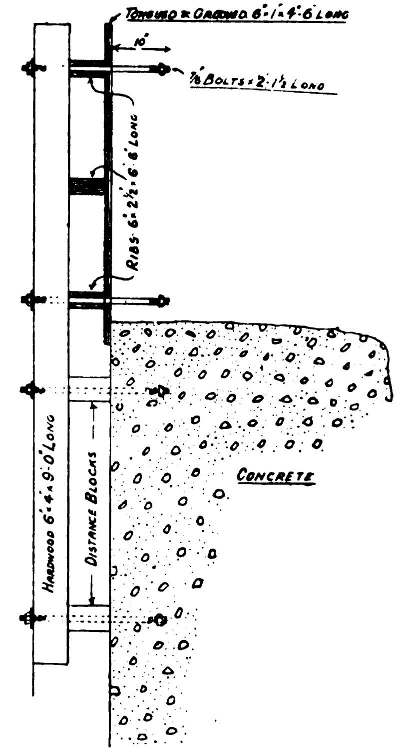
That the adoption of this form of construction should have been continued over such a long period, coupled with the fact that the whole of the dams constructed to this design have given saisfaction, is important as showing that whatever views may be entertained as to the distribution of pressure in the structures, the actual result in practice, from the point of view of stability, is satisfactory.

The formula used in the design of these curved dams is simplicity itself, and is the same which would be used to ascertain the thickness of a cylinder closed at the bottom, which it was proposed to immerse vertically in water. That is to say, the thickness of the dam wall at any level is directly proportional to the radius of curvature and to the depth of the water, and inversely proportional to the working pressure which it has been decided to allow upon the concrete or masonry of which the dam is constructed. In other words, where T denotes the thickness at any level in feet, R the radius in feet, P the water pressure in tons per square foot, and S the allowable stress in tons per square foot on the material used, then $T = \frac{RP}{S}$. It is simply assumed that the dam is a segment of a concrete or masonry cylinder fitted vertically into the gorge or valley to be dammed and subjected to an uniform load due to the pressure of the water and varying only with the depth of the water. No account is taken of the action of the weight of the concrete in resisting

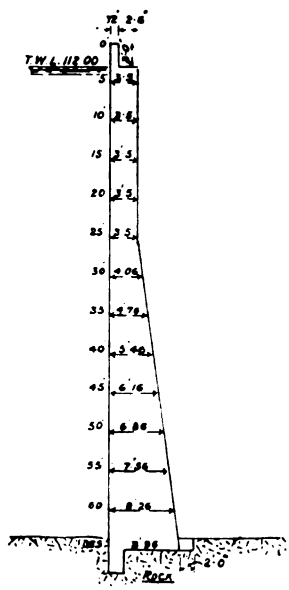


Plan.

Size of Moulding-Boards. Segment 6'6" Height 4'6"

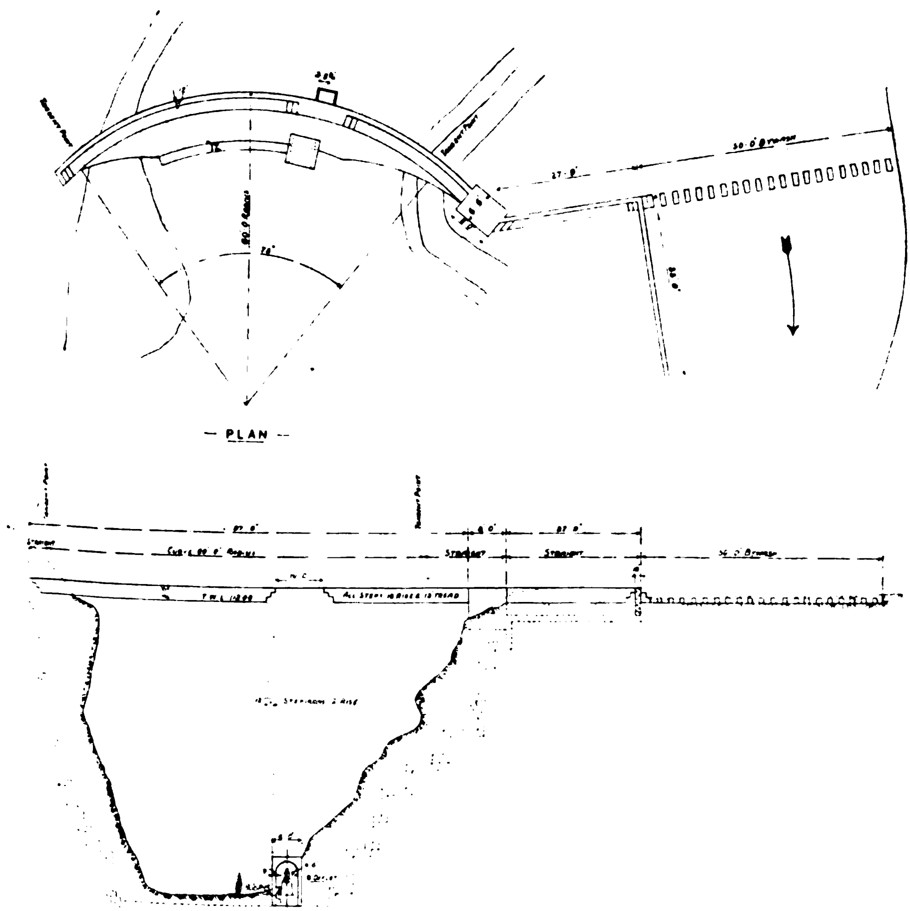


Arrangement of Moulding Boards.



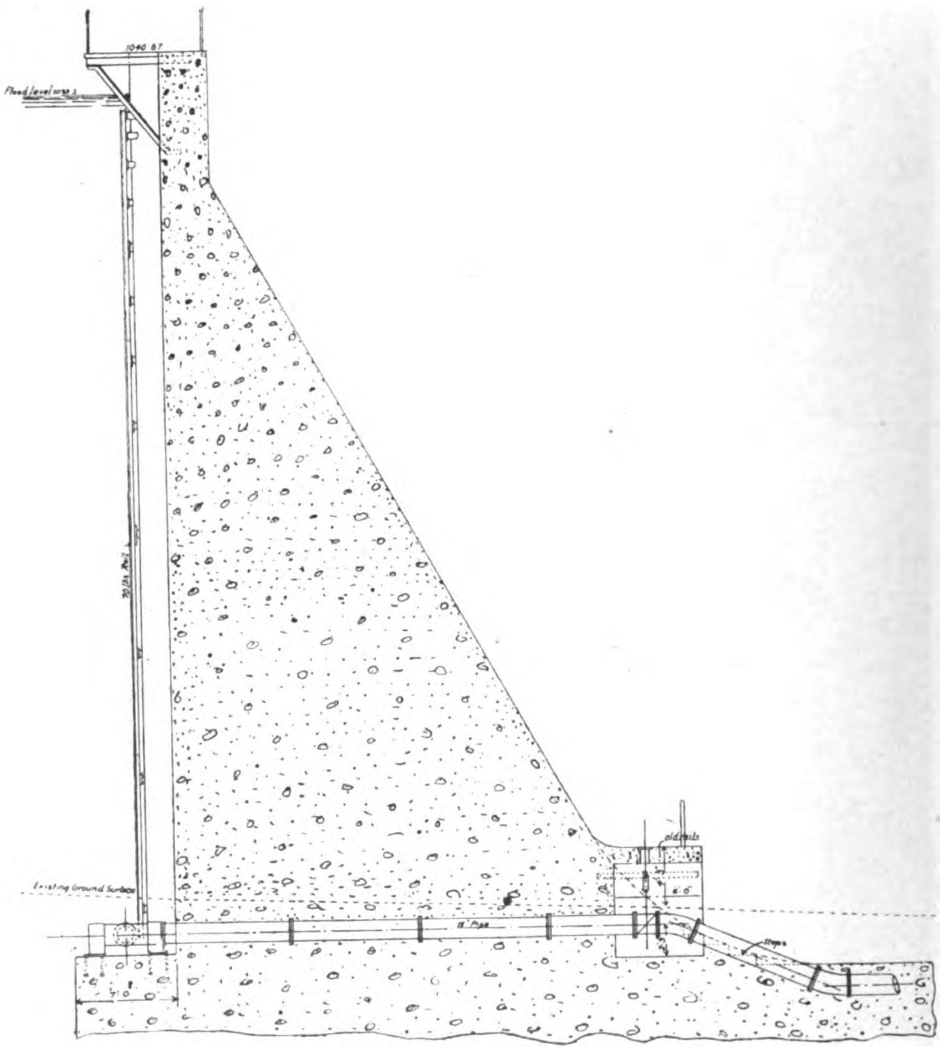
Type Cross Section.

overturning moments, as is done in the case of the calculations for a gravity section straight line dam, and the result of using this form of structure is that, provided the valley or gorge in which the dam is to be constructed is narrow, great saving in material results; but a few simple calculations will show that, assuming the width of the valley at the level of the crest of the dam to exceed 600 ft., and assuming the working pressure per sq. ft. on the concrete to



Elevation Looking Up-stream.
THE MEDLOW DAM, NEW SOUTH WALES.

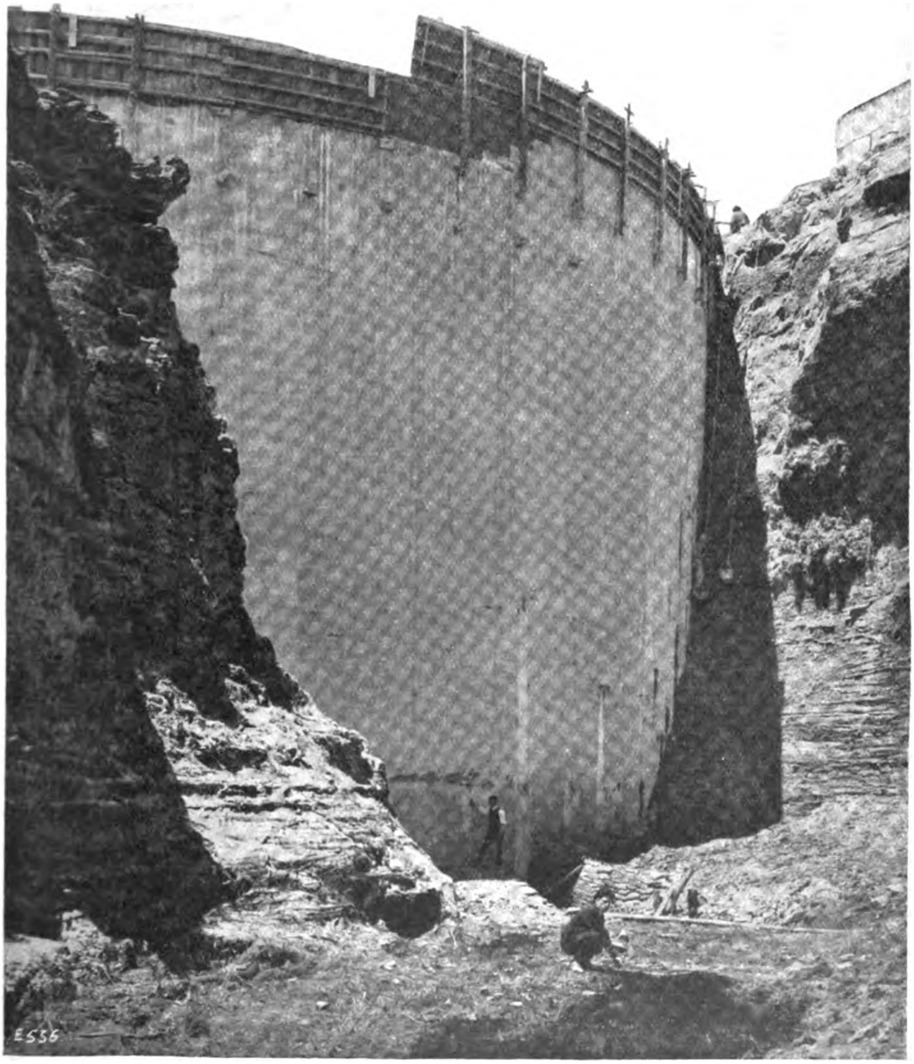
be used in construction to be limited to 12 or even 15 tons, the curved form is no longer economical, as the thickness of the dam required under these conditions of large radius, coupled with the increased material due to the length of the curve, results in an expenditure of more material than would be necessary to construct a straight dam on the chord of the usual gravity section. It is for this reason that the greatest radius in plan adopted for any of the curved dams, either constructed or in course of construction by the writer in New South Wales, is 300 ft., as in the case of the Cordeaux Dam, while the smallest radius occurs in the case of the Medlow Dam (plans and sections of which are given herewith), where the radius to the water face is 60 ft., the maximum height to T.W.L. is 62 ft., the thickness at the top



Section.
THE MEDLOW DAM, NEW SOUTH WALES.

is 3 ft. 6 in., and at the maximum depth 8·96 ft. The calculated thickness was based on a limiting pressure of 12 tons per sq. ft. on the concrete and a surcharge of 2 ft. over the crest of the spillway. This dam impounds 67,000,000 gallons of water.

It may be urged that the extremely simple formula quoted above does not cover the problem: that these dams possess in themselves, apart from their action as arches, a certain stability against overturning due to the weight of the concrete in the structure. Any stability derived from this source is



Up stream Face of Dam.
THE MEDLOW DAM, NEW SOUTH WALES.

in addition to the stability derived from the action of the dam as an arch pure and simple.

Again, it may be considered that these dams derive some additional strength and resistance to failure from the fact that they are, both in the bed of the creeks and at the sides, embedded in the rock strata. This aid also is excluded from the calculations, and it is well here to emphasise the point that in no case have these dams been constructed on other than perfectly sound rock foundations, both in the bed of the river and in the sides of the valley

To calculate the assistance derived by the dam from the weight of material used in its construction and from insertion into the bed and sides of valley is a problem which may well interest mathematicians, and those who care to follow the subject would do well to read the discussion on curved dams in New South Wales contained in Volume CLXXVIII., *Proceedings of the Institution of Civil Engineers,* in which are included, on page 60, some remarks by the writer on the importance of keeping the vertical joints in the concrete radial, and where an attempt, based on actual observations of a dam constructed under the supervision of the writer, is made to ascertain its movement under varying conditions of water pressure and temperature.

It will be remarked that in the curved dam on Barren Jack Creek, on which these experiments were conducted, a certain number of old rails were embedded; there was no necessity to introduce these rails as a reinforcement; but, having them in hand, the writer placed them in the concrete in order to observe the effect, and it will be for readers to form their own opinions as to the extent to which the introduction of these rails affects the diagram showing the movement of the dam in response to changes of temperature and pressure.

A further interesting contribution to the subject of curved dams will be found in the *Transactions of the American Society of Civil Engineers,* Volume LXXVIII., 1915, where a description of the Huacal Dam, Mexico, is given by Mr. Hawgood, member of the American Society of Civil Engineers, followed by an interesting discussion on the stresses in such structures. It appears doubtful to the writer if any finality can be reached mathematically, and perhaps it is difficult to sum up the position better than to quote the remarks of the late President of the Institution of Civil Engineers, Sir Alexander Binnie, in the *Proceedings* of the Institution referred to when commenting on these curved dams, as constructed in New South Wales, as follows:—

> "It was not a matter for cavilling at theory or formulas. The dams had been built and were standing. The problem that now arose was for mathematicians to show how the strains were accommodated in such apparently narrow walls. That they were accommodated was a fact."

Leaving the mathematical side of the question and turning to the adaptation of these structures to varying conditions, it may be that, while the lower portion of a valley or gorge is sufficiently narrow to admit of the arched or cylindrical type of dam being used, the upper portion is flatter, and it is necessary to provide an artificial abutment for the upper portion of the arch. A good example of this type is that of the Cordeaux Dam, the particulars of which are as follows:—

Radius to water face, 300 ft.; maximum height above foundation, 61·25 ft.; thickness at top, 3 ft. 6 in.; thickness at greatest depth, 35·85 ft. The

TABLE.

COMPLETE LIST OF CURVED DAMS CONSTRUCTED, OR IN COURSE OF CONSTRUCTION, IN NEW SOUTH WALES, AUSTRALIA, IN WHICH THE ARCH IN PLAN IS RELIED UPON TO RESIST THE PRESSURE OF THE WATER.

Locality.	Max. Height above Foundation.	Total Length.	Top Thickness.	Depth below Crest of Top Thickness.	Thickness of Base.	Surcharge allowed for.	Radius of Curved Part.	Limit of Pressure in tons per sq. ft.	Approx. Storage.	Character of Rock forming Construction.	Date of Construction.	Remarks.
	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.		Gals.			
Parramatta	52	225	4·8	—	15	2	160	15	130,000,000	Sandstone ..		Original height 41 ft. of masonry in Roman cement, built 1858, raised to 52 ft. with concrete in 1898
Lithgow No. 1	35	178	3·5	3·5	10·88	3·5	100	10	15,000,000	Sandstone ..	1896	—
Parkes	33·5	540	3	6	13·5	5	300	24	114,000,000	Granite ..	1897	—
Picton	28	112	7·01	—	13·62	10	120	12	14,000,000	Sandstone ..	1897	Constructed to be raised 14 ft. when required. (See Footnote No. 1.)
Cootamundra	46	640	3	8	13	1	250	25	136,000,000	Granite ..	1898	—
Tamworth	61	440	3	3	21·5	2	250	20	50,000,000	Granite ..	1898	—
Queen Charlotte Vale ..	32	113	3	6	8·65	2	90	10	—	Quartzite ..	1898	—
Wellington	48	350	3	7	10	2	150	20	27,000,000	Conglomerate	1899	—
Mudgee	50	498	3	5	18	1	253	20	42,000,000	Altered slate	1899	—
Wollongong	42	535	3·5	5	11·62	1	200	20	160,000,000	Basalt	1902	—
Lithgow No. 2	87	221	3	3	24	3	100	10	88,000,000	Sandstone ..	1906	—
Medlow	65	124	3·5	21	8·96	3	60	12	66,800,000	Sandstone ..	1906	—
Barren Jack City ..	38	—	2	15	5	—	80	17	—	Granite ..	1908	—
Mittagong	30	171·9	3·6	12	6·28	3	100	12	7,500,000	Sandstone ..	1908	—
Upper Cordeaux	61·25	909	3·6	3·3	35·85	3	300	15	260,000,000	Basalt	1912	Gravity ends.
Katoomba	50	344·6	3	6	20·29	1	220	15	34,300,000	Sandstone ..	1915	Gravity ends. (See Footnote 2.)
Kiama	41	342·6	3·6	8·4	15·7	1	200	15	13,500,000	Basalt	1915	Gravity ends.
Goulburn	36	350	3·6	5·6	14·88	4	200	15	81,000,000	Granite ..	1916	—
Orange (Meadow Cr.) ..	47·2	658	3·6	10·45	15·81	4	180	15	150,000,000	Basalt	Under construction	Gravity ends.
Murwillumbah	40·7	328	3·6	6·5	16·23	3	200	15	6,000,000	Granite ..	Under construction	Gravity ends.

Note 1.—The Picton Dam has since been raised 8 ft.

Note 2.—In the case of the Katoomba Dam the foundation and portion of the dam to the full thickness for that height was constructed for an ultimate height of 50 ft., presenting the appearance of a curved dam with buttresses, the object being to obtain a complete bond between the lower and upper portions of the dam when raised. Keyholes were left in the work into which steel joists were inserted to act as bonds when the structure was carried to its ultimate height. The whole arrangement was found most satisfactory and the dam as carried to the full height of 50 ft. in 1915 leaves nothing to be desired.

calculated thickness was based on a limiting pressure of 15 tons per sq. ft. on the concrete, with a surcharge of 3 ft. over the crest of the spillway. The total capacity of this dam is 260,000,000 gallons.

On page 89 is a table showing the number of curved dams built, or in course of construction, in New South Wales, with the thicknesses, limiting pressure, radius, etc. It should be mentioned that in this table no reference is made to the great concrete dam now in course of construction at Barren Jack (distinct altogether from the small curved dam referred to above) or to that at Umberumberka, both in New South Wales, in both of which a gravity section is adopted, but a curvature of some 1,200 ft. radius is also used.

The table above mentioned is more complete than any yet published, and it will be seen that in some of the earlier constructed dams, notably in the case of Cootamundra, very high limiting pressures were adopted. It is not, however, the present practice of the writer to exceed 15 tons on the sq. ft. for concrete in which the very best material is available.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.—ED.

THE CONCRETE INSTITUTE.

PILE-DRIVING AND THE SUPPORTING POWER OF PILES.

By HENRY ADAMS, M.Inst.C.E., etc. (Past President).

The following is an abstract from a Paper read before the Concrete Institute at their meeting on December 21st, 1916. We also give a résumé of the discussion which followed.

TWENTY-FIVE years ago the author read a paper before the Society of Architects upon "Timber Piling in Foundations and other Works." The notes then collected and since added to relate chiefly to timber piles, with which the author has had considerable experience, and upon which much scattered information has already been published; but all driven piles, whatever the material, must behave more or less according to the same laws, and the knowledge gained concerning ordinary timber piles will be likely to enable us to discover the laws and regulate the practice of driving and using piles of other material, including reinforced concrete.

In order that the formulæ given in the paper may be easily compared, advantage has been taken of the Standard Mnemonic Notation issued by the Concrete Institute. This notation can be used with any system of units.

By converting the different formulæ into Standard Notation it is made abundantly clear that many formulæ which were formerly considered as divergent are really identical in every particular, except notation.

DRIVING PILES.

Ordinary piles are driven by what is called a "pile engine." It is virtually a large hammer, the weight being arranged to fall freely and strike a succession of blows upon the head of the pile. It consists of a tall framework, with vertical guides on the face to keep the hammer or ram in a direct line with the head of the pile. The base of the pile engine is placed just above the finished level of the pile head, so that in driving long piles a high framework is required. It is, however, sometimes impossible to get the framework high enough for this, and it is then set 6 or 8 ft. above the finished level, and a punch, dolly, or follower, of hard wood, hooped at both ends, is used on the head of the pile when it gets as low as the base of the frame, but the blow is not so effective and the method should be avoided when possible; it is said to reduce the effect of the blow one-third, more or less, according to the rigidity of the material. The length of a pile is generally determined by the local conditions of site and soil, the sectional area chiefly upon the load it has to sustain, usually the ratio

$$\frac{L}{A} = \frac{1}{4} \text{ to } \frac{1}{8}$$

but no general rule can be laid down, as it depends to some extent upon the unsupported length above ground.

PITCHING AND DRIVING.

In pitching a pile care must be taken that it is started in the right place, as it cannot be shifted, but if the point is not truly in line with the axis of the pile, or gets pushed to one side by meeting an obstruction before it has entered very far, the lower end of the pile will be drawn over to the side to which the point leans. In spite of the greatest care they will sometimes be found slightly out of position, and they have then to be drawn back into place by chains, twisted like a surgeon's tourniquet, while being bolted to the other timbers. If it be necessary for them to be scarfed, the upper portion can be adjusted by cutting the scarf a little out of line to suit. All piles are now required to be vertical; in building jetties the outside row of piles is often doubled, the outer pile being a raking one, at 15 to 30 degrees from the vertical, for increasing the stability, acting like a buttress. At the corners of jetties the outer piles are usually raking both ways, say about 15 degrees from the vertical. When necessity arises piles may be drawn from the bed of a tidal river by lashing empty barges to them and letting them lift by the tide. Against a river wall or round the foundations of a bridge piles should be sawn off by a diver as low as he can get at them in preference to drawing them, to avoid any risk of scour and undermining of the foundations taking place. On land a pile may be drawn by lashing a short piece to the top and then prizing it up by another baulk used as a lever, or by a pair of powerful jacks.

WEIGHT OF RAM.

One of the most interesting questions in connection with pile-driving is the proportion between the weight of ram and the fall to produce a given result. The ram usually weighs from 5 to 30 cwt., and is allowed to fall, say, from 6 to 20 ft. Upon a superficial consideration it would seem that a ram of 5 cwt. falling 20 ft. would produce the same result as a ram of 20 cwt. falling 5 ft., as they would both have 5 ft.-tons energy, but the proportion of the total energy ($W\ h$) which is usefully expended in sinking the pile depends *inter alia* upon the ratio of the weight of ram to the weight of the pile. Some of the total energy is always wasted.

A light ram with a long fall will not have the same effect as a heavy ram with a short fall. In practice it is found that with too great a fall the effect of the blow is to bruise and "broom" the head of the pile, or to shiver the timber instead of to force it downwards. A heavy ram, producing the same effect in distance driven as a light one with greater fall, does less injury to the pile. Dobson says, "In working with a fall from 12 to 20 ft. it is common for every tenth pile to be more or less shaken." Of course he meant to say "one pile in ten." It is as if the top of the pile were driven down while the bottom remained stationary, owing to the inertia of the mass of the pile.

For the first few blows the pile goes down a considerable distance, which gradually becomes less at each blow until the resistance is so great that it will not go any further, or, as it is technically called, "refuses." Were the material of the pile perfectly rigid and inelastic the impact, however slight, would produce an infinite pressure, but the material is very elastic, and so the fibres of the pile are compressed without the point going any farther, and the amount of this compression and the elasticity are strikingly shown in the rebound of the ram when the pile refuses. Generally the driving is stopped when the "set," or distance driven by the last blow, does not exceed ¼ in., or the sum of the last three blows 1 in., but of course for this to be any measure of the supporting power the weight of the ram and height of fall must be in some recognised proportion to the dimensions and weight of the piles.

Rankin says, "According to some of the best authorities the test of a pile having been sufficiently driven is that it shall not be driven more than 1-5 in. by 30 blows of a ram weighing 800 lb. and falling 5 ft. at each blow," and there is probably no one who would dispute the fact that if it stood this test it had been sufficiently driven; many would consider that it had been over-driven and that valuable energy had been wasted. The tendency of late years has been to increase both the weight of the ram and its fall, especially where heavy duty in supporting power is required.

THE SUPPORTING POWER OF PILES.

The sustaining power of a pile depends chiefly upon three circumstances—

(1) The resistance at the point or shoe to further penetration.

(2) The friction of the earth on the sides of the pile, and

(3) The strength, as a column, of the pile above the ground or above the firm subsoil.

Although it would seem that these are simple elements, each of which could be fairly estimated, the complexity of the case is shown by the numerous formulæ which give results ranging up to about 450 per cent.

The first two factors are usually combined into one formula founded chiefly upon experiments. The best-known formula is that of Major Sanders, U.S. Eng., quoted by Rankine and Molesworth—

$$R = \frac{W h}{8 s}$$

This equation is unitally complete, h and s are in the same units of length, and R will be in the same units as W.

For example, if W is in tons, then R will be in tons.

This is the same as calling the safe load one-eighth of the mean resistance to the energy of the blow, assuming it to be expended entirely in penetration without compressing the pile. Although this formula may be good enough for ordinary cases, it can at best be only approximate, and it will be instructive to compare it with other formulæ which have been given from time to time.

In Newman's "Earthwork Slips and Subsidences" the frictional resistance of timber piles is stated to be less through wet soils than dry, in the following proportions—

In sandy gravel 5 to 10 per cent. less.

In sand about 12 per cent. less.

In sandy clay or gravelly clay about 40 per cent. less.

Experiments with cast-iron piles by McAlpine gave about ½ ton per sq. ft. of surface as the supporting power from friction when sunk 20 to 30 ft. in rocky gravel. He considers it would amount to 3 tons per sq. ft. in fine earth, but this seems to be an extravagant assumption. In experiments made previous to the sinking of concrete piles for the works of the Vienna-Danube Sand Dredging Company in 1909 it was found that the frictional resistance was about 14·19 lb. per sq. in. of surface = 2054·36 lb. per sq. ft., or just over 18 cwt.

G. P. Bidder was of opinion that "in clay or wet soils it was not advisable to trust a greater weight than 12 tons upon each pile, but in gravel there was scarcely any limit to their vertical bearing strength."

French engineers (vide Berg's "Safe Building") allow a pile to carry 50,000 lb. provided it does not sink perceptibly under a ram falling 4 ft. and weighing 1,350 lb., or does not sink ⅓ in. under thirty blows.

The following rule has been given for steam driving. When a pile is driven a feet vertically into the ground by n blows of a steam hammer fastened to the head of the pile, p being the mean pressure of the steam in pounds per square inch, d the diameter of the piston in inches, l the length of the stroke in feet, W the weight in pounds of the moving part of the hammer, W_p the weight of the pile and the fixed part of the steam hammer attached to it in pounds, the mean resistance of the ground in pounds will be:

$$W_p + W + \frac{n W}{W + W_p}\left(W + \frac{1}{4} d^2 p\right)\frac{l}{a}$$

For the ultimate resistance, the result of, say, the last ten blows may be taken.

A common rule for safe dead load on each pile is 5 tons per sq. ft. of cross-section in soft ground, or 1 ton per in. side of square piles in firm ground.

The New York Building Regulations permit a load of 20 tons per pile, but the size is not specified.

The author believes they use Wellington's formula (15) for safe load.

Haswell (*Min. Proc. Inst. C.E.*, cxv., p. 318) says: "In deciding upon a factor of safety in a formula for pile-driving, the following elements must be considered: The friction of the machine; the resistance of the atmosphere to the fall of the ram and the cushioning on the head of the pile, however square it may be dressed off; the want of verticality both in the fall of the ram and in the plane of the pile, and the consequent lateral vibration; the inertia; the vibration and condition of the soil. Were all the conditions known definitely and allowed for, a factor of safety of 2 would be ample, but as the formulæ do not take account of all the conditions a larger margin is necessary. In some ascertained supporting powers recorded by Trautwine they were found to be from 2·3 to 3·7 times greater than given by the formulæ.

There seems to be no general rule as to the factor of safety it is desirable to adopt; the practice appears to vary from 2 to 10, the former being suitable for dead loads and the latter for live or vibrating loads. Intermediate factors would be produced with varying proportions between the dead and live loads. Obviously, unless the ultimate resistance given by the formula is reliable, the resulting factor is unknown.

In Dobson's "Foundations and Concrete Works" (Weale's Series) we are told that "of the comparative effect of impact and pressure in driving piles we as yet know nothing, and the question is so complicated, from the great number of points that have to be taken into consideration in reducing the results of experiment into a definite form from which some rule for our guidance might be obtained, that we can only lay down in general terms the following empirical rule that in *ordinary case* if a pile will safely resist an *impact* of a ton it will bear without yielding a *pressure* of 1½ tons," and he gives Wv = impact, therefore safe load = $1{\cdot}5\ Wv$.

Dobson is, however, wrong in his theory; he assumes that the force of a blow is measured simply by the product of the weight into the velocity, and this assumption leads him to conclude that a 1-ton ram with a fall of 16 ft. will have the same effect on the head of a pile as a 2-ton ram falling 4 ft., while the former takes double the expenditure of power to raise it. In other words, he says $f = mv$, instead of $ft = mv$, which is the well-known formula where f = force, t = time, m = mass = $\frac{w}{g}$, v = velocity. That is, a force f, acting for time t, will move a mass m, with a velocity v, but action and re-action are equal in magnitude but opposite in direction, therefore a mass m moving with a velocity v, and expending its energy in time t, will produce a mean pressure

$$f = \frac{mv}{t}.$$

Weight = product of mass into force of gravity, or $W = mg$, therefore $m = \frac{W}{g}$, or $f = \frac{Wv}{gt}$, instead of $f = Wv$, as Dobson puts it. The same error is made by Molesworth, p. 117, and a table of results is given assuming that the force of the blow varies as the square root of the fall instead of directly as the fall. The product mv gives the momentum in its original sense. It is also known as *quantity of motion*, but it cannot be compared with force or pressure unless time be taken into account.

The sort of test that is required to prove the accuracy of any formula is to measure the distance moved by the head and by the point during, say, the last four blows, and take the average for each. Cut off a foot from the top of the pile to receive the load on a good surface. Carefully level through from a fixed bench mark to find the level of the top of unloaded piles. Calculate the safe load on the pile and load it up until the head of the pile has sunk to the amount to which it was previously compressed (*i.e.*, previous average movement of head– average movement of point); note this load. Then continue loading and note level of pile at each ton addition until the head of the pile has sunk, say, double the previous compression, *i.e.*, previous average movement of head minus average movement of point. Then leave it loaded for twenty-four hours and note whether it has sunk farther and how much. Remove the load and note the result.

The difficulties in the way are:

(*a*) Finding enough load.
(*b*) Supporting the load on the pile without friction.
(*c*) Measuring the results accurately.
(*d*) Avoiding personal danger throughout the test.

REINFORCED CONCRETE PILES.

The advantages of reinforced concrete piles are so manifest that they need no express recommendation here. The chief physical differences from timber piles, as regards driving and their supporting power, are due to their extra weight and their friable nature. They should be made with slow-setting cement six weeks before driving, but if made with quick-setting cement they must be left eight weeks, because in the latter case the outside hardens first and leaves the interior soft. They should be driven by steam or drop hammer with a 3-ton ram, having a fall of 3 ft. with a steel helmet filled with sawdust, and preferably without a dolly.

In America the use of a water jet is found greatly to facilitate the sinking of concrete piles.

Hollow cylindrical reinforced concrete piles have been used at Southampton, Newcastle-on-Tyne, and Liverpool. They are lighter and cheaper than solid piles and more effective. Those at Brockelbank Dock, Liverpool, were 20 in. diameter. Reinforced concrete piles of circular section are easier to drive than square piles, and as they have no sharp angles are less liable to be damaged by coming into contact with boulders, etc.

As reinforced concrete piles are made horizontally, care must be taken in lifting them; the points of attachment for lifting should not be less than half the length apart, and if lifted with one end on the ground the attachment should be one-third the length from the other end.

The reinforcement rods (about 2½ per cent.) should preferably be hooked at the top and electrically welded together at the bottom. They should be bound helically by, say, ¼-in. wire, 4-in. pitch, carefully secured at the top.

It is a debatable question whether reinforced concrete piles are more easily and economically driven to the required depth by a drop hammer or by a steam hammer. The probability is that upon a trial with equal weights of hammer the advantage of the steam pile-driver in the case of wooden piles would be maintained with reinforced concrete piles.

The building laws of most of the cities in the United States allow on concrete piles a safe load from 350 to 500 lb. per sq. in. on the concrete, plus from 6,000 to 7,500 lb. per sq. in. on the vertical reinforcement. This is irrespective of the nature of the soil or depth driven, but they are supposed to be proportioned according to the Wellington or *Engineering News* formula.

It is a commonly received notion that a reinforced concrete pile will safely carry double the load that a timber pile of similar dimensions would do, but the writer has not found any data from which such a conclusion could be absolutely derived. He has not found a single case of a test load which has caused a concrete pile to sink farther. There are many accounts of loads put on piles which did not cause any sinking, but these have no practical value for checking the formulæ.

Mr. Charles Gow, in a paper read before the Boston Society of Civil Engineers, considered 30 tons the safe approximate load on concrete piles, but the size of the piles was not stated.

In the Dittman Factory, Cincinnati, Chicago, one concrete pile was considered equivalent to two or more wooden piles.

The "Raymond" concrete piles are not reinforced, but are made by first driving with a solid steel core a thin conical steel shell, which excludes sand and water, and is filled with concrete after the core is withdrawn. For the Friede Globe Tower at Coney Island, 700 ft. high, where the soil consisted entirely of fine set sand, the concrete piles were about 8 in. diameter at the point and 20 in. at the top, driven to a depth of about 30 ft. They were calculated to have a bearing capacity of 300 tons each, but are loaded with only 57 tons each.

In the case of the 14-in. square reinforced concrete piles of the wharf at Lower Pootung, Shanghai (*Min. Proc. Inst. C.E.*, 1911-12, clxxxviii. p. 80), driven in river silt with a crust of stiff sandy clay, and designed to carry a load of 11 tons each, it was estimated that the skin friction was 5 cwt. per superficial foot, exclusive of their own weight, with a final set of 1 in. per blow from a steam pile-driver with a falling weight of 3½ tons dropping to 6 to 8 in. upon a short timber dolly and no cap. The additional dead weight of cylinder, etc., resting on the pile was 1½ tons. In one pier the four piles sank rapidly under the dead weight of the hammer and cylinder to the required depth without any driving, and had to be checked by holding up the weight when they reached that depth, but after the lapse of a month these four piles were tested with a load of 45 tons, under which they settled 1¾ in. in a fortnight, coming to rest at the end of that time. This example shows the special value of skin friction in the case of concrete piles.

SCREW PILES.

Screw piles of reinforced concrete have been patented by Mr. Vernon Inkpen, of Portsmouth, and they would very probably be found very useful in a peaty or wet sand foundation.

Rankin's "Useful Rules and Tables" say, "The load supported by a screw pile in practice ranges from 3 to 7 times the weight of earth which lies direcly above the screw blade." This seems to be a very peculiar way to measure the supporting power, and appears to be based upon the resistance of the "spewing-up" effect of the downward pressure by the screw blade, and not on the direct resistance of the soil below the blade to compression. The fact is that the soils vary so much between the extremes of plastic clay and firm gravel that whatever rules may be laid down personal judgment must come in as the most important factor, whatever kind of pile or method of driving may be employed.

DISCUSSION.

The President said they had listened to a most important paper, in which Professor Adams had got up a mass of information, facts and theories. The latter, if somewhat bewildering, were nevertheless likely to be of use in the pursuit of the elusive problems before them. Their discussion was likely to be of great interest, but practical experience was the great thing to be considered, and he hoped those members who had it would give them the benefit of their knowledge. As he had to leave for Southampton, where he was engaged on important war work, he had to ask the indulgence of members, and he would ask Mr. E. Fiander Etchells to take his place.

Mr. Etchells then took the chair, and the discussion was opened by

Mr. C. E. Melk, who said that what struck him most was the variation in the formulæ in estimating the ultimate loads which the piles would carry. In three of them there was a variation from 38 tons to 192 tons for the sample pile; that represented a variation of 500 per cent. That would be very misleading to an engineer who did not know which formula to use. At the same time there was no doubt that the circumstances and the condition of the ground had to be taken into consideration. For instance, there was a difference between Thames ballast and soft clay. According to formula a pile driven in clay ought to carry double the load owing to the skin friction of the pile, and there were instances where the skin friction was in itself sufficient to carry the load. If the pile was hardened the weight was increased, and with regard to timber and concrete piles the latter could take double the load, showing that in all cases the formula could not be applied. With regard to the factors of safety there appeared to be an enormous difference between the authors of the different formulæ. He would say that the figure 3 was ample, and in the case of concrete piles 2. Of course, if they had to deal with vibrating loads they must make allowances.

Mr. C. J. Jackaman said he had a considerable experience which had been more of a practical than a theoretical character. He would be glad if a definite number could be stated instead of the phrase "the last few blows." It was usually taken to be ten blows, and it would be of use to have something definite, especially to those associated with reinforced concrete piles. He wished to give an experience in Thames ballast, and where one pile had been driven much further than another though they were only 18 in. apart. Whether that was due to the hardening up of the surrounding ground or not he could not say, but it looked like it.

Mr. Border said: It was difficult to choose a formula for one's work, and Professor Adams, by his labour in accumulating all that information, had rendered them inestimable service. There was one point as to the driving of sheet piles, one of the chief troubles was that they were thin in one direction, and bending did take place momentarily under the blows of the monkey.

Mr. C. F. Marsh said that generally speaking about timber and reinforced concrete, he could never see why there should be differences as regards the formula used, the only difference being that one was heavier than the other, but that allowed for harder driving, as the concrete piles were stronger than the timber ones. He referred to the danger of electrical currents getting into the concrete. It did not appear that any formula was useful, as there were such a lot of things which had to be taken into consideration. The best way, when engaged on big works, was to drive test piles and to drive sufficient, for it was astonishing how soil varied over a small area.

Mr. H. J. Shelbourne entirely agreed that formulæ were practically useless, and he cited two recent instances of work he had done which were conclusive proof of his assertion. The piles he had driven were only meant to support iron-framed buildings with glass roofs, but the results with the test piles were most varied. He never used a heavier monkey than could be helped, because they had, as contractors, to make a profit and did not want to move heavier machinery than was necessary. In practice he had never heard of failure with foundation piles.

Mr. A. Stewart Buckle gave an interesting account of his experiences abroad, and said he had found concrete piles to be cheaper than wood. On an island off Ceylon he had to carry out some cylinder sinking, and as they had no timber they had to use trunks of trees with a lot of pith in the centre, but the wood was hard and they drove very well indeed for temporary work. His account of what he had done was quite news to engineers in Ceylon, but it was a case of necessity, and he had to use what was available.

Mr. W. A. Green said, in spite of the assurances as to the usefulness of the formulæ as to which doubts had been expressed, he was personally grateful to Professor Adams for his paper. It would be of interest to know that pedestal piles were used a great deal on the other side of the Atlantic.

Mr. Ewart S. Andrews, who had devoted some attention to the question as to the amount of energy available from two colliding bodies, not the two mythical billiard balls of the text-book, but the colliding bodies of the ram and the pile, said in using any of the formulæ the resistance of the piles and the strength of them had to be judged from three points of view :—

1. Penetrability indicated by the amount of depression.
2. Friction caused by resistance on the side of the pile.
3. Strength of the pile on the assumption that it had found a solid bearing.

These three points of view must be kept in mind, and they must find some of the formulæ which looked likely to be unsafe and unreliable when they came to the consideration of the ultimate load. As to the value of formulæ he did not want to enter into a thorny subject, except to say that if there were no formulæ they would be beating about in the dark. Formulæ were necessary, but they must eliminate those based on unreliable reasoning. In treating this part of the subject he had gone into the theory of impact, he had a formula which was exactly the same as that of A. M. Wellington. But he was not satisfied that the theory of impact was applicable to any system of pile driving, for they could not get any absolute formula which would stand the test.

Mr. Stewart Buckle, in reply to questions, said in Ceylon they tried iron shoes, but they soon ran out of things in the East, and so they did the best they could with the hoop iron from cement barrels, and they proved to be very useful.

The Chairman (Mr. Etchells), in moving a vote of thanks to Professor Adams for his paper, said the Science Committee would take up the subject and endeavour to find one formula of a practical character, which would allow, as far as possible, for all the conditions and complexities which arose in practice. The amount of energy was the same in the case of 12-in. and 18-in. piles, but in one case the vibration would be more and that had to be accounted for. They must, in the last resort, use some sort of safety formula, and take an average of the collective factors which reduced the energy. With regard to the assertion that concrete piles were twice as strong as those of wood, that seemed to be proved to be true, but it lacked confirmation. Where the area was the same the resistance of four piles was greater, but formulæ, as a rule, did not take into account the frictional resistance of clay after a lapse of time. But they all recognised that certainty was impossible, though realising that it was necessary to have some common basis, however useless formulæ might be.

Professor Adams, in replying to the vote of thanks, which was cordially passed, said the kindness of the criticisms left him little to answer. The great difficulty was in testing the supporting nature of the soil, but the final set of the pile would be the test of the soil.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course or construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

A REINFORCED CONCRETE RETAINING WALL AT PORT ELIZABETH, SOUTH AFRICA.

THE following short particulars of some work executed in South Africa may be of interest :—

Some time ago Messrs. Jones and McWilliams, architects, of Port Elizabeth, designed and had carried out a retaining wall for the playground of the North End Grey School of that town, which has some novel features.

Originally an ordinary concrete wall was designed for this work, but it was found to be very much cheaper to reduce the concrete mass and reinforce instead.

The height of the retained earth varies from about 8 ft. at one end to 13 ft. at the other end; the maximum wall thickness is only 14 in., tapering to 8 in. at the parapet.

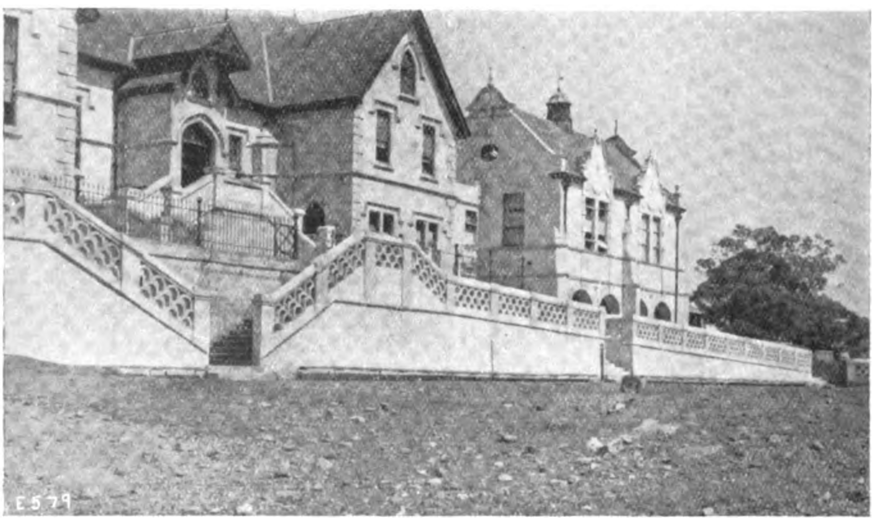


FIG. 1. Showing portion of retaining wall along cutting and steps to school terrace.
REINFORCED CONCRETE RETAINING WALL, NORTH END GREY SCHOOL, PORT ELIZABETH, SOUTH AFRICA.

The stability of the wall is secured by reversed buttresses or anchor buttresses, springing off anchor slabs 2 ft. 6 in. wide by 6 ft. 6 in. long, reinforced in such a way as to resist the tensile strain of the rods in the buttresses.

The buttresses divide the wall into 10-ft. bays, and the intervening wall space is reinforced to convey the thrust of the embankment to the buttresses, thus dispensing with the gravity of the concrete and depending upon the anchor slabs, which are held in position by the weight of earth filled in on top of them.

Another wall was erected at the opposite end of the playground against the cutting. The greatest height of this cutting was about 9 ft., the lower strata being in rock

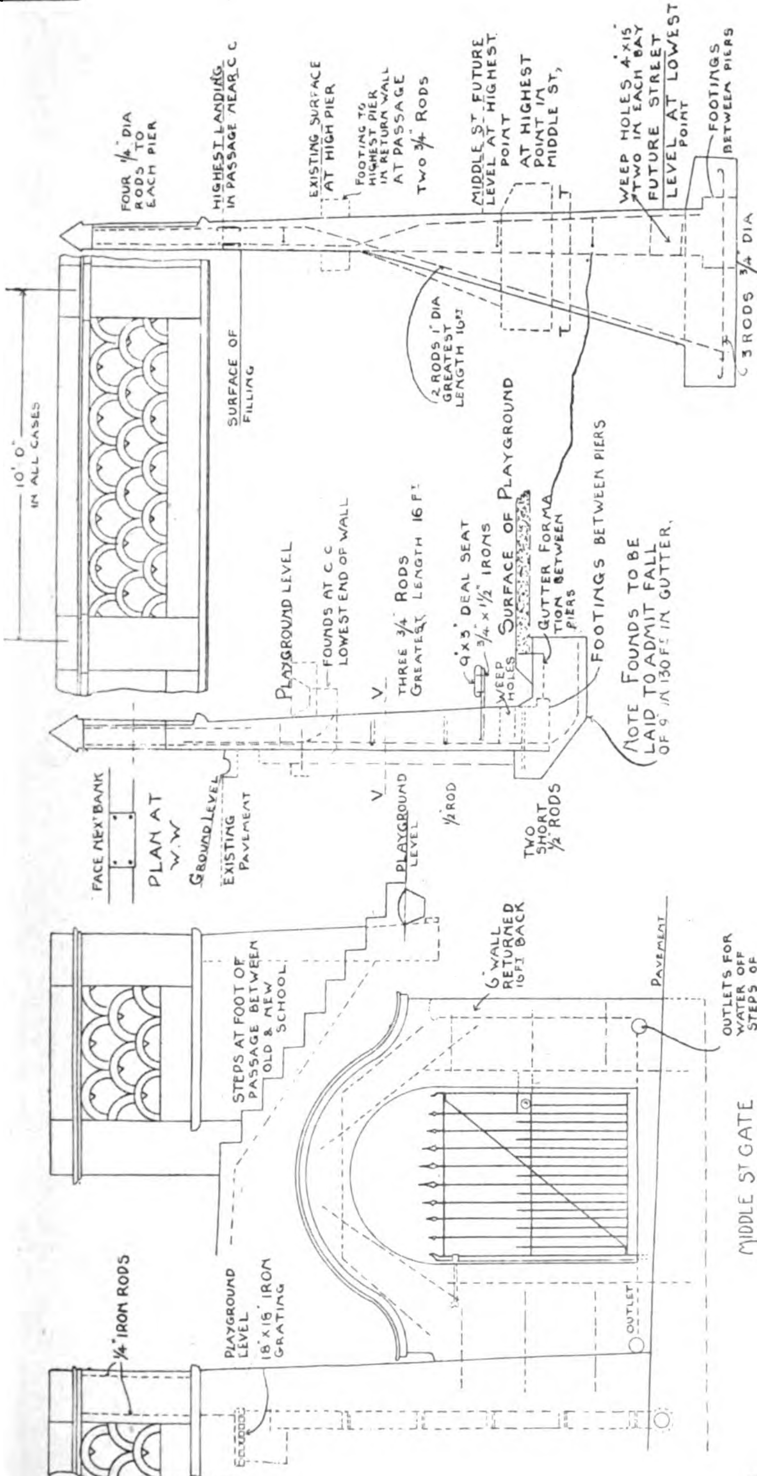


FIG. 2. DETAILS OF REINFORCED CONCRETE RETAINING WALL, NORTH END GREY SCHOOL, PORT ELIZABETH, SOUTH AFRICA.

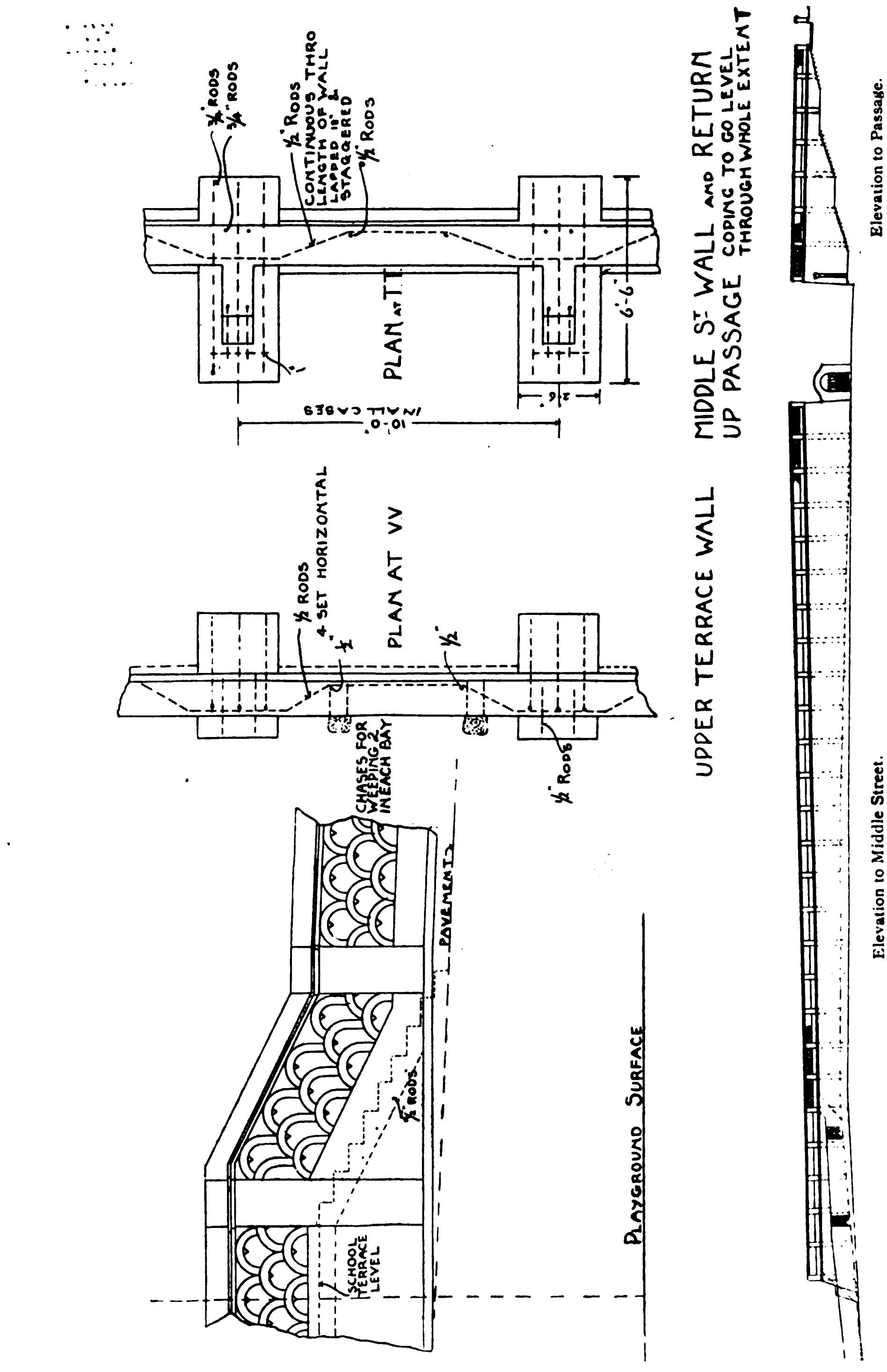


Fig. 3. Details of Reinforced Concrete Retaining Wall, North End Grey School, Port Elizabeth, South Africa.

formation. This bank was retained by anchoring a nose or horn of the foundation into cuttings in the base of the bank at intervals of 10 ft. with a tail slab from each projecting forward from the wall and away from the bank, and these were reinforced with three rods ¾ in. diameter in the normal wall thickness.

The parapets of all walls were divided into bays by pedestals at 10 ft. centres and filled with cast concrete half-round cylinder cases, the whole being left as from the forms and whitewashed.

These walls, we are informed, have been standing for some considerable time, and are entirely free from any signs of yielding, only the ordinary fine contraction cracks being evident.

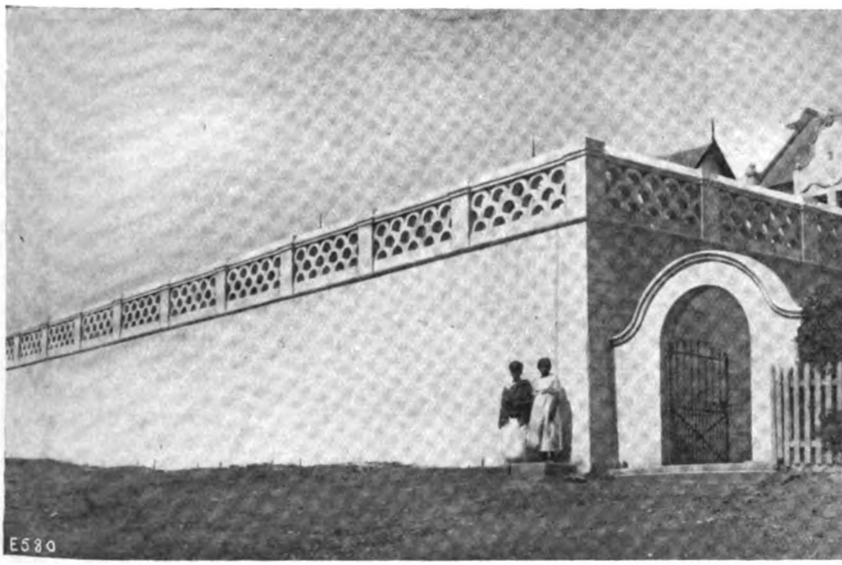


Fig. 4. Showing Middle Street Elevation—about half the length.
REINFORCED CONCRETE RETAINING WALL, NORTH END GREY SCHOOL, PORT ELIZABETH, SOUTH AFRICA.

NEW BOOKS
AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

The Portland Cement Industry. By William Alden Brown, Assoc.Am.Soc.C.E.

London: Crosby Lockwood & Son. 7/6.

Of recent years a great deal has been written on the subject of the manufacture of Portland cement, and Mr. Brown gives us another treatise on the subject, which follows in its general lines the model of earlier works on the same subject. In his introductory remarks Mr. Brown shows the amiable weakness of so many Englishmen for believing that their own countrymen are hopelessly in arrear as compared to their competitors in other countries, and, in common with those who write from this standpoint, he does not present the British side of the case quite fairly. To quote only one instance, Mr. Brown suggests that Americans are ahead of us in "promoting and encouraging technical research" in this industry, but no mention is made of the British Concrete Institute, which was founded more than five years before the corresponding American Institute. Following the time honoured custom, Mr. Brown devotes short chapters to historical notes and the development of the industry before proceeding to describe modern methods of manufacture. In neither of these chapters does he tell us anything new, and in the later chapters, dealing with design and construction, it is noticeable that he has not been able to resist the temptation - into which previous writers have fallen—of making this more in the nature of a catalogue of various types of machinery rather than a guide to the most approved type for each department. Chapter ix. is devoted to "Costs and Statistics," and whilst the consumer will, no doubt, be delighted to learn on the authority of Mr. Brown, that cement can be produced so cheaply, we rather imagine that manufacturers to-day would, if they could be induced to reveal so sacred a thing as their actual manufacturing costs, including all those charges omitted from Mr. Brown's estimate, place a very different complexion on the matter. Several chapters are devoted to the testing of cement, and, although certain parts require revising to bring into line with the practice laid down in the latest edition of the "British Standard Specification for Cement" (March, 1915), there are undoubtedly many hints here which will be of value to the cement user, so long as he is not tempted to imagine that with their aid the testing of cement becomes a simple business, which can be carried out by anybody without previous experience and practice.

Stresses in Structures. By A. H. Heller. Third edition revised by Clyde T. Morris.

London: Chapman & Hall, Ltd. (New York: Wiley & Sons). 374 pp. demy 8vo. Price 11s. 6d.

If Solomon could have seen the number of books which are "made" nowadays—especially American books upon structural engineering—he might have strengthened his famous proverb. But he would not necessarily have been right in the implied suggestion that too many books are produced, particularly technical books. As a nation we have not yet acquired the book habit sufficiently, so that books containing very valuable information are not so well known as they deserve to be.

Professor Heller's book, which was first published in 1906, has for its aim to combine a "student's text-book with a book of reference for the practical engineer whose time is too much taken up to get, with advantage, from elaborate treatises a working theory for whatever problem he may have on hand."

The following chapter headings give an idea of the scope of the book: Stresses and Deformations within the Elastic Limit—Stresses and Deformations beyond the Elastic Limit—The Laws of Equilibrium and their Application—Applications to the Structure as a Whole; Reactions—Applications to a Part of a Structure; Stresses—Stresses in Beams and Girders—Deflections of Beams and Girders—Special Cases of Beams and Girders—Stresses in Blocks and Columns—Roof Trusses—Bridge Trusses—Stresses in Simple Bridge Trusses for Uniform Loads—Stresses in Railway Bridges from Wheel Loads—Stresses in Bridges from Horizontal Forces.

On the whole the author has succeeded

very well in achieving the object which he had in view, and it is to be regretted that Professor Heller died before he completed the book, so that some of the questions that he intended to deal with—such as the application to the computation of stresses of the principle of least work—do not find a place in the book. At the same time, as Professor Morris points out, the book covers a course which is sufficiently extensive for most students, and the consideration of the more advanced problems may be left to the text-books specialising in them.

The treatment in the book resembles that favoured by British writers much more than is usual in American books, which, as a rule, are much more valuable as reference books than as text-books for students in this country.

The style is concise and many references to other books are given, although we would suggest that the reviser has not revised these references sufficiently for the new edition, so that text-books appearing since 1906 do not appear to be referred to. For these students, to whom Professor Karl Pearson used to refer as the "weaker brethren," the treatment will probably be found to be rather too concentrated, especially for those who have to study without the aid of a tutor to help them over their difficulties.

The book is very well printed and illustrated, and contains a very useful set of exercises to be worked by the students; the value of these exercises would be still greater if the answers to more of them were given.

Concrete Construction for Rural Communities. By Roy A. Seaton, M.S.

London: McGraw-Hill Book Company Inc., 6 Bouverie Street, E.C. 223 pp. + xi.

Contents.—Materials—Plain Concrete—Reinforced Concrete—Miscellaneous Matters—Typical Applications of Concrete.

The question of using concrete for rural purposes is a very important one, and it is receiving a great deal of attention at the present time; thus this book, which forms one of the Agricultural Engineering Series, is of particular interest.

The text is divided into five parts under the respective headings given above, and each of these contains several chapters. In the first part the materials, their testing, proportions, and properties are explained, while mixing, handling, and construction of forms are dealt with in the second part.

Reinforced concrete is considered in two chapters, in which general principles are explained and various classes of construction are considered.

The most interesting matter in the book is undoubtedly that contained in Parts 4 and 5, where some very useful notes are given on surface finishes and casting in moulds, and examples of various concrete features and structures are illustrated. In the latter it will be seen that concrete can be successfully applied in numerous instances of rural construction, ranging from small articles to complete structures, and giving a pleasing appearance, and proving economical and lasting. The book is well written, and deserves to be read by all those who are interested in the problem of executing work in rural districts at a reasonable cost.

Tests of Reinforced Concrete Flat Slab Structures. By Arthur N. Talbot and Willis A. Slater.

London: Chapman & Hall, Ltd. 128 pp. Price 65 cents.

Contents.—Introduction—The Shredded Wheat Factory Building Test—The Test of the Flat Slab of the Soo Line Freight Terminal — The Schulze Baking Company Building Test—The Worcester Slab Test—The Test of the Factory Building of the Curtis-Leger Fixture Company—General Comments.

This volume is Bulletin No. 84 of the University of Illinois Engineering Experiment Station, and it forms a useful addition to the excellent and educational works which have been published under the auspices of the body.

There is a great difference of opinion among engineers as to the action of the flat slab under loading, and much uncertainty on the analysis of the flat slab, and thus the results of any tests which are made in this direction are bound to be of some value to the engineering profession, even if such tests do not produce entirely definite conclusions. The authors explain that many circumstances rendered the testing difficult, and although every care was taken, the tests cannot be considered as giving final evidence in all cases. Descriptions are given of the work tested and the method of conducting the experiment, and the notes are illustrated with several drawings and photographs.

In the general comments at the end of the Bulletin the results obtained by the tests are summarised, and it is here that valuable information can be gained. The authors conclude by stating that progress in obtaining experimental knowledge of flat slab structures may best be made through a series of tests on structures designed solely for test purposes and planned systematically to bring out the fundamental differences between different types of design and the effect of varying certain elements of design.

A Text Book of Practical Hydraulics. By James Park.

Published by C. Griffin & Co., Ltd., London, 1916. 12/6.

This excellent text-book is admirably suited for students in mining schools, technical colleges, and similar institutions; but it is also likely to prove of even greater value to those engineers who require a ready work of reference on all matters relating to the flow of water and to the construction of appliances for directing or retarding that flow. The author does not deal unduly with the theory of his subject, and in most cases he gives formulæ and equations without cumbering the reader with lengthy explanations of their origin and mode of construction. Hence, as a work of reference, this volume cannot be too highly appreciated.

To the readers of this journal the most important chapter is that on the construction of masonry and concrete dams, in which the author deals with the mean pressure, the centre of pressure on the dam-wall, the best shapes for the profile of the wall and of spill-ways, water-cushions, under-sluices, and the other features in masonry or concrete. The very important question of the effect of gravity on the wall when the dam is full and empty respectively is shown by means of suitable formulæ.

The author considers that in curved dams there is no need to use reinforcing rods for normal stresses, unless they are employed to prevent the shearing of large blocks bounded by cracks. He gives the chief particulars of twenty-six curved dams already existent in the United States or Australia, but omits to state the extent to which concrete and reinforcement are used in these. This policy of constant reference to existing structures is one of the characteristic features of the volume, though it is to be regretted that so little reference is made to those in the British Isles, most of the references being to Australia or to the United States. This may be a limitation deliberately imposed by the author on account of his position as professor of mining and lecturer on hydraulics in an Australasian university.

We wish that the use of concrete for the construction of dam-walls had been described more thoroughly, for it is of increasing importance, for many and obvious reasons, and an additional three or four pages would have been well spent on this branch of the subject. It would then have been possible to have included a description of *Fig.* 110, which shows a section of the Vyrnwy Dam, Wales, but is devoid of textual details.

In the calculation of concrete quantities the author uses Fuller's rule, which is not wholly reliable, and the inclusion of the various other factors given (for instance) in Van der Kloes' "Manual for Masons" would have been invaluable in the present work.

The only examples given of concrete-lined ditches are part of the Santa Ana Canal in California, the Los Angeles aqueduct, and the Treeton Canal, Washington, only the first one being illustrated. No comment is made on the qualities of this form of lining beyond an introductory remark that it may be used to prevent scouring in places where the ditch passes over loose sands or gravel.

The only representative of a concrete weir to which special attention is drawn is that at Leith, which is 39 ft. long and 2 ft. high, and runs obliquely across the stream. The author does not emphasise the value of concrete for this purpose beyond remarking that "some very effective weirs have been built of strong concrete."

The construction of pipes of reinforced concrete is dealt with very briefly, the statement being made that "obviously plain concrete pipes could not be made to withstand safely even the lowest hydraulic pressure used for power purposes," though no mention is made of the use of plain concrete pipes for carrying water for other purposes. Nor is it clearly stated whether the author means pipes which are surrounded by hoops or have the hoops embedded in the concrete, though, in a note on the object of the manufacturer of such pipes, he clearly states that the embedded metal gives them the requisite strength. He states, without further details, that "experiments have shown that a concrete pipe made with gravel is less permeable than one made with sharp screenings," and recommends that the completed pipe should be lined with a "coating of cement mortar, 1 in. thick, consisting of one part of cement and one part of fine sharp." It would be interesting to know the reason this particular mixture is recommended, as there are many objections to it, as have been shown by the experiences of engineers, both in this country and in the United States. Can it be that Professor Park does not realise that a mortar which is too rich in cement may be as bad or worse than one which is deficient in this material? In any case, the use of reinforced concrete for pipes is a matter of increasing importance, and in a future edition of this work we hope it may receive somewhat greater notice.

The author is evidently alive to the danger of concrete pipes being destroyed by seepage, though it is questionable whether his suggested explanation of the formation of a soluble carbonate is in all cases correct. When Portland cement is mixed with water one of its decomposition-products is free lime, and it is this, rather than any carbonate, which is dissolved by the seepage water. This can readily be ascertained by an analysis of the deposited encrustations, which seldom show more than a trace of carbonate, and that chiefly on their surface. The only means of preventing the formation of these encrustations known to the reviewer consists in adding some material to the concrete which will combine with the lime set free when the cement is mixed wth water, so that this added matter will form an insoluble compound of lime. If the new compound is of a hydraulic nature, so much the better. The use of these added materials was much better appreciated by the ancient Romans than by modern engineers, and it is only recently that the latter have paid any attention to this branch of the subject.

The volume contains a large number of tables of great importance for reference purposes, it is well arranged and has a good index. There are numerous illustrations and plates; some of the latter are so large that they have to be folded several times before they can be reduced to the size of the pages of the volume. The printing is particularly clear, and we have found it exceedingly free from "printer's errors."

Dwelling Houses.—A Code of Suggestions for Construction and Fire Protection.

The National Board of Fire Underwriters, New York. 115 pp.

Contents.—General Discussion—Quality of Materials—Walls—Floor and Roof Construction—Major Structural Requirements—Chimneys, Flues, Smoke Pipes, and Fireplaces—Heating and Lighting Equipment—Fire Stopping—Frame Dwellings—Concrete Construction—General Precautions for Fire Protection.

This interesting little book is published by the National Board of Fire Underwriters as a result of requests received by them for construction specifications which will properly protect dwelling-houses against fire. It is intended for the use of owners and builders, and the matter has been prepared in such manner that the layman can understand the provisions, and there are no complicated technical legal expressions which usually occur in building by-laws. American underwriters are considering plans for a scientific classification of cities and buildings based upon questions of fire hazard and construction, with a view to giving recognition to all buildings of good construction, and the volume should therefore be well considered by American builders and owners. The requirements generally are in accordance with those specified in this country for fire-resisting construction, but are necessarily somewhat different in various details, as they are drawn up to suit American practice.

The chapter on concrete construction is very general in character, and merely gives those requirements which will be complied with in the ordinary course of construction by any conscientious designer or builder.

The book is illustrated throughout with drawings and photographs, and it will be found quite interesting to readers in this country, even if all the provisions are not applicable to their own class of work.

MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Ministry of Munitions.—The Minister of Munitions gives notice that in exercise of the powers conferred upon him by the Defence of the Realm (Consolidation) Act, 1914, the Defence of the Realm (Amendment) No. 2 Act, 1915, the Defence of the Realm (Consolidation) Regulations, 1914, and all other powers thereunto enabling him, he hereby prohibits, as from the date of this Order, the use of magnesite and magnesite products for or in connection with: (1) The construction or repair of any building (other than a furnace) or any flooring or deck; or (2) the manufacture of any insulating or non-conducting material, except under and in accordance with the terms of a permit granted by the Minister of Munitions.

NOTE.—All applications in reference to this Order should be addressed to: Director of Steel Production (W.J.J.342), Armament Buildings, Whitehall Place, S.W.

Reinforced Concrete for the New Lifeboat Station at Wick.—A new lifeboat house and launching slipway have just been completed at Wick. The site is about 850 ft. east of the harbour in a very exposed situation, 550 ft. west of the ruins of the old breakwater.

The boat house measures 60 ft. by 21 ft. internally. The walls are of stone, plastered outside and inside. The roof is boarded and slated and carried by king-post timber principles, and the floor is of concrete, reinforced with mild steel rods. The house stands on mass concrete piers built on a sloping shelf of rock, known as the Salmon Rock.

The slipway is of reinforced concrete work, carried on mass concrete piers. The lower end, or toe, is of mass concrete, partly above and partly below low water level. The gradient of the slipway is 1 in 7 and its length from boat house doors to extreme toe is 201 ft. 6 in. The keelway is fitted with rollers from the boat house to the upper end of the slipway toe in order to ensure a good launch of the lifeboat.

The work was carried out by contract for the Royal National Lifeboat Institution, being designed by and executed under the supervision of their engineers, Messrs. Douglass, Lewis and Douglass. The contractors were Messrs. Clark and Chapman, of Aberdeen.

Landing Stage of Concrete.—The Mersey Docks and Harbour Board have just successfully replaced the worn planking of their riverside landing stage with concrete.

Waterworks, Watford.—The construction of the new waterworks at Watford is now completed. The reservoir has a capacity of 2,000,000 gallons and has been built on modern principles. The softening tank is of reinforced concrete.

Concrete Ships.—In one of our issues we made a short reference to the work of a Norwegian firm in the construction of reinforced concrete ships, and we hope shortly to be able to publish some further particulars and illustrations. In a recent issue of the *Engineering Record* a letter is published by the President of the Cement Gun Construction Co., of Chicago, on the building of reinforced concrete vessels. As the question is at the moment arousing considerable interest and attention in the Press generally, we give below an abstract from the above mentioned letter, showing how the writer claims to have contributed to the solution of some of the difficulties and objections to vessels built of reinforced concrete. The writer, after referring to the methods so far adopted, says :—

> I have invented and developed a series of entirely new methods of construction which not only solve the problem in a scientifically correct manner, but allow the building of large and small concrete vessels of remarkable elasticity and of comparatively light weight. In addition to this, the cost of construction is greatly reduced because no forms are required. All concrete is handled, applied and finished by machinery especially designed by me for this purpose. The risk of poor workmanship is almost completely eliminated. . . The general outline of the method is as follows :—
>
> The ship's hull consists of a strong framework of steel, which is so designed that the combined strength and advantages of steel and concrete are fully recognised. This truss frame is erected and riveted in the ordinary manner. In the completed ship the steel frame is entirely encased in concrete and thereby protected against rusting. By this encasing the steel members are also stiffened and the buckling stresses are greatly reduced. For this reason the steel members of the frame are of simple design and relatively light weight.
>
> After the steel frame is completed it is covered with my multiple-unit wall construction of varying thickness. The walls are formed of a high-grade concrete applied by compressed air, and each section is independently reinforced by networks of light steel bars and wire mesh. All ship walls, bulkheads, decks and partitions are formed in a similar manner without the presence of any construction or connection joints, so that the completed ship is one seamless, monolithic structure.
>
> The concrete is composed of Portland cement and crushed quartz or other suitable stone material. All pieces not passing a ½-in. screen are rejected. These materials, with the necessary waterproofing medium and the water for proper hydration, are mixed and ground together, and before being placed are properly conditioned to reduce the danger of cracking because of excessive expansion and contraction.
>
> The material so prepared is applied in even and uniform layers by means of a powerful stream of compressed air with a special machine named the "Tector," especially designed for this purpose. For the material combination thus described the name "Torcrete" has been adopted. It is really a waterproof concrete of highest possible quality.
>
> After the last coat of Torcrete has sufficiently hardened, the outer surfaces are rubbed down to an even, smooth finish with rotary compressed-air-driven grinders, and the entire ship may be painted as usual. . . .
>
> These methods can also be advantageously employed for reconstruction and repair of old steel ships and for placing of bulkheads, tanks and decks in old hulls.
>
> The principal advantages of these ships are low cost and the rapidity with which such vessels can be built. . . .

Reinforced Concrete Sewer at Belfast.—It was reported at the last meeting of the Belfast City Council that the construction of the reinforced concrete outfall sewer (a description of which was given in the last issue of this journal) has been stopped by the Ministry of Munitions. It was decided to ask the Local Government Board to hold an enquiry with a view to deciding the conditions on which the contract with Messrs. J. and R. Thompson, the contractors, should be determined.

Reinforced Concrete Sign-Posts.—The City of Modesto, California, has adopted a traffic sign-post unique in design, being in the form of a vase surrounded by a receptacle holding ferns, etc. In the square below, and showing four ways through red bulls' eyes, is a 40-watt incandescent lamp, which is connected with the electric main in the street. The posts are made of reinforced concrete and weigh about 400 lb.

Concrete Pavement in the United States.—All the concrete pavements in the United States are being subjected to a maintenance survey by the field engineers of the Portland Cement Association, and already nearly 22,000,000 of the 70,000,000 sq. yds. of such pavement have been examined and reported upon. Over a hundred engineers are making the inspection. One of the objects of the survey is to acquire data based on actual experience, so that methods of construction and maintenance that have produced the best results may be definitely determined, with a view to raising the standards of practice in concrete pavement construction generally.

Reinforced Concrete Aqueduct.—Eleven tenders have been received for the construction of the Shoal Lake aqueduct pipe between Deacon and the Red River,

Winnipeg, Manitoba, and the contract will be let early this year. The work comprises approximately 9½ miles of reinforced concrete aqueduct, 6 ft. 6 in. in interior diameter.

Reinforced Concrete Pulp Mill in Russia.— H.M. Consul at Helsingfors reports that a timber company is erecting a large pulp mill at Karihaara, at the mouth of the Kemi River. The buildings are to be constructed of brick and reinforced concrete.

Canadian Concrete Road.—The Imperial Trade Correspondent at Toronto reports that a concrete highway has now been completed, with the exception of a few short gaps, between Toronto and Hamilton, a distance of about forty miles. This is the first important highway of this nature to be constructed in Ontario.

Port Works in Straits Settlements.—In his annual report to the Colonial Office the Governor of the Straits Settlements reports that the contractors, Messrs. Topham, Jones and Railton, have made very satisfactory progress with the reconstruction of the Tanjong Pagar main wharf. During the year 46,750 cu. yds. of concrete blocks were set, and 4,420 cu. yds. of reinforced concrete work constructed. It is further reported that the total cost of the Singapore Harbour Works executed by Messrs. Sir John Jackson, Ltd., was £1,676,114 8s. 9d.

Driving 106-ft. Concrete Piles in San Francisco Piers.— Pier construction in San Francisco Bay has called for concrete piles of unusual length because a considerable depth of soft mud and ooze overlies the solid bottom in many places where all-concrete structures have been built. The engineering department of the State Harbour Commission has designed and built longer and longer piles as the work has progressed, until on the outer end of Pier 35 it was deemed advisable to use piles up to 106 ft. in length in the last few bents.

The longest piles were 20 in. square at the butt, with wedge-shaped tips 10 in. by 20 in. in cross-section. The reinforcing consisted of eight 1-in. bars with continuous hooping of No. 3 wire wound on 3-in. centres, except for 4 ft. at either end, where the winding was on 2-in. centres. The Harbour Commission's standard concrete mix was used, consisting of one part of cement and five parts of aggregate proportioned for maximum density. Thus far only two piles have been lost, it is reported, on account of breakage in driving.

The piles are cast at a point from which they could be conveniently skidded upon barges, which were towed to the driver, so that there was no unnecessary handling between casting yard and pier. In lifting piles more than 80 ft. in length it is the custom to sling each unit from lines attached at four points. A three-drum hoisting engine is used, the third drum being used to operate the steam hammer. The concrete structure, or the pier proper, is protected by a fender line of creosoted piles with triple car-spring buffers between fender-line stringers and concrete beam. The creosoted piles are protected by green timber sheathing.

The piles have been designed under the direction of Jerome Newman, chief engineer, State Harbour Commission.—*Engineering Record.*

Concrete Flume in New Zealand.— A hydro electric scheme, over 2,000 ft. above sea level, has been constructed at Ohakure, New Zealand. Water has been diverted from the river Mangawbero and carried by a flume to the power station about half a mile away. The flume, which has a fall of one in 1,200 throughout its length, is constructed principally of concrete. Where the flume crosses under the roads it has been roofed over with reinforced concrete.

Development of Port Weller.—It is reputed by the Imperial Trade Correspondent at Toronto that in the development of the harbour of Port Weller, at the Lake Ontario end of the canal, 3,250,000 cubic yards of material have been deposited in the two embankments which extend 1½ miles into the lake on either side, forming a sheltered channel with over 6,000 ft. of specially constructed reinforced concrete docking and protection for vessels in transit. The 55 reinforced concrete cribs which form the dockeye and protection of the harbour entrance, and measure 110 ft. by 37 ft. by 35 ft., are said to be the largest in the world. They are constructed on floating pontoons, towed to the site and sunk by the raising of removable buttons. Six of them have been placed and are ready for filling.

PROPOSED NEW WORKS

Hove.—The time limited by the Hove Pier Order, 1912, for the completion of the works, has been extended by the Board of Trade for one year from December 13th,

1916. Plans for the construction of the first portion of the pier in reinforced concrete have been approved by the local authority.

Bolton.—Large works are foreshadowed in the Bill which the Corporation are bringing before Parliament next session for the construction of new waterworks. Three new reservoirs are scheduled.

Bristol.—The Bristol Waterworks Co. is promoting a Bill in Parliament to construct new waterworks at Axbridge and sewerage works at Cheddar.

Chile.—A law has been passed authorising the Chilian Government to call for tenders for port improvement works at Antofagasta. Tenders are to be invited in Chile, Europe, and the United States within a period of three years. The cost of the works is not to exceed £1,700,000.

Hoylake.—The engineer of the Hoylake and West Kirby Urban District Council has prepared plans for a concrete wall to deal with the nuisance which arises from the drifting sand at King's Gap.

Newport (Mon.).—The Borough Engineer has been instructed to take the necessary steps to satisfy the Local Government Board as to the suitability of the land the Corporation has provisionally acquired on which to construct four reinforced concrete tanks for dealing with the sewage of the works of the British Mannesmann Tube Co., about to be erected.

TRADE NOTES.

Aiding Food Production.—As within the next few months it is of the utmost importance that every agricultural implement in the kingdom should be available for use on the land if the aims of the Board of Agriculture and the Food Controller are to be realised, the attention of the farming community cannot be too strongly directed to the modern system of sientific welding, by means of which broken machinery (of any metal) may be quickly restored equal to new. Barimar Scientific Welding Experts, of 10, Poland Street, Oxford Street, London, who have successfully replaced the German specialists in Britain, are making special arrangements to deal promptly with agricultural machinery in view of the urgency of the situation.

CONCRETE THE MONEY SAVER

SMALL CONCRETE GARAGES.

By ALBERT LAKEMAN, M.S.A.

(*Concluded from last issue.*)

In this concluding article some notes have been added on the important question of the storage of petrol, lighting, ventilation, etc. Our illustrations have been reproduced from a pamphlet issued by The Portland Cement Association of U.S.A. on the subject of concrete garages.—ED.

ROOFING.

THE roof will naturally be one of two types, viz., flat or pitched, and each will be found to possess certain recommendations as compared with the other. The flat roof will generally be cheaper and more fire-resisting than a pitched roof, and it appears to be the logical covering for a concrete building as it can be simply and easily constructed in concrete, and thus the structure will be of one material throughout. Generally speaking, however, the appearance of a pitched roof is preferable and it is often adopted for this reason alone, especially when the garage is to be in conformity with other buildings in the vicinity. With a pitched roof it is not so easy to acquire the necessary amount of fire-resistance unless a good deal of expense is incurred, and it is not a good policy to adopt a suitable fire-resisting material for the walls and floor without giving the same amount of consideration to the roof.

Flat Roof.— In a flat roof the concrete should have a minimum thickness of 4 in. and a maximum thickness of 6 in. or 7 in., the difference being necessitated by the fall, which should not be less than 1 in. in every 7 ft. The roof construction should be carried right over the full thickness of the wall, and when a projection is desired in the form of a string course at the top of the building, it is carried beyond for a distance of from 6 to 12 in. The concrete flat will require reinforcement, and in the small size garage this will usually be in the form of ½-in. diam. rods spaced at 6 in. or 7 in. transversely, and ¼-in. diam. distribution rods at about 12 in. centres longitudinally. A small parapet formed of concrete is usually provided around the flat roof, and when this is done alternate rods should be bent up and carried into the parapet.

When monolithic walls are adopted the reinforcement in these should be bent over and extended into the roof for a distance of about 2 ft.

The flat will need some finishing material to guarantee water-tightness, and this may be asphalt or a screeding of cement and sand to which a water-proofing compound has been added.

Pitched Roof.— If a pitched roof is adopted this will be constructed either of timber with a suitable covering or with metal lathing. A suggestion for a roof of the latter type is given in *Fig.* 9. The hips are formed with 1½-in. gas barrel bolted to a 3-in. by ½-in. steel ring 8 in. in diameter at the apex and connected to the concrete at the foot by means of a ¾-in. diam. rod which is embedded in the concrete wall for a distance of 2 ft. and bent over to pass inside the gas barrel for a distance of 12 in. The vertical rods throughout the walls are bent over and extended up the roof slope for a length of 18 in., and the metal lathing is fastened to these and the gas barrel at the hips. The roof is finished off with 2 in. of good, fine concrete above the lathing and 1 in. of plaster below. This method provides a simple inexpensive form of roof covering and is quite suitable in the case of small concrete garages.

When timber is used in a pitched roof this should be of the simple collar type with 4 in. by 2 in. rafters at 12 in. spacing and with 4 in. by 2 in. collars placed about one-third the length of the rafters from the springing. The feet of the rafters should be spiked to a 4½-in. by 3-in. wall-plate bedded on the inner edge of the walls. To overcome the great risk of fire that is present with a timber roof,

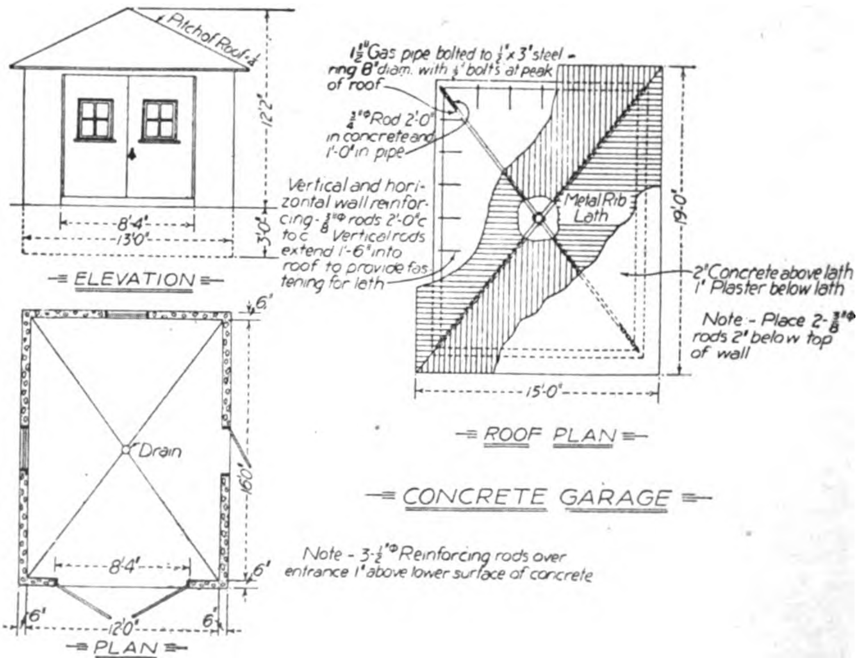


Fig. 9. Design for Concrete Garage with monolithic walls and roof construction of metal lath with concrete above and cement plaster below.

SMALL CONCRETE GARAGES.

it is advisable to protect this as far as possible on the underside, although additional expense will, of course, be incurred. A very good method is that of lining the soffites of the sloping and flat portions with asbestos sheets attached to the underside of the rafters and collars, using as few joints as possible. As these sheets are obtainable in 8 ft. lengths there need only be one set of transverse joints in a garage 16 ft. long.

Another method is to cover the underside of the timber with expanded metal lathing and apply 1 in. of plaster to form a ceiling. This will afford a certain amount of protection against fire, but it cannot be compared for fire-resistance with a flat concrete roof. The outer covering of a pitched roof may be executed with slates, tiles, or concrete roofing-tiles. The latter make an excellent material for a small concrete building as they are comparatively cheap, lighter than clay tiles, and when of the interlocking type it forms a safer roofing than any other covering, as

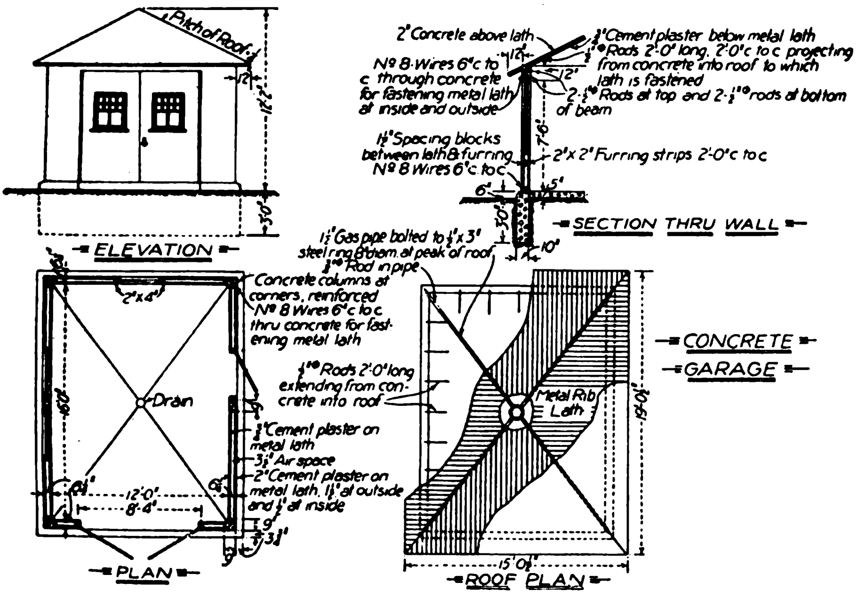


Fig. 10. Design for concrete garage for cement plaster on metal lath.

Fig. 11. A concrete garage with living quarters above.

the strongest wind will not lift the tiles or make a hole in the roof. Most readers are familiar with the thin slates made with Portland Cement and asbestos fibre as these are much used in buildings of all sizes. They give excellent results and may be successfully used in motor-garage roofs as they are cheap and effective.

WINDOWS AND DOORS.

To maintain a suitable fire-resisting garage throughout, the windows should be formed with metal sashes and preferably glazed with wired glass. Wrought-iron sashes will be found to resist fire better than cast-iron, and they are generally more reliable as regards strength and shape. If wood sashes are employed they should be of hard wood such as oak or teak if they are to be fire-resisting.

The doors and frames should also be of hard wood when the expense can be incurred, as it must be remembered that it is essential to prevent the car being damaged by fire from outside where adjacent buildings are of a combustible nature. This is a point, however, that it is seldom necessary to enforce, as a clear space must

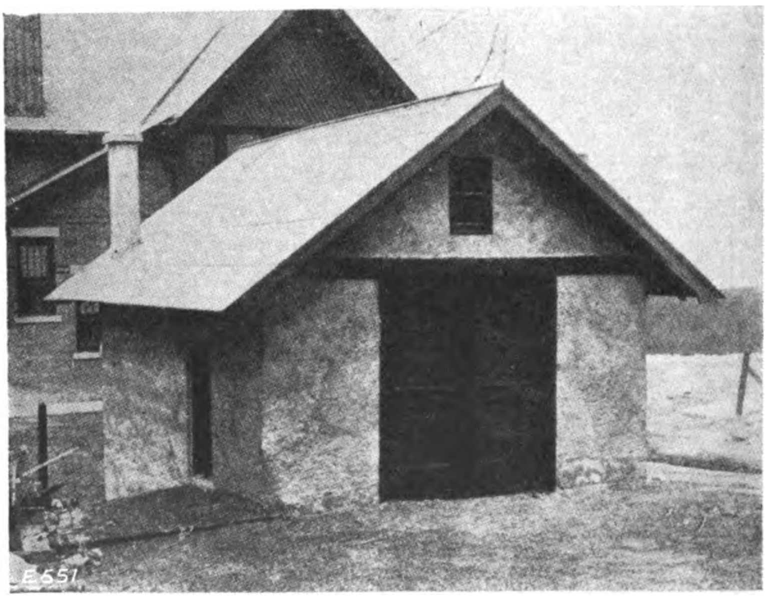


Fig. 12. An Inexpensive Plain Monolithic Garage.

SMALL CONCRETE GARAGES.

be provided in front of every garage for the ingress and egress of the car, and it is rather unlikely that the main entrance doors will be subjected to any fire other than that which may occur on the inside, and in the latter case they would be opened for the purpose of attacking the fire. The doors should not exceed 9 ft. in width or they will become unwieldy and liable to drop on the hinges. A clear width of 8 ft. 6 in. will always be sufficient for the average size car to enter, and thus each leaf will be 4 ft. 3 in. wide. The windows should not be placed too high in the walls as a good light will be required near the floor level for the examination and repair of the car. The light should be distributed as far as possible around the building so that all sides of the car will be readily seen.

Various types of doors and windows are shown in *Figs.* 11, 12, 13, and 14, which illustrate different garages that have been built with concrete walls.

In the case of the building given in *Fig.* 11, it will be noticed that living accommodation is provided over the garage, and in such a case as this it is absolutely necessary to provide the maximum amount of fire-resistance for the sake of the occupants. This can only be done if the garage and living-rooms are separated by a concrete floor and all combustible material is omitted in the construction of the garage.

THE STORAGE OF PETROL.

Petrol should never, under any circumstances, be stored in a motor-house. It should always be kept away from the building and stored in a separate portable iron cupboard or small building, and arrangements should be made for efficient ventilation. If a pipe is taken to the garage with a pump for the purpose of filling the tank it should not be carried inside the building, but the filling should be done outside.

LIGHTING AND HEATING.

Electric light is undoubtedly the best method of artificial lighting, and this should be executed with screwed conduit and all the work done in the best possible manner. Naked lights of all kinds should be avoided, as petrol is inflammable and

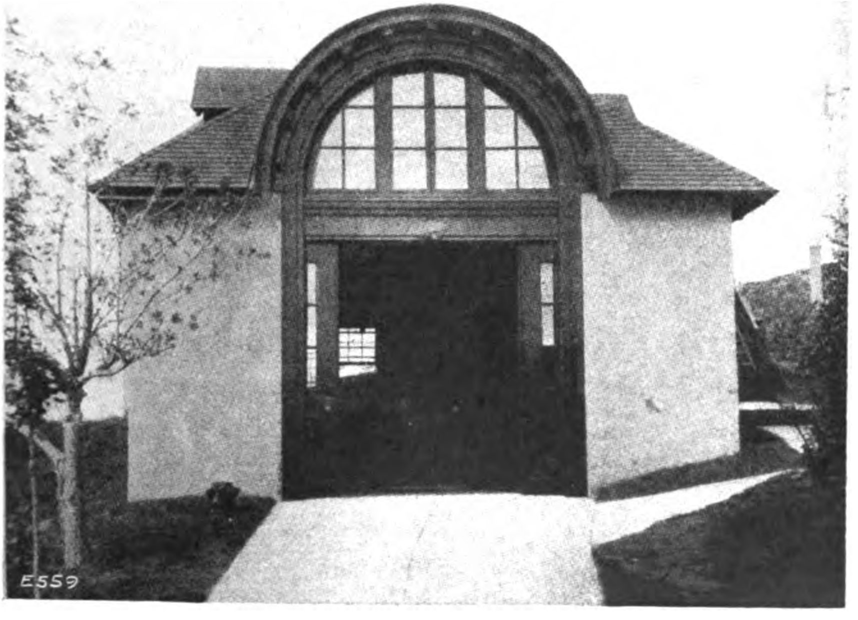


Fig. 13. Showing Garage built of concrete walls.

SMALL CONCRETE GARAGES.

its fumes highly explosive. A plug to which a movable hand-lamp can be attached will prove very useful in the examination of the car, and especially in the case of work executed in the pit. If the garage has to be entered at times when artificial light is necessary an electric hand-torch may be used if permanent electric lighting is not available, and if any other kind of light is used it is advisable to open the doors and windows for a short period to allow any accumulation of fumes to escape before the light is used.

For the heating, electricity, hot water, or steam are the best, and an open fire, whether of coal or gas, must not be used. In some cases hot water pipes can be extended from an existing apparatus attached to a greenhouse or conservatory, and where such is not possible the fire for heating the pipes must be kept outside the garage. Injudicious heating has been the cause of many garage fires, and it will not prove economical to keep down the cost in this installation if the car and building are to be endangered.

VENTILATION.

The ventilation is a very important point, and the general arrangement should be such that a continuous and free passage of air is given. The vapour thrown off by petrol is heavier than the surrounding atmosphere and consequently it drops to the floor level. A sufficient number of ventilators should, therefore, be provided at a low level, and these should be capable of being closed if required during very frosty weather. Ventilation at a high level should also be provided to carry off smoke caused by over-lubrication of the car. Opening skylights are sometimes adopted for this purpose, but there is great difficulty in keeping these watertight, and they are not to be recommended in a garage. If gables are provided at each end a small opening sash in these will induce sufficient draught to carry off the

Fig. 14. Garage built partially of concrete.
SMALL CONCRETE GARAGES.

smoke and obviate the difficulty caused by skylights. Another method is to provide a 4-in. flexible tube communicating with the outer air, which tube can be coupled to the exhaust pipe when necessary.

INSPECTION PIT.

The question of providing a pit for inspection and repairs is one upon which there is some difference of opinion amongst motor-car owners. If extensive repairs are contemplated a pit is a necessity, but a small garage is often better without one, as water is liable to find its way into the pit and dampness will result. If the adjoining drains are sufficiently low a gulley can be provided in the bottom of the chamber and this disadvantage overcome to some extent. If the pit is placed outside the garage, however, as is sometimes done, it is a great detriment to the car to stand unprotected for some considerable period while repairs are being executed.

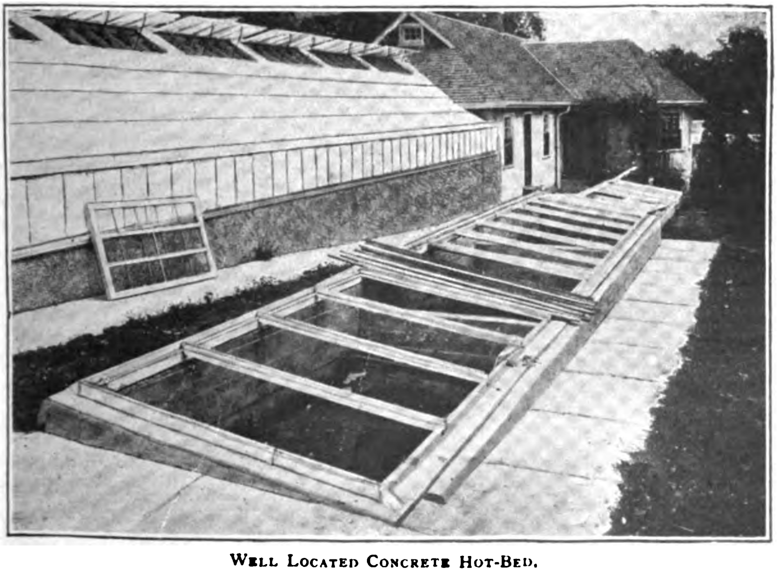
When a pit is provided the most satisfactory material for its construction will be concrete. The size should be 6 ft. long by 3 ft. wide and 4 ft. 6 in. deep, with projecting ledges on each side to take movable boards 3 ft. 6 in. down from the top. The walls should be of 9 in. concrete, and the bottom 6 in. thick, recesses being formed at a convenient level in each side wall to hold tools and small parts. A rebate should be formed at the top of the concrete walls to take a cover flush with the floor level, this being formed with 2 in. boards fitted with sunk lifting handles. If a gulley is provided in the bottom the floor should be made to fall towards same. When a pit is provided inside the garage it will be necessary to do any washing to the car outside, and, in fact, the washing is better if done outside as it prevents a lot of dirt and water inside the building. A small concrete-paved area should be formed in front of the building with a gully in the centre, and this will form a convenient washing space.

Drains carrying petrol should not be connected directly to the sewer owing to the danger of gas accumulating in the sewer and causing explosion. To overcome this difficulty the effluent from the garage should be taken through a special set of three chambers which are each ventilated above the water level. The drainage inlet in each chamber is at a high level and the outlet at a low level, and the direct passage of floating oil is prevented. The chambers should be covered with sealed manhole covers, and the walls and bottoms can be constructed economically with plain concrete which is brushed over with Portland cement immediately upon removal of the shuttering.

CONCRETE HOT-BEDS AND COLD FRAMES FOR GROWING WINTER VEGETABLES AND EARLY SPRING PLANTS.

THE following particulars of how to build concrete hot-beds and cold frames may be useful. By making these frames and beds of concrete much money is saved in annual repairs :—

Locate the bed on the sunny, wind-protected side of a building. A four-sash bed is usually large enough except for commercial purposes. A standard hot-bed sash is 3 ft. by

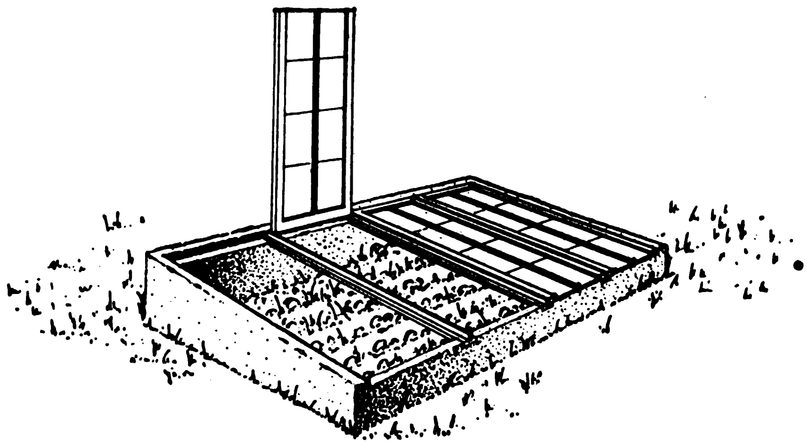


WELL LOCATED CONCRETE HOT-BED.

6 ft. Lay-out the bed 6 ft. 8 in. wide by 12 ft. 10 in. long. The concrete walls are 6 in. thick. Dig the foundation trenches 2 ft. 6 in. deep within the lines given above. Make forms of 1-inch lumber to carry the south (front) wall 6 in. and the north (back) wall 14 in.

above ground. Forms are not required below ground level. The tops of the end walls slope to the others. Before filling the forms with concrete, test the dimensions of the bed by means of the sash. See that the sash lap the forms 2 in. on all sides.

Mixing and Placing the Concrete.—Mix the concrete mushy wet in the proportion of 1 bag of Portland cement to 2½ cu. ft. of sand to 5 cu. ft. of crushed rock, or 1 bag of cement to 5 cu. ft. of bank-run gravel. Fill the forms without stopping for anything. Tie the walls together at the corners by laying in them old iron rods bent to right angles. While placing the concrete set ½-in. bolts about 2 ft. apart to hold the wooden top-framing of the bed to the concrete; or make grooves in the top of the concrete for counter-sinking the sash to the level of the walls with an allowance of one-quarter inch for clearance. This can be done by temporarily imbedding in the concrete wooden strips of the necessary dimensions. During this operation, by means of blocks nailed to the strips, make provision for the centre-bars



Cold Frame Grooved for Sash.

described below. Remove the strips as soon as the concrete stiffens. Take down the forms after five days. The extra 2⅝ inches in length of the bed is allowance for the three centre-bars between the sash. These sash-supports are of dressed 1-in. stuff, shaped like a capital "T" turned upside down. The length of the stem of the "T" is equal to the thickness of the sash and the top is 3 in. wide. Sufficient materials for the concrete will be supplied by 14 bags of Portland cement, 1¼ cu. yds. of sand and 2½ cu. yds. of crushed rock; or 14 bags of cement and 2½ yds. of pit gravel.

Preparation and Care of the Hot-Bed.—If the bed is to be used as a cold-frame, it is finished when covered with glass. For a hot-bed, dig out the dirt to the depth of 2 ft., tramp in 18 in. of fresh horse manure well mixed with leaves or bedding and cover it with 4 to 8 in. of rich soil. Bank the excavated earth around the outside of the bed. Put the sash in place, hang a thermometer on the inside, and allow the bed to heat up. After a couple of days, when the temperature has dropped to 85 or 90°, planting may be safely done.—(*Taken from a circular issued by the American Portland Cement Association.*)

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CONCRETE AND CONSTRUCTIONAL ENGINEERING

MARCH 1917. VOL. XII. No. 3.

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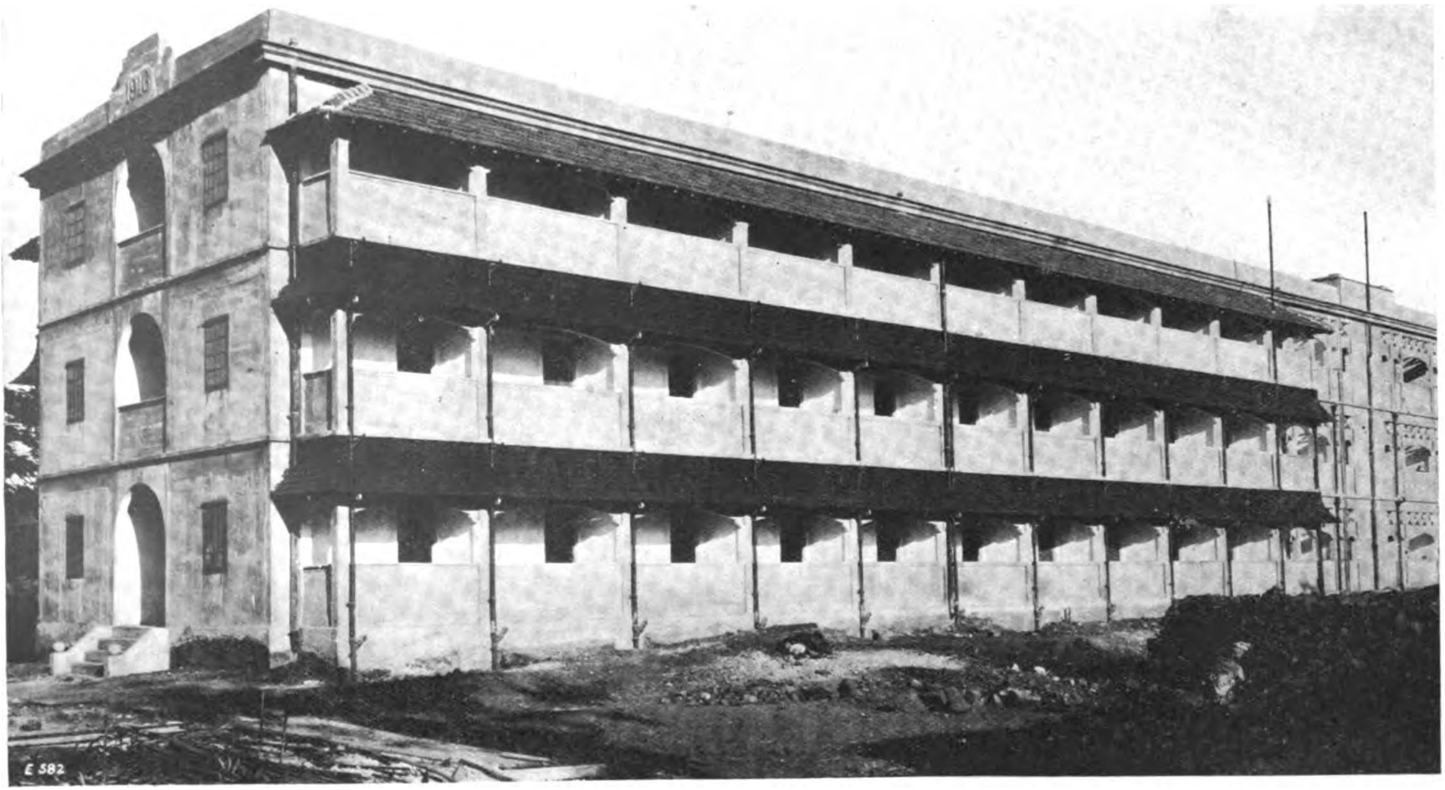


REINFORCED CONCRETE CHAWLS FOR MILL WORKERS IN INDIA, AT SPRING MILLS, NAIGAUM ROAD, DADAR, NR. BOMBAY.

(*For description see page* 158.)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XII. No. 3. LONDON, MARCH, 1917.

EDITORIAL NOTES.

THE FIRE RESISTANCE OF CONCRETE AND REINFORCED CONCRETE IN THE GREAT EXPLOSION.

As indicated in our previous issue, the explosion which occurred in the neighbourhood of London on January 19th, presented some exceptional features as to the value of concrete and reinforced concrete in building construction. There were two buildings in the vicinity of the structure in which the explosion originated where reinforced concrete had been largely used. One of these buildings—a very extensive one—was mainly affected by a fire that had been started through an external cause; the other seems to have been affected equally by shock and by fire. In both cases there is no doubt that reinforced concrete has made a very good showing. In both buildings, however, reinforced concrete would, we think, have made a far better showing if the question of fire resistance had had closer consideration when the reinforced concrete was specified.

Thames ballast aggregate was used, and Thames ballast, however excellent for carrying heavy loads and meeting stresses and strains, is, in our opinion, one of the most unsuitable aggregates where fire resistance and shock come into question. This fact was scarcely fully realised at the time when the more important of the buildings under review were in course of construction, for the block dates back to 1904 or 1905, when reinforced concrete was still a novelty in London.

That the reinforced concrete structures stood up as well as they have done under circumstances that would have involved entire destruction of anything in the form of steel frame or brick construction, is obviously very creditable to the modern system of building. But, given better aggregates and greater consideration from the fire point of view, there is good reason to believe that these buildings would have practically escaped even the damage that they have sustained under present circumstances, and the repairs required would have been infinitesimal in the larger premises here under review.

Whilst the war is on it is inappropriate, and also impossible, to speak of individual structures or to go into questions of technical detail, but the great tangible lesson of the catastrophe has been to show that the advocates of suitable reinforced concrete as a fire-resistant—as frequently demonstrated by experiment and test—have had their prophecies fulfilled on a scale that could scarcely have been anticipated, and in a manner that must give them the greatest possible satisfaction.

Where fire-resistance is required in large structures (particularly of the industrial and warehouse class) nothing better can be advocated than a suitable

B

reinforced concrete construction, but, at the same time, those who are the advocates of reinforced concrete can do the subject no greater harm than by imagining that *any* concrete aggregate is suitable from the fire point of view, for test and experience has proved exactly the reverse to be the case.

Whether the great lesson here shown will lead to different aggregates being used or lead to all reinforced structural features of importance being protected against fire by applying coverings, such as are frequently applied to protect steel frame, is a matter which those entrusted with the consideration of these problems will, no doubt, report upon in due course. In any case some further research is now necessary to determine the advantages and limitations of individual aggregates and system of protection.

What the British Fire Prevention Committee did prior to the war in the matter of enquiry into the fire resistance of reinforced concrete requires amplification. What was done at the Regent's Park Testing Station with very limited funds requires handling on more exhaustive lines by that body, whose experience in these matters is unique, and it seems to us that this is a case where the Government may be well advised to step in and assist the Committee's endeavours, as the amount of post-war building necessary on economical lines is sure to be of vast extent, and a considerable amount of additional information appears to be required. But, whatever the result of further enquiry, the lessons to be obtained from further investigations with individual aggregates must follow the great principle that suitable reinforced concrete is the best fire resistant available for industrial buildings. This, to repeat, is the technical feature that stands out in this terrible catastrophe.

And one final word, it reaches us with particular satisfaction that the country's leading architect, Sir Aston Webb, R.A., when speaking before the London Insurance Institute on February 19th, emphasised the value of concrete and reinforced concrete from the fire point of view, and told his audience of the remarkable demonstration of the efficiency of reinforced concrete made on this occasion. It is a matter of congratulation that an eminent architect should have so promptly given his views on the matter.

WAR ECONOMY AND THE SAVING OF TONNAGE.

THE uses of timber are to be economised. For the last ten years we have been advocating concrete and reinforced concrete as economical substitutes for timber.

Can it be true that the Government and its Timber Committee actually do not realise the advantages of these substitutes in the third year of the war and when timber means a greater outlay in money and waste of tonnage? Is it not time to use concrete systematically for pit props? Is our insularity really to preclude our doing what American and enemy countries can do? Are we really to continue to close our eyes to the advantage of reinforced concrete for telegraph and telephone poles? Are concrete fence posts, concrete sleepers for sidings, to be neglected?

With the present development of farming is timber really to have preference over concrete for reasons of conservatism or prejudice? Is it not time to "wake up" and realise that almost every locality has the necessary gravel, stone, and other aggregate suitable for concrete, and that Portland cement is readily procurable?

A NEW REINFORCED CONCRETE FACTORY.

By ERNEST G. W. SOUSTER, A.R.I.B.A.

The suitability of reinforced concrete work for factory construction has been emphasised repeatedly in these pages, and the following particulars and illustrations present an interesting example of factory building in reinforced concrete.—ED.

It is well known that the present war has led to the erection of factories upon an unprecedented scale, and that all types of materials have been used in their building. From the beginning reinforced concrete was used for a large proportion of them, and now it may be said to be the material most used.

The building here described and illustrated is one of the largest factories in the Midlands, and is an interesting example of the possibilities of the material and of the speed with which the work can be executed. Within five weeks of the signing of the contract the whole of the reinforcement to Blocks 1, 2 and 3 was delivered; machines were running, and work was being carried out on the ground floor, four weeks after the first floor slab was finished.

Fig. 1 shows the ground plan of the whole building, which consists of four blocks, each 299 ft. 7 in. long by 50 ft. wide (inside dimensions). Cleaning rooms 22 ft. by 29 ft. project from blocks 1, 3 and 4 into the areas between the various blocks. These areas are 32 ft. wide and across each of them, at first and second floor levels, three bridges are formed, thus giving access from one block to another. Staircases and lifts are constructed in the areas adjoining the bridges and on either side of them, and the possibility of fire spreading from one floor to another, or from one block to another, is practically eliminated.

At one end of the factory are two one-storey buildings containing muffle furnaces, boilers and generators. The first, 63 ft. 4 in. wide, extends the full width of blocks 1, 2 and 3 and the areas between them, whilst the second is an extension of block No. 4, measures 50 ft. by 63 ft. 4 in., and carries on its roof a water tank with a capacity of 35,000 gallons of water.

The site of the building was mostly made-up ground, and a good bottom was only found at considerable depth. As will be seen from Fig. 2 the foundations are stepped in places and consist of a reinforced concrete slab with a central longitudinal beam which supports the columns. The wall columns rest on a slab 3 ft. wide and varying from 5 in. thick at edges to 9 in. at the juncture with beam. These slabs are connected to a beam 15 in. deep and 13 in. wide, and thus the whole forms an inverted T.

The central slab is similar, but 4 ft. wide, and varies from 5 in. at edges to 11 in. at beam, which is 15 in. deep and 14 in. wide. These beams are haunched at columns to give resistance against reverse bending moments.

In block 4 these slabs are not stepped, but keep to a uniform datum 9 ft. 6 in. below ground, lower depths, where necessary, being filled in with mass concrete up to the 9 ft. 6 in. level.

The external columns, which are spaced at 10 ft. centres, are 22 in. by 13 in. from ground floor to 3 ft. 6 in. above second floor level, where they are

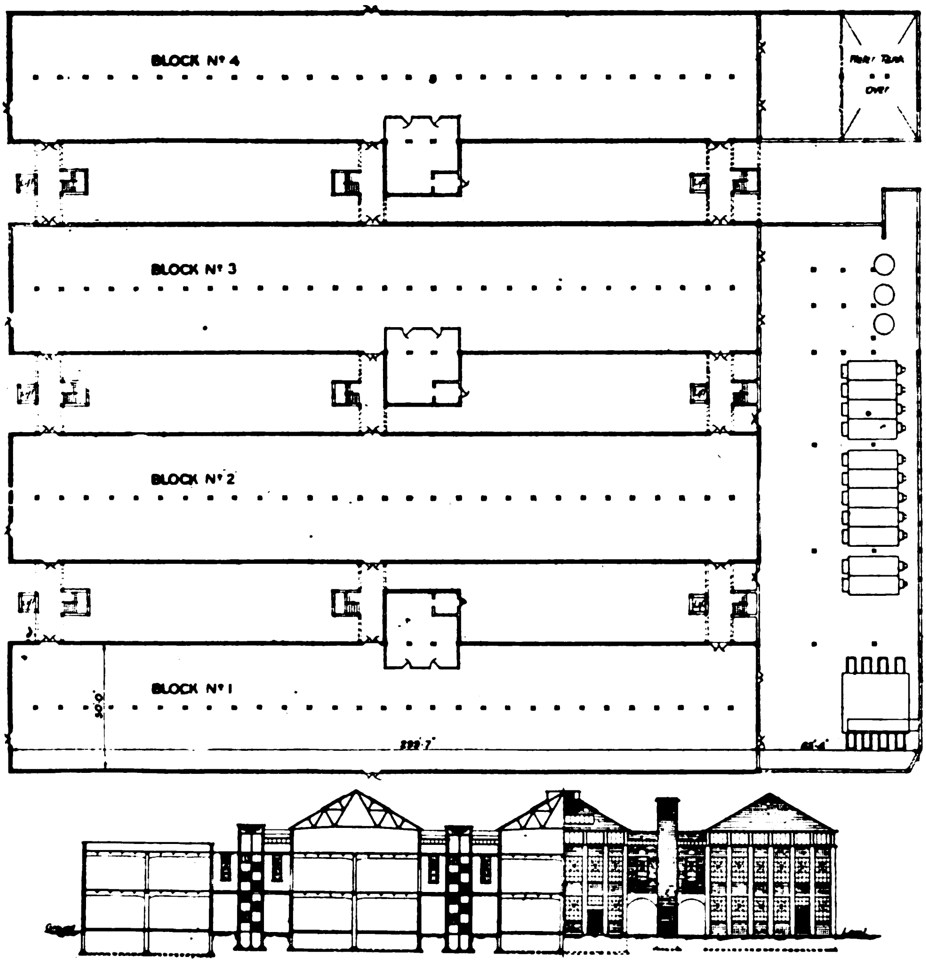


Fig. 1. Ground Plan.
A New Reinforced Concrete Factory.

reduced to 15 in. by 13 in. and are connected at top with a 10 in. by 6 in. tie beam running around each block. These columns are grooved for a 4½ in. brick wall up to the cill level, and for steel window frames up to window heads.

The central columns are, from ground to first floor, 18 in. by 18 in., and are reinforced with eight bars vertically and with binding links horizontally; from first to second floor they are 13 in. by 13 in. with four vertical bars. This applies to blocks 1, 2 and 3, but in block 4 six bars are used, having, how-

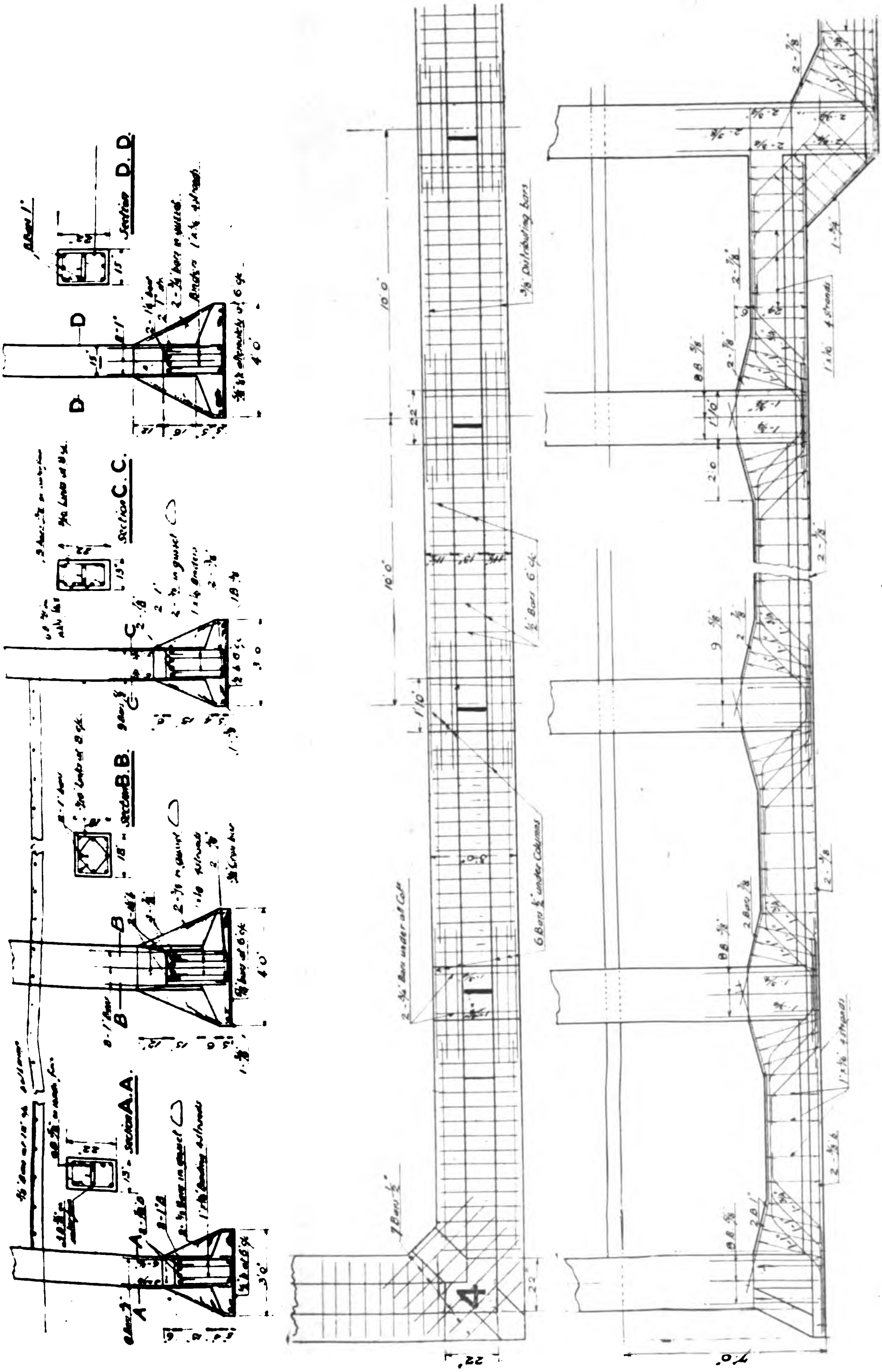


Fig. 2. Details of Foundations, showing Bases to Columns, Part Plan of Columns, and Part Elevation of Columns.

A New Reinforced Concrete Factory.

ever, the same sectional area. Both external and internal columns have brackets bolted to them for the shafting.

The external walls from ground to first floor are carried by a beam 9 in. deep and 13 in. wide, which is connected to the columns and supports two 4½ in. walls with a 2 in. space between them, and for the upper stories similar walls are used up to the cill level. These latter rest on beams 10 in. deep

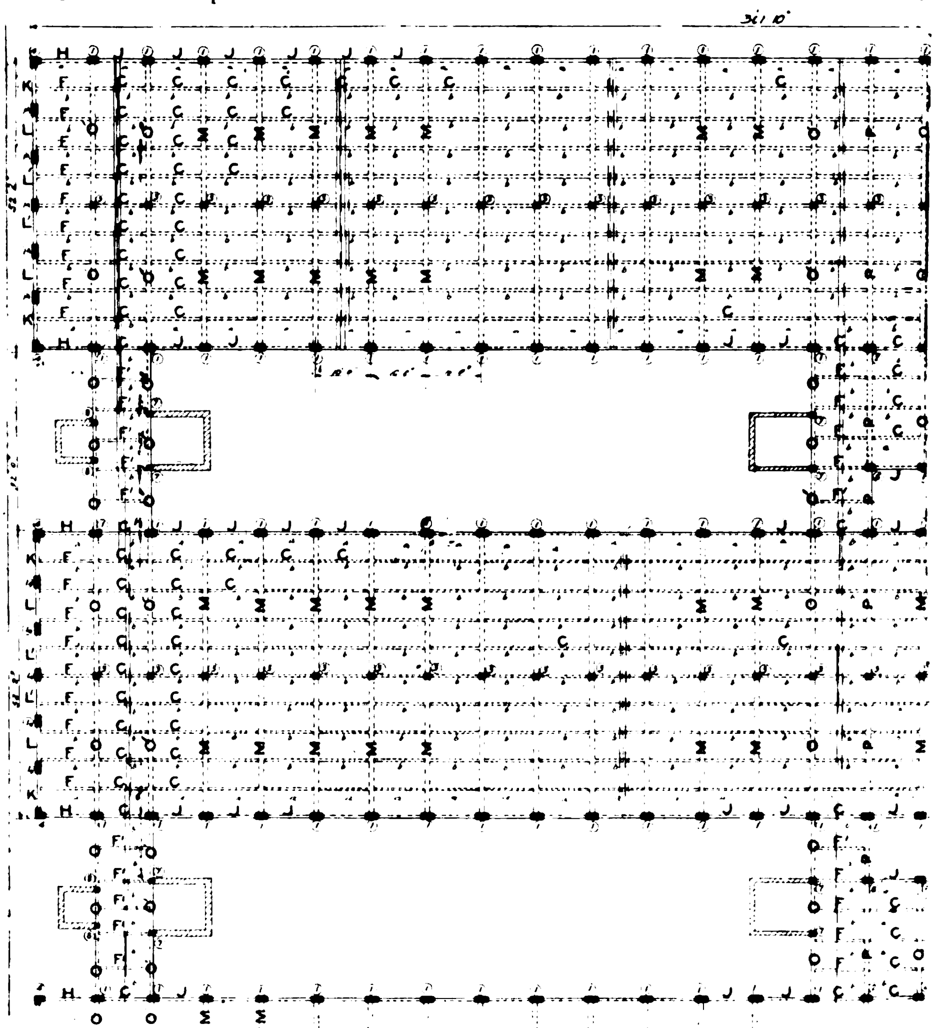


Fig. 3. Part of First Floor Plan.
A New Reinforced Concrete Factory.

below slab and 5 in. wide, the floor slab being thickened out to 8 in. in the 6 in. next to the beam.

The ground floor of each block consists of a 6 in. slab of concrete reinforced on top with steel mesh, whilst over the trench where foundations of central columns occur bars are inserted at bottom to prevent cracking owing to subsidence of the made-up ground.

This ground floor slab is quite independent of walls and columns, and should the made-up ground below it subside the slab would adjust itself to the new level.

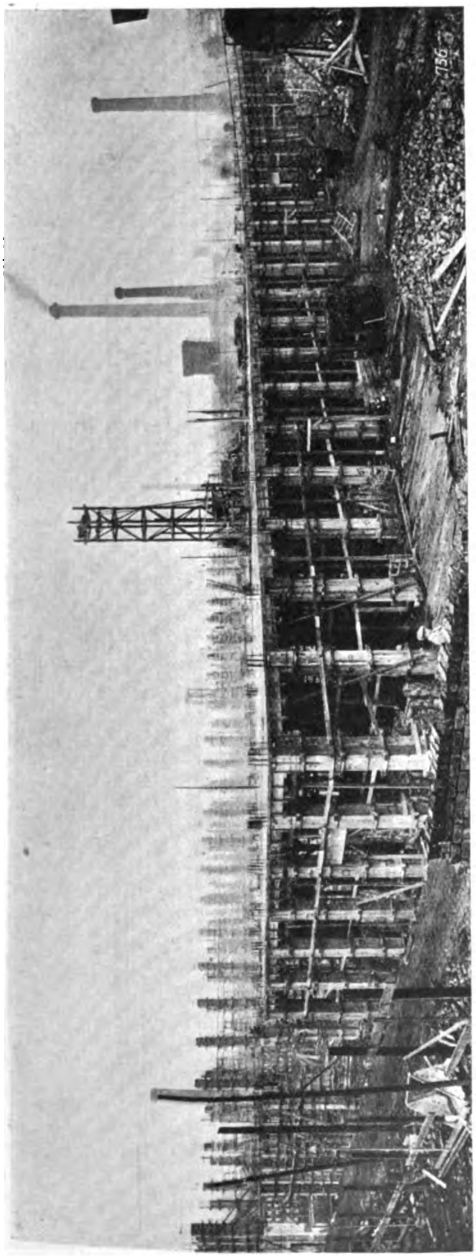


Fig. 4. Showing Building in course of construction. A New Reinforced Concrete Factory.

The first floor slab is designed for 5 cwt. per foot sup., and is 4 in. thick reinforced with bars, half of which are bent up over the beam support. This slab rests on secondary beams 10 in. deep below it, spaced at 5 ft. centres and supported at ends by the main beams. As these beams are continuous, and as loading might occur in some bays whilst adjoining ones were unloaded and thus give rise to negative tension stresses, two tension bars are placed in the top of each beam.

The main beams, 25 ft. span and at 10 ft. centres, are 24 in. by 11 in. below slab, and are haunched down to columns. These main beams are reinforced with seven bars, five of them bent up at support and carried over top of beam over central column support to take negative tension at top of beam. The negative compression over centre column support at the bottom of beam is resisted by increasing the depth of the beam at column by means of a haunch and by putting in extra compression bars at bottom for 3 ft. from the centre column.

To take the negative tension stresses in slab over the beams and to guard against shear stresses reinforcement was put in slab for 3 ft. on either side of the main beams.

The floor slab at second floor level was constructed similarly to that of first floor, except that falls were given to it on account of it being designed as a

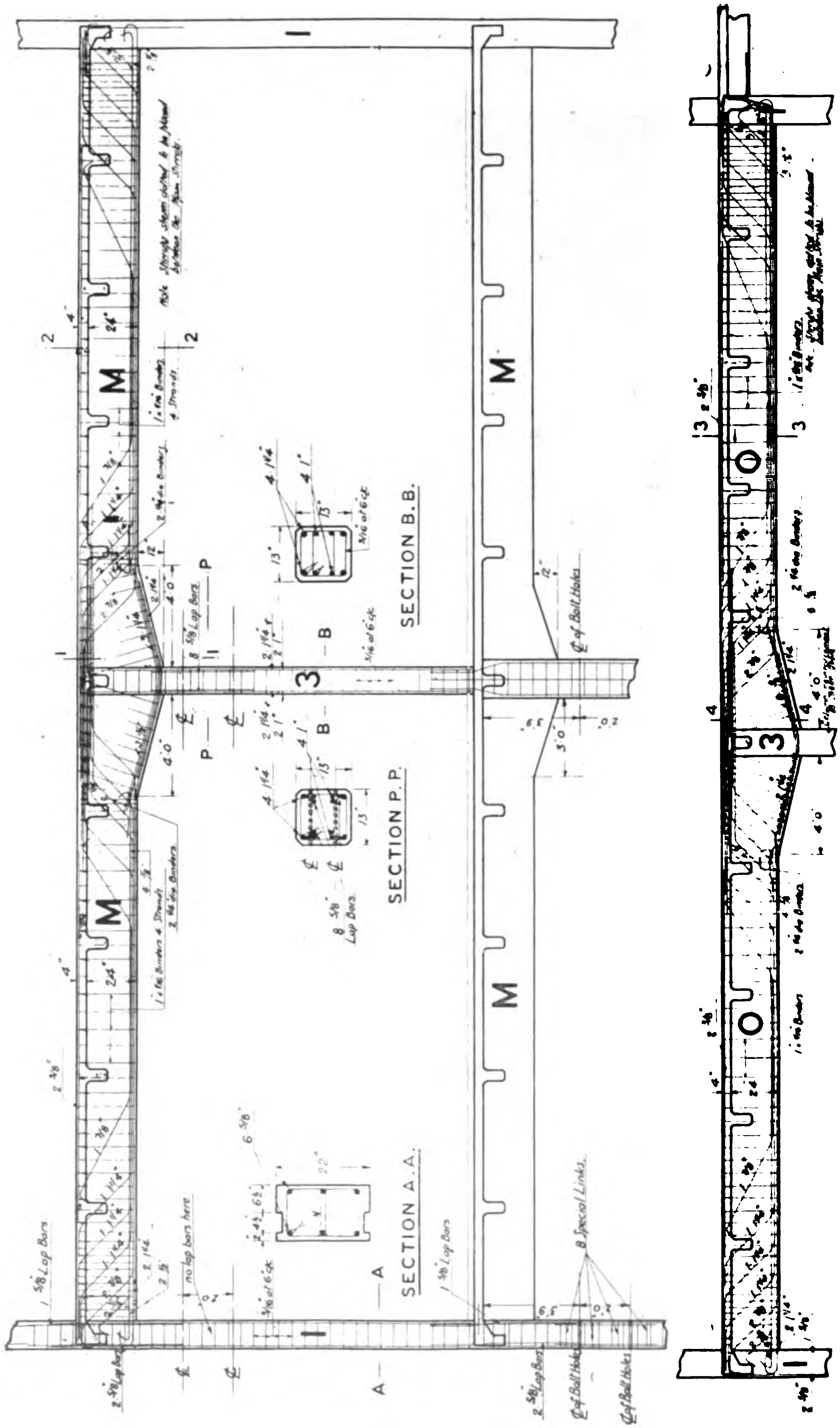


Fig. 5. Details of Beam Construction to Block No. 2 for Supporting Walls.
A New Reinforced Concrete Factory.

temporary roof. The great and increasing rush of work, however, caused a need for more space, and the external columns were carried up and finished as before mentioned.

The roof trusses are of steel, 50 ft. span, and support the light asbestos roofing slates with which the building is covered.

The staircase and lift wells are encased by 14 in. brick walls carried by beams at ground floor level. These beams rest on columns on separate foundations carried down to the clay, and the columns next bridges are carried up to roof and support reinforced concrete tanks over the second floor in two cases. These tanks are constructed to hold 1,500 gallons of water.

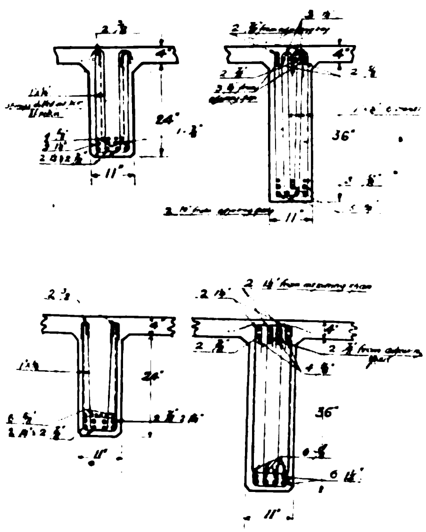


Fig. 6. Details of Beams Sections.
A New Reinforced Concrete Factory.

The bridges between stairs and lifts consist of a 4 in. reinforced concrete slab of 6 ft. span, supported by 10 in. by 5 in. secondary beams which rest upon 24 in. by 9 in. main beams carried by the columns. These main beams also carry the enclosing brick walls. Sinkings 12 in. deep are formed in the floor of the bridges for weighing machines, and thus all work coming from the factories can be weighed before entering the lift. The bridges are roofed with asphalte laid on reinforced concrete flats.

The furnace house building is enclosed with a 14 in. wall with reinforced concrete columns about 12 ft. centres to carry the roof trusses. These columns

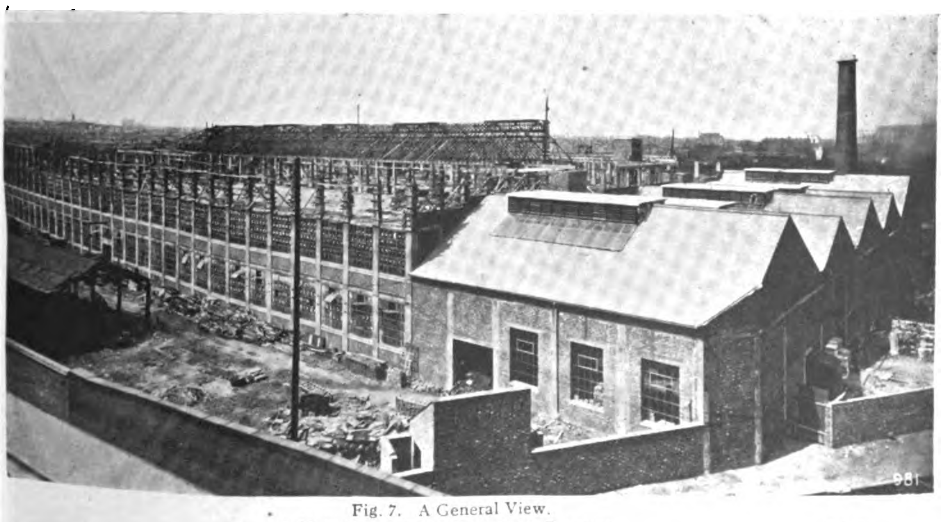


Fig. 7. A General View.
A New Reinforced Concrete Factory.

are 14 in. square, are carried down to clay level and rest upon a slab and beams, inverted T foundation. Opposite block No. 3 a floor was formed over the

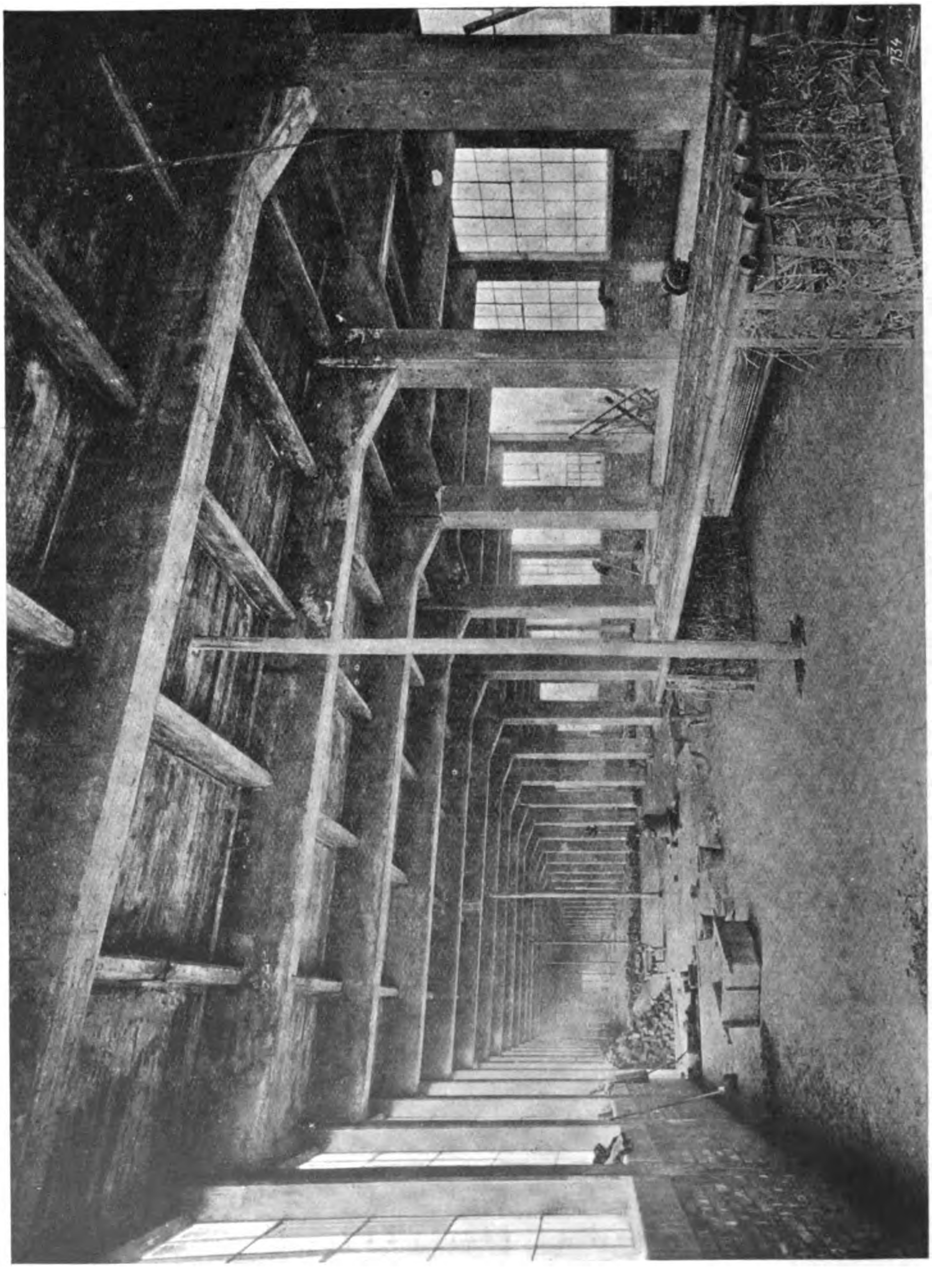
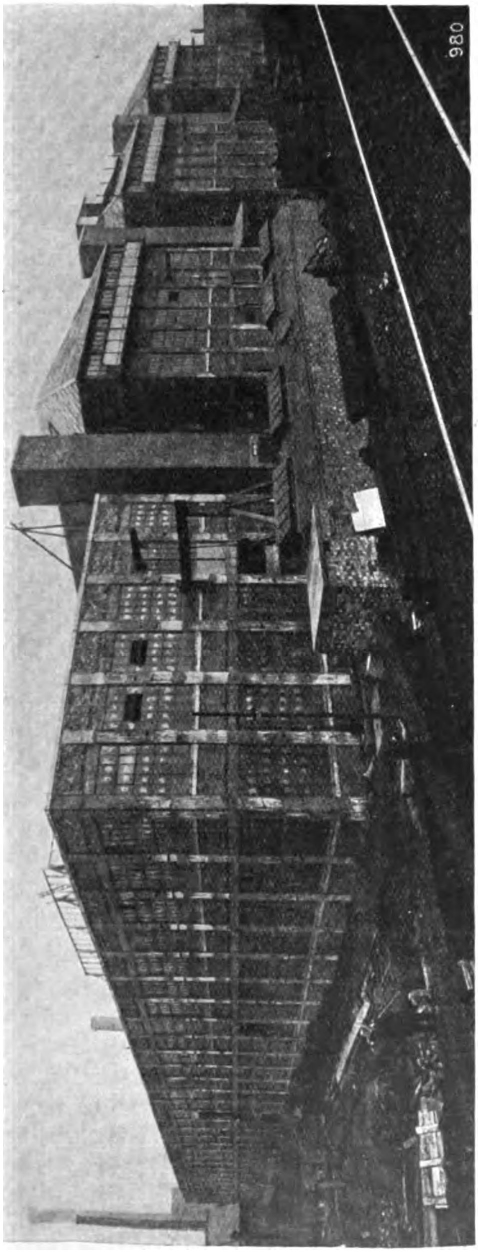


Fig. 8. Interior View.
A New Reinforced Concrete Factory.

generators for coal storage. This floor is 10 ft. above ground and carries coal 5 to 6 ft. deep, and consists of a 4 in. slab of spans from 6 to 10 ft. supported by 16 in. by 8 in. and 20 in. by 10 in. beams. Columns 14 in. square support these beams and are carried down to isolated footings. The furnace and boiler-house opposite block 4 is of similar construction, its special feature being the tank over to hold 35,000 gallons of water. This is 49 ft. 8 in. long by 30 ft. wide and 4 ft. deep, and is supported by three external and eleven internal columns. The floor slab of this tank is 4 in. thick and 6 ft. span resting on 26 in. by 8 in. secondary beams of 25 ft. span. These beams are reinforced with six bars and are supported on main beams 28 in. by 10 in. in section.



A New Reinforced Concrete Factory.

The side walls are 6 in. thick and serve as horizontal beams between the columns and finish against a 14 in. by 6 in. coping beam at top which takes the reaction from water pressure.

The architects for the work were Messrs. Buckland, Haywood and Farmer, of Birmingham, and the contractors Messrs. William Moss and Sons, Ltd., of Loughborough. The Indented Bar and Concrete Engineering Co., of Queen Ann's Chambers, Westminster, were responsible for the complete design and details of the reinforced work, and their indented bars were used throughout the whole building.

A BENDING MOMENT PROBLEM.

By EWART S. ANDREWS, B.Sc.

Beam fixed at one end and supported at the other, carrying a point load.

THIS case, which is not usually treated in the text-books, can be dealt with as follows:—

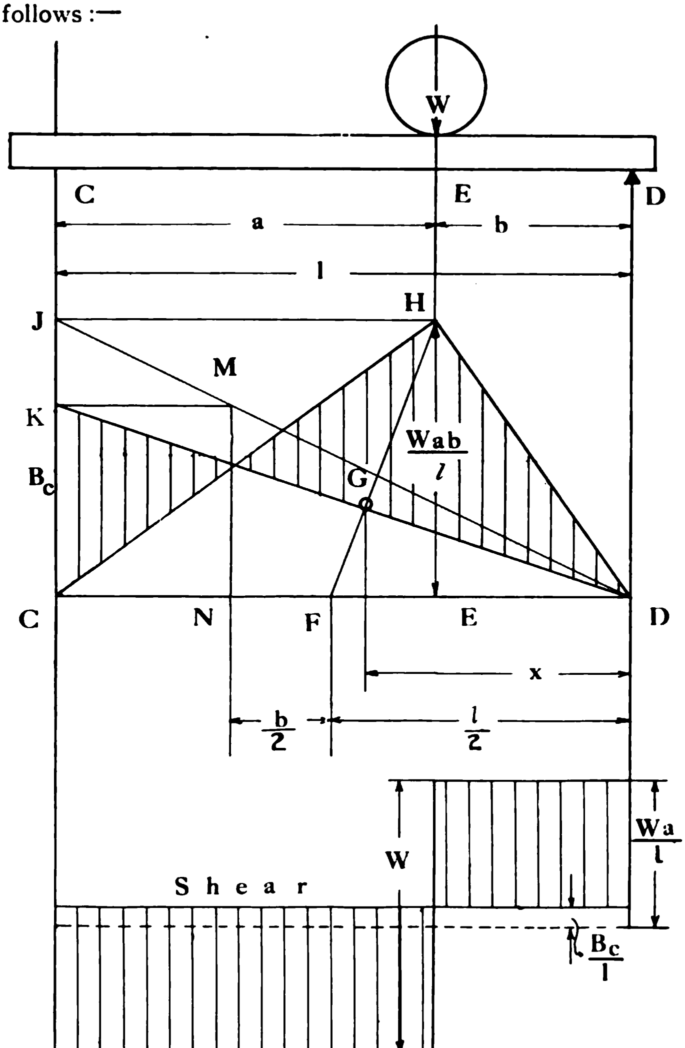


Fig 1

Let a beam $C D$, *Fig.* 1, be fixed at C and supported at D and carry a point load W at a point E, the span being l and the distance from E to C and D being a and b respectively.

First draw the "free" Bending Moment Diagram $C H D$, $E H$ being equal to $\frac{Wab}{l}$.

The general formula for determining the reverse bending moment B_c at the fixed end C is

$$B_c = \frac{3 A x}{l^2}$$

where

A = area of free B. M. diagram.

x = distance of its centroid from the free support D.

In the present case

$$A = \frac{1}{2} \cdot EH.CD$$

$$= \frac{1}{2} \frac{Wab}{l}.$$

$$= \frac{Wab}{2}$$

$$x = DE + \frac{2}{3} EF$$

$$= b + \frac{2}{3}\left(\frac{l}{2} - b\right)$$

$$= \frac{(l + b)}{3}$$

$$\therefore B_c = \frac{3\ Wab}{2\ l^2} \cdot \frac{(l+b)}{3}$$

$$= \frac{Wab\ (l + b)}{2\ l^2}$$

A length CK is then taken to represent this value and KD is joined, the resulting B. M. diagram coming as shown shaded. The maximum positive B. M. occurs under the load and is given by

$$B_E = \frac{Wab}{l} - \frac{B_c \cdot b}{l}$$

$$= \frac{Wab}{l} - \frac{Wab\ (l + b)\ b}{2\ l^3}$$

$$= \frac{Wab}{l} \left\{ 1 - \frac{b\ (l + b)}{2\ l^2} \right\}$$

The point K can be found graphically as follows:—

Project H horizontally to meet the vertical through the fixed end in J and join JD. From the mid-point F of the span mark the point N at distance $\frac{b}{2}$ from F towards C, and draw a vertical through N cutting JD in M. Then draw MK horizontally to meet the support vertical in K and join KD.

Values of the support Bending Moment B_c can be read off readily from the curve in *Fig*. 2 which is an "Influence-Line" for B_c.

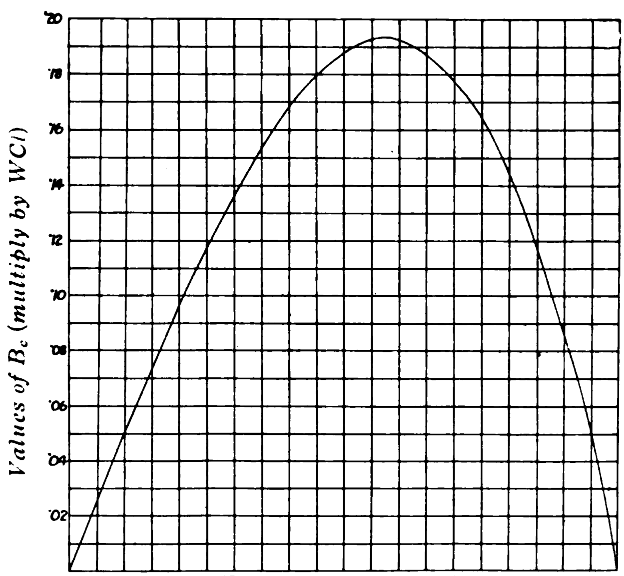
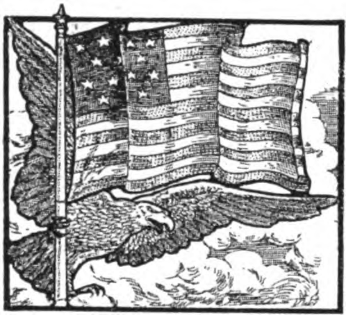


Fig. 2.

The horizontal distances on this diagram represent $a \div l$ and the vertical distances represent B_c as coefficients of Wl; *i.e.* we obtain B_c by multiplying the figures shown on the diagram by Wl.

Shear Diagram.—The shear diagram is obtained by drawing the "free" shear diagram and setting up the base line by an amount $\frac{B_c}{l}$ as shown in *Fig*. 1.



MOUNTAIN-TOP FOUNDATIONS TO SUPPORT LARGE TELESCOPE.

The following very interesting particulars and illustrations have been reprinted from The "Engineering Record," U.S.A.—ED.

ON the summit of Mount Wilson (elevation 5,889 ft.), near Pasadena, California, there is now nearing completion the foundation and steel dome for a 100-in. reflecting telescope to be equipped with the largest mirror ever cast. From the outset great interest has attached to this work from the astronomers' viewpoint, and since the structure has been begun unusual problems of an engineering nature have been presented. Transportation has entered very largely into the enterprise; when the work on other instruments of the observatory was laid out and started in 1904 all equipment and material had to be brought over a rough mountain trail by burros.

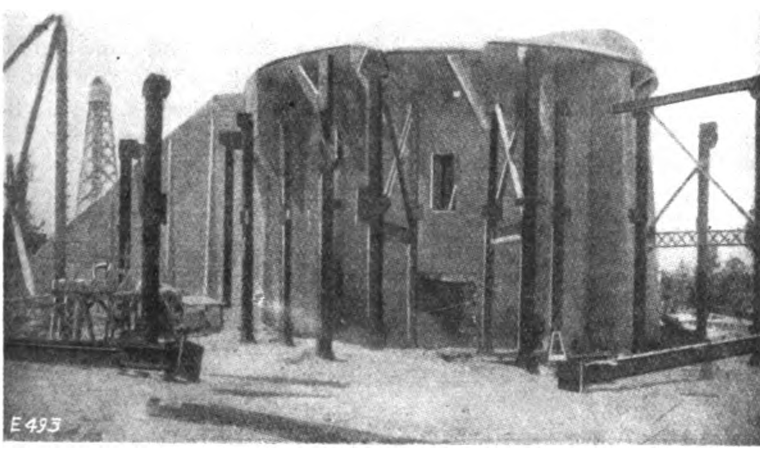
The trail leading up the mountain was later replaced by a road which has been improved from time to time and in recent months has been traversed frequently by automobile trucks of capacities up to 6½ tons, which are now conveying the material to the summit. The present road, however, which is nine miles long, is still extremely crooked and narrow, with grades running as heavy as 20 per cent. or more, and sharp curves on the verge of deep gorges.

The foundations on which the steel building and dome are erected were made heavy enough to withstand the stresses of a 75-mile wind against the dome, which is 100 ft. in diameter and 106 ft. high. The large concrete pier, which is the main element of the telescope foundation, is 33 ft. high and 53 ft. in diameter on top. There are three floors in the pier, and an elevator is provded for handling the 100-in. mirror which will be taken to a lower floor occasionally for resilvering. The second floor is used for water tanks and auxiliary mechanical equipment. At the south end of the pier is an extension on which a spectroscope 50 ft. long will be mounted. This extension is covered first with a concrete house and then by a metal structure calculated to keep temperature conditions constant.

The greatest care was used to keep all parts of the pier away from the steel building and its foundations, so as to avoid the possibility of vibration which might be transmitted to the instrument through such contact. The earth at the site, which is decomposed granite, was removed from around the foundations and later thrown back loosely as an additional protection against vibration and in order to cushion the structure from even the slightest local disturbance. As no sand was available for mixing the concrete, clear decomposed granite that had passed through the rock crusher was used as a substitute. This gave excellent results, it is stated, the only apparent difference being that it caused a slightly greater shrinkage of the concrete than when ordinary sand was used.

SUPERSTRUCTURE AND EQUIPMENT.

The lower part of the building, up to and including the tracks on which the dome revolves, was erected in 1914. The tracks were placed with great care, and to insure a perfect surface on which to rotate the dome, a home-made radial arm, supported on a pivot in the centre, was used to swing a grinding machine around the circular track. With this equipment the track

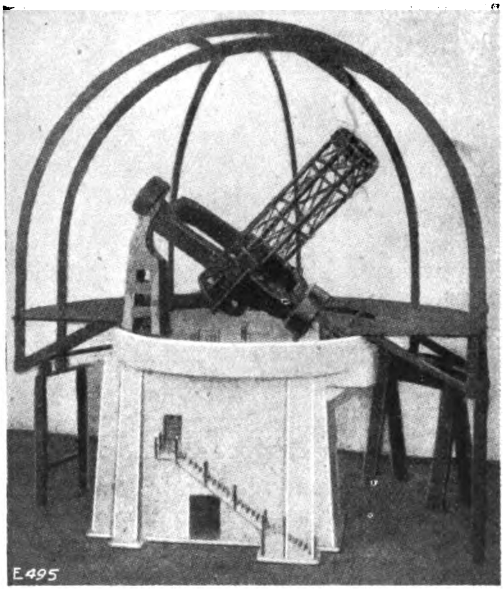


Concrete Pedestal with steel frame under construction.
MOUNTAIN-TOP FOUNDATIONS TO SUPPORT HUGE TELESCOPE.

was worked down until an extremely true and smooth surface was secured. In 1915 the steel superstructure of the observatory was completed to a point where it was considered waterproof, and some of the operating mechanism was installed. This included the trucks on opposite sides of the dome and the motors and connections by which it is operated and controlled.

The steel dome has a double wall and roof throughout to ensure stable temperature conditions, and the main floor is a part of and revolves with the dome. This floor, however, is separated from the pier walls by a 2-in. clearance. A movable observers' platform, giving access to the instrument in any position, is hung from the dome and a wind shield is installed to shelter the telescope from wind coming through the openings. The opening through which observations are made is 20 ft. wide and is equipped with shutters arranged to roll to one side when the telescope is in use.

The steel for the dome was manufactured in Chicago, where it was erected before shipment to ensure exact fit. When re-erected on Mount Wilson no



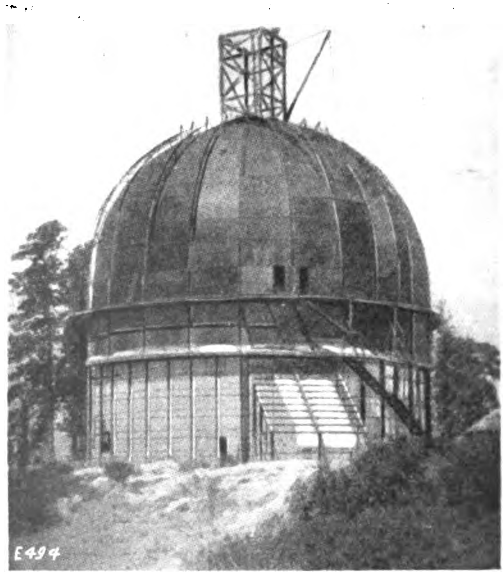
Model showing how the great lens will be mounted.
MOUNTAIN-TOP FOUNDATIONS TO SUPPORT HUGE TELESCOPE.

serious difficulty was encountered, although two 8-ton parts had to be lifted bodily into the main arch nearly 100 ft. above the ground. The heavy parts of the telescope mounting, which weighs about 135 tons, were made by the Fore River Ship Building Company, in Quincy, Mass., but all of the smaller and more accurate mechanism has been made in the Pasadena instrument shop of the observatory. Four pieces of the tube were too large to be shipped by rail, and so had to come by steamer around Cape Horn. Loads of steel weighing as much as 11 tons have been taken up the road to the observatory site by a single 6½-ton Saurer truck.

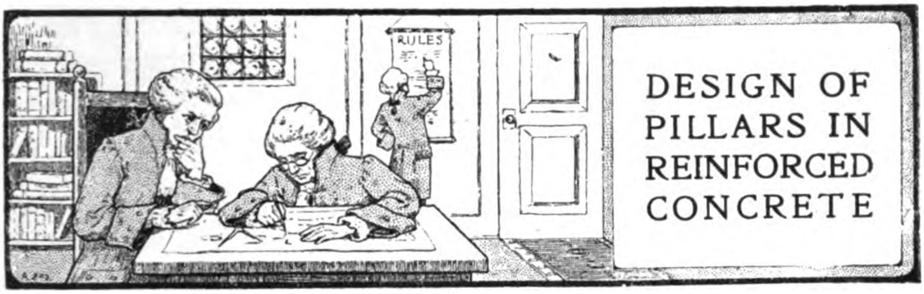
4½-TON GLASS CASTING.

The difficulty in the casting of a 100-in. reflector is that for so great a diameter a thickness of 13 in. was considered necessary in order to prevent bending. This would require a perfect glass casting weighing 4½ tons. A satisfactory casting was finally secured, however, at the plant of the St. Gobain Glass Co., of Paris, France. Since the lens arrived at the observatory optical shop several years ago work on it has been constantly carried on, and it is expected that the polishing process will be finished early in 1917.

Dr. George E. Hale is director of the Mount Wilson Observatory, and, in addition to the structure now nearing completion, has had charge of the installation and operation of other astronomical equipment in use there.



View of Dome, 100 ft. in diameter and 106 ft. high.
MOUNTAIN-TOP FOUNDATIONS TO SUPPORT HUGE TELESCOPE.



IN ACCORDANCE WITH THE L.C.C. REGULATIONS.

By F. E. DRURY, F.I.S.E., M.C.I.

Head of the Department of Building and Civil Engineering, Royal Technical Institute, Salford.

Concluded from last issue, p. 79.—ED.

RADIUS OF GYRATION OF REINFORCED CONCRETE PILLARS.

THE radius of gyration of reinforced concrete sections in general use for pillars is fairly well understood by structural engineers, but in view of the importance of this dimension, and its adoption by the L.C.C. as the chief basis of assessment of the working stresses on pillars, the following notes and diagram may be of value in the ultimate saving of labour in preparing and checking designs.

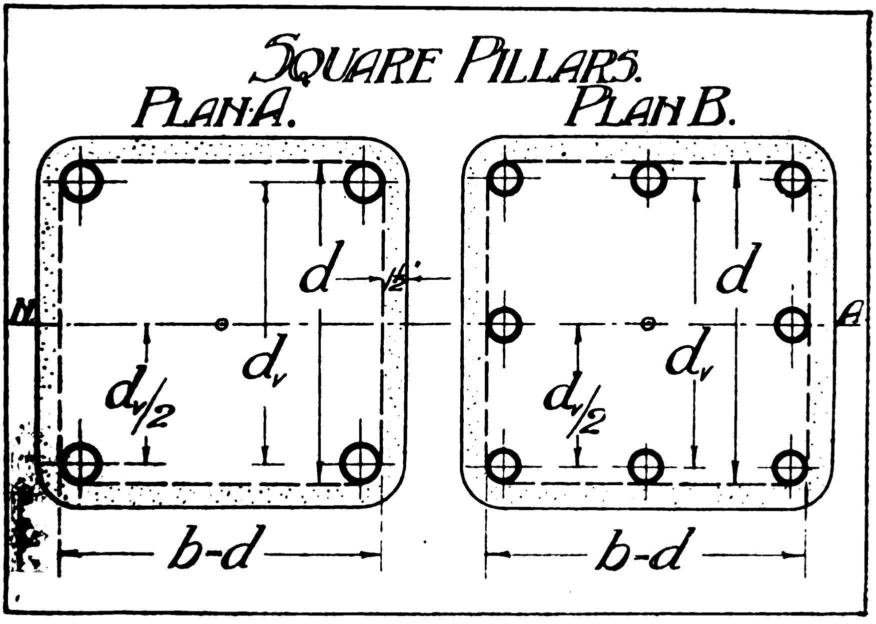


FIG. 10.

Let g = radius of gyration.

I_E = moment of inertia of equivalent area.

A_E = equivalent area of concrete; where the steel is conceived to be replaced by concrete of an equivalent area and in the same position relative to any axis of bending.

Then $g=\sqrt{\frac{I_E}{A_E}}$

Considering the square pillar section of plan A, *Fig.* 10, and taking the sum of the moments of inertia of plain concrete and equivalent concrete replacing the steel, we obtain

$$I_E=\frac{Ad^2}{12}+2\ (m-1)\frac{A_v}{2}\left(\frac{d_v}{2}\right)^2=\frac{Ad^2}{12}+\frac{(m-1)\ A_v d_v^2}{4}$$

also $A_E=A+(m-1)\ A_v$, or $A+r\ (m-1)\ A$.

Where A = nett effective area = d^2.

A_v = area of vertical reinforcement.

d_v = distance between centres of vertical reinforcement.

m = modular ratio.

r = ratio of A_v to $A=\frac{A_v}{A}$ or $A_v=rA$.

If plan B of *Fig.* 9 be adopted the effect of the two bars lying in the axis is lost, and we obtain

$$I_E=\frac{Ad^2}{12}+2\ (m-1)\ \frac{3}{8}A_v\left(\frac{d_v}{2}\right)^2=\frac{Ad^2}{12}+\frac{3}{16}\ (m-1)\ A_v d_v^2$$

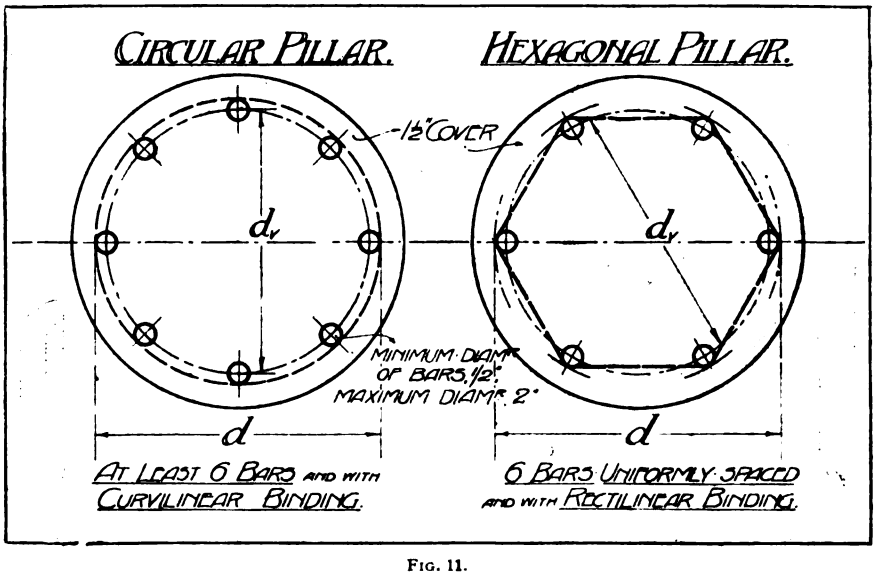


FIG. 11.

In the case of a regulation round pillar having at least six rods spaced cylindrically round the circumference of the section and laterally bound by circular hoops as in *Fig.* 11, the effective area is $A_E=\frac{\pi}{4}\ d^2+(m-1)A_v$ and the value of I_E can be obtained approximately by conceiving it to be replaced by a thin cylinder of steel having the same mean diameter (d_v) as the steel bars, the equivalent inertia of this being added to the inertia of the plain concrete as before.

The I (solid circle) $=\frac{\pi}{64}d^4$. The A (solid circle) $=\frac{\pi}{4}d^2$

$$\therefore\ \frac{I}{A}=\frac{\frac{\pi}{64}d^4}{\frac{\pi}{4}d^2}\qquad\qquad \therefore\ I=\frac{Ad^2}{16}$$

The I (hollow circle) $=\frac{\pi}{64}(D^4-d^4)$ and $A=\frac{\pi}{4}(D^2-d^2)$ where D and d are the outer and inner diameters respectively,

$\therefore$ replacing the steel ring by equivalent concrete we get

$$\frac{I_v}{A_v}=\frac{\frac{\pi}{64}(D^4-d^4)}{\frac{\pi}{4}(D^2-d^2)}(\mathrm{m}-1)$$

and $I_v=\frac{(m-1)}{16}A_v(D^2+d^2)$, but as D and d are practically equal to d_v (see *Fig.* 11) we obtain approximately, $I_v=\frac{(m-1)}{8}A_v d_v^2$

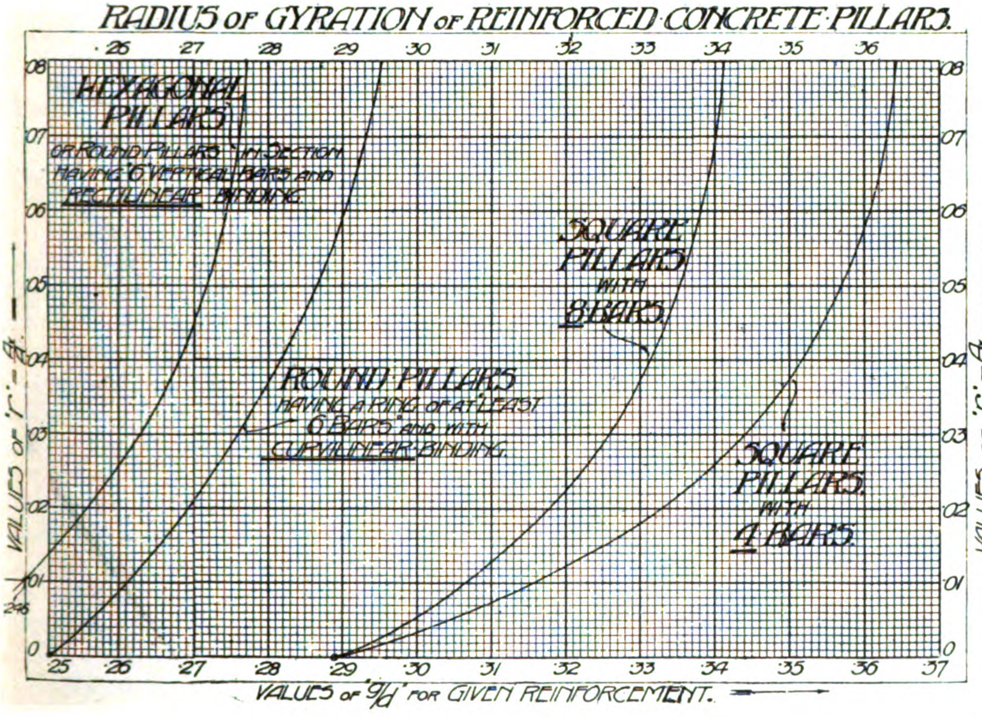


FIG. 12.

$$\therefore I_E=\frac{Ad}{16}+\frac{(m-1)A_v}{8}d_v^2.$$

In any case having obtained I_E and A_E, $g=\sqrt{\frac{I_E}{A_E}}$.

To save the tedium involved in calculating the value of "g" the author has calculated and plotted the average values of $\frac{g}{d}$ for the three dispositions referred to, for percentages of steel up to 8%, or ·08 of the A of concrete, and g for any diameter $=d\times$ the value of $\frac{g}{d}$ from the graph. See *Fig.* 12.

In round pillars where six bars are employed the lateral binding would usually be hexagonal in plan, as in *Fig.* 11, to the right—unless the pillar be small—and it should be understood that these are not classed as round pillars although the concrete or plaster clothing is of circular section.

A fourth graph, for these hexagonal pillars with rectilinear binding, is given on *Fig.* 12, showing the variation of $\frac{g}{d}$ to a close approximation.

The graph commences at 1% reinforcement, this percentage being reckoned, as before, upon the area of concrete enclosed within the laterals. It may be noted here that for a plain hexagonal pillar enclosed within a circle of diameter "d," $g = \cdot 228d$.

The values for plotting, or for checking any special case, may be obtained as follows:—

Let A = area of hexagon within laterals.
d = diameter outside the vertical bars.
d_v = diameter centre to centre of the vertical bars.

Then $A = \cdot 65d^2$.

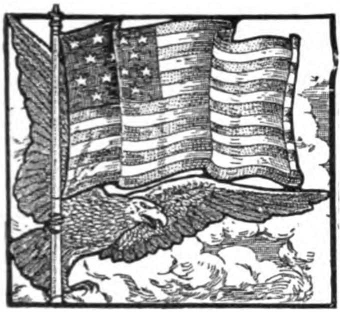
$I_E = I$ (hexagon) $+ I$ (vertical bars)
$= \cdot 034d^4 + \cdot 1256\,(m-1)\,A_v\,d_v^2$.

and if $m = 15$

$I_E = \cdot 034d^4 + 1\cdot 756A_v\,d_v^2$.

Then the equivalent area (A_E) as before $= A + (m-1)A_v$.

and $g = \sqrt{\frac{I_E}{A_E}}$.



THE NEW COTTON WAREHOUSES AND TERMINALS OF THE PORT OF NEW ORLEANS.

Concluded from last issue.—ED.

Materials and Construction.—The selection of materials for the warehouses required a more careful study. Of the fire-resisting materials available the one first considered was brick. It was found, however, that brick-bearing walls would not be suitable, both because of their excessive cost, due largely to the great thickness required and the cost of the foundations for supporting this weight, and also because they would be poorly adapted to resist eccentric loads caused by the cranes and lateral loads due to piles of cotton stacked against them or to the swelling of the cotton if saturated in case of fire.

A skeleton form of construction, therefore, became desirable from every point of view, and the choice was, of necessity between structural steel and reinforced concrete. Of these materials the reinforced concrete was found to be much the cheaper, partly on account of the necessity of a fire-resisting covering to the steel if it should be used. The next question was the material for the dividing walls, and here the choice lay between hollow tile, brick, and reinforced concrete. The hollow tile possessed many advantages, but the insurance companies did not consider that they were a sufficient protection against the spread of fire, and their requirements for brick walls to be at least 50 per cent. thicker than a reinforced one under the same conditions led to the adoption of the latter, which also had the advantage of allowing much less costly foundations.

Whilst preparing the designs it was seen that a great increase in structural strength could be secured without additional cost by distributing the reinforcing material through the walls instead of concentrating it in the skeleton, thus securing a much better distribution of the steel and a better distribution of the load on the foundations. The final design adopted for the warehouses was in reality a combination of a skeleton and a bearing wall design, and provided for a building of unusual structural strength, and particularly well suited to the soil conditions where the bearing power at particular points was extremely uncertain, although the general supporting power was quite satisfactory.

Reinforced concrete also allowed more convenience of construction, the ability to use more unskilled labour with less likelihood of labour troubles.

The Design.—The design of the warehouses was controlled largely by the dimensions of the site available, the method of storing the cotton, and the

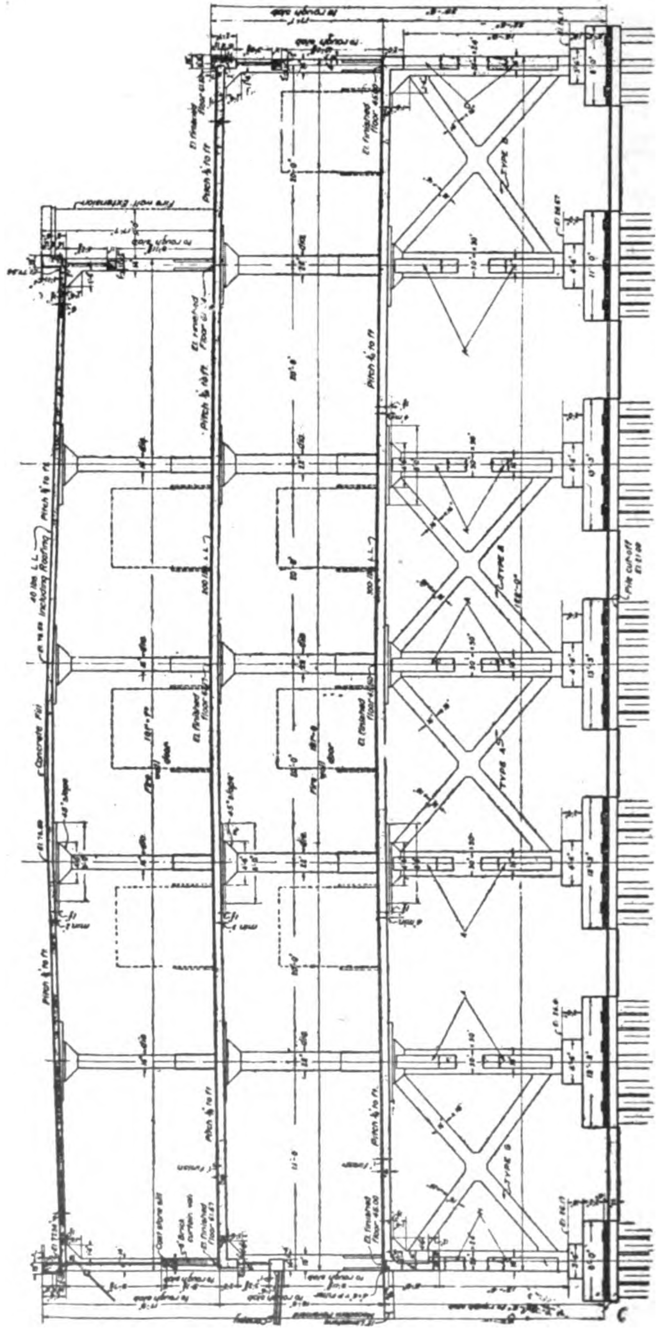


Fig. 7. Section through Wharf House.

REINFORCED CONCRETE CONSTRUCTION IN THE NEW COTTON WAREHOUSES AND TERMINALS OF THE PORT OF NEW ORLEANS.

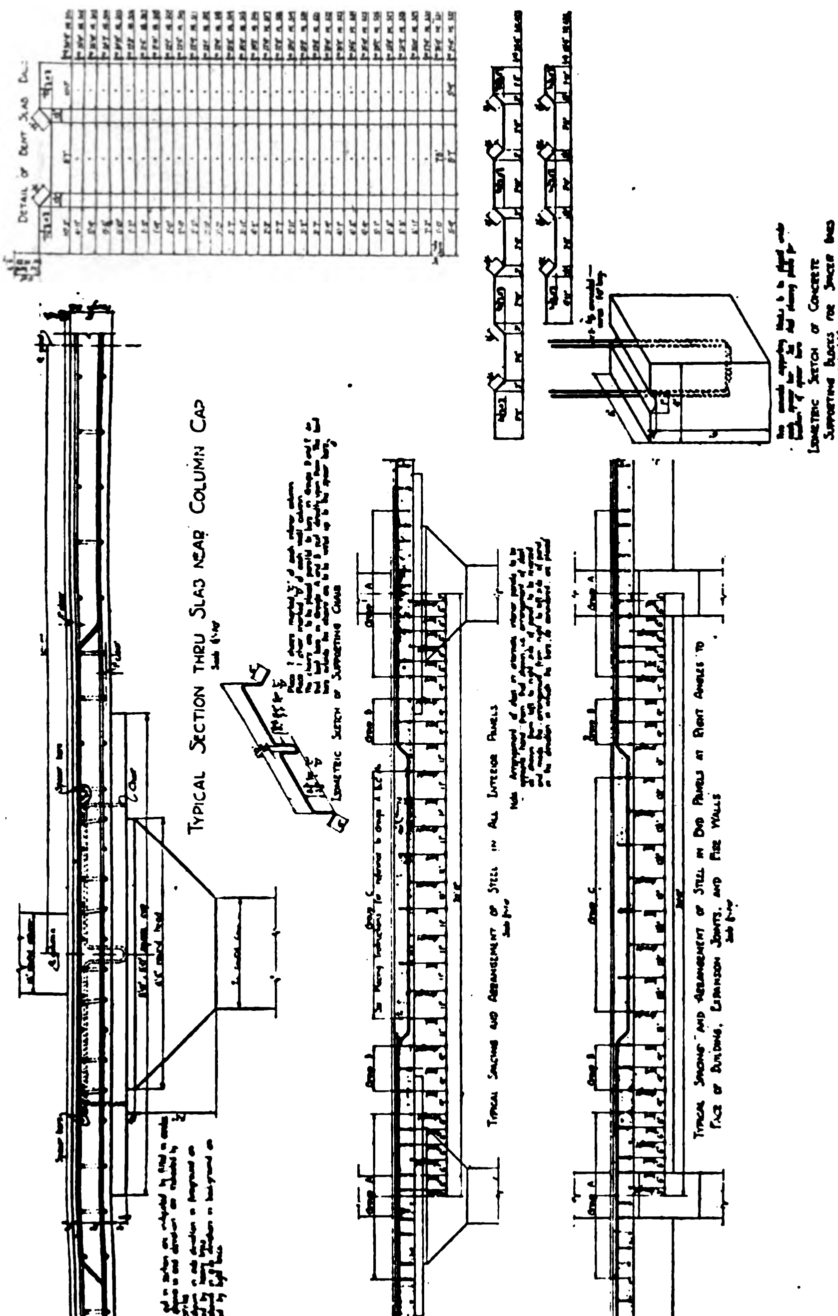


Fig. 8 Section through the Second Storey Flat Slab of Wharf House.

Reinforced Concrete Construction in the New Cotton Warehouses and Terminals of the Port of New Orleans insurance companies' requirements. These factors limited the width of the buildings to approximately 275 ft., inclusive of the platforms. It was desired that the upper platforms, or balconies, be wide enough to permit of ranging and sampling cotton without interfering with the passage of trucks in either

Fig. 9. Interior of Typical Warehouse Compartment.
REINFORCED CONCRETE CONSTRUCTION IN THE NEW COTTON WAREHOUSES AND TERMINALS OF THE PORT OF NEW ORLEANS.

direction. In order that cotton could be handled by the cranes from the lower platform to the upper one, or to the interior of the buildings, the lower platform was made to project more than the upper one.

Two of the warehouses are each 203 ft. wide, exclusive of the platforms, and 420 ft. long, and two are of the same width, but 580 ft. in length. A two-storied platform is provided along each side, the lower 35 ft. and the upper 25 ft. wide.

These warehouses are divided into compartments each 32 ft. wide and

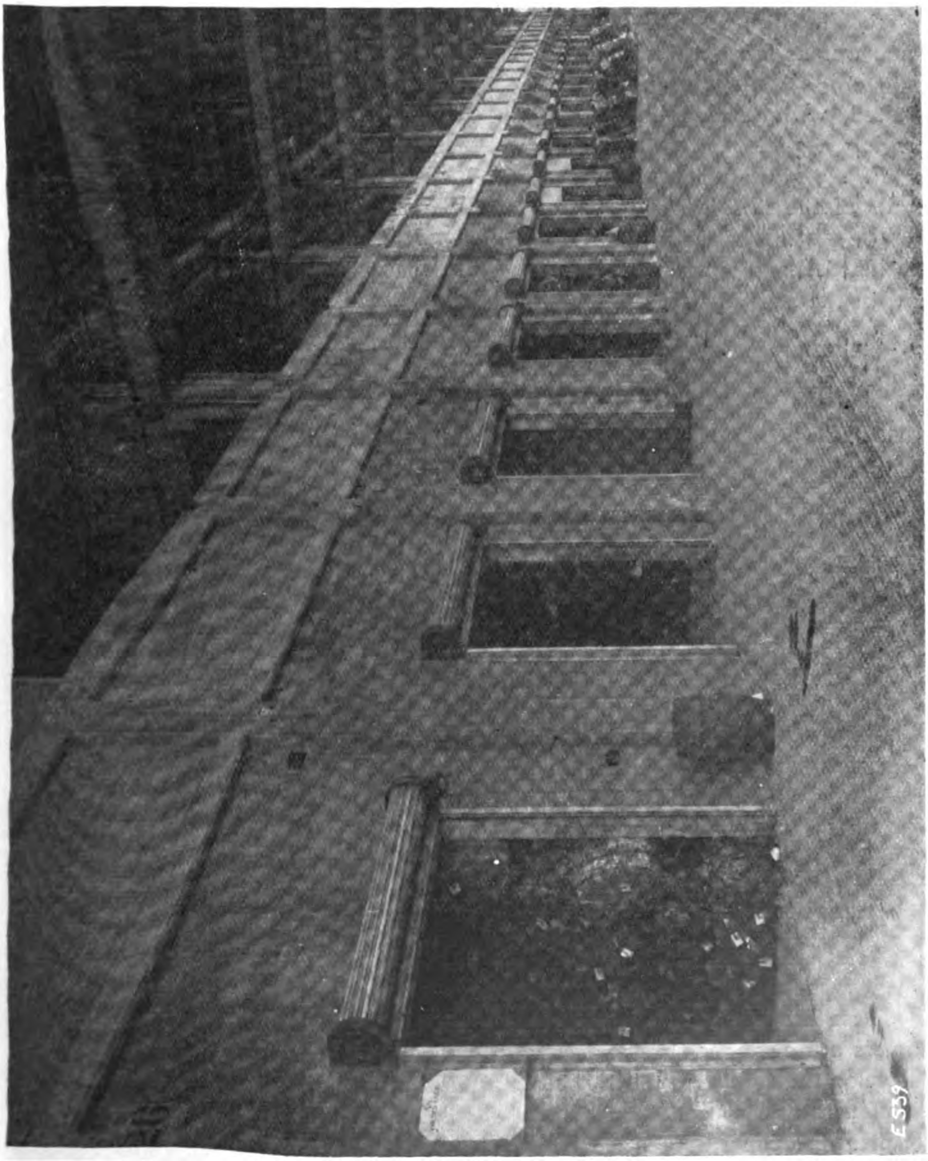


Fig. 10. Lower or Receiving Platform North Side of Warehouse.

REINFORCED CONCRETE CONSTRUCTION IN THE NEW COTTON WAREHOUSES AND TERMINALS OF THE PORT OF NEW ORLEANS.

about 100 ft. long, and have a clear storey height of about 36 ft. The concrete walls are 12 in. thick, and near the top of each is a reinforced concrete shelf to receive the crane rails.

Fig. 1 is a key plan of the whole scheme.

Fig. 2 is a key plan of one of the warehouses, and shows the arrangement of the walls and the columns supporting the upper platforms. The spacing of the fire walls partly depended on the fact that one end of each bale must be on an aisle and also on the fire insurance requirements. With spaces 32 ft. wide and 100 ft. long the capacity was nearly 2,000 bales, a risk of about $100,000, which was as large as it was desirable to handle.

Roofs.—After careful cost comparisons a ribbed slab type of roof was adopted, with ribs 20 in. deep, 6 in. wide, spaced 4 ft. 2 in. centres, and carrying a 3-in. slab.

Fig. 3 gives a plan of a portion of the warehouse roofs, and *Fig.* 4 gives details of the ribs.

Fire Walls.--*Fig.* 5 gives details of the fire walls, which, it may be mentioned, have temperature reinforcement amounting to four-tenths of 1 per cent. of the area of the concrete horizontally and half this amount vertically.

Fig. 11. Interior of Compress Room
REINFORCED CONCRETE CONSTRUCTION IN THE NEW COTTON WAREHOUSES AND TERMINALS OF THE PORT OF NEW ORLEANS.

These fire walls are broken by pilasters at intervals of 16 ft. 8 in. These pilasters are 24 in. square and contain sufficient reinforcement to enable them to develop the full strength of the concrete in case they were called upon to act as stiffeners and prevent buckling of the walls. The amount of reinforcement was also sufficient to take care of the entire eccentric loading of the cranes, which might be concentrated at the pilasters because of their great stiffness, and to take care of the lateral pressure due to the cotton stacked against the walls. A sufficient reserve strength was also allowed for to guard against any lateral pressure which might be exerted by swelling of the cotton if saturated by water in case of fire.

Crane Shelf.—The crane shelf is of rather unusual design. It is a continuous bracket, and also acts as a distributing beam along the wall.

The end walls are similar to the fire walls, except that they are also designed to resist a wind pressure of 30 lb. per sup. foot of wall surface. In all walls the reinforcement is near the outer face, and the nearest bars are 1½ in. from the surface.

Foundations.—Pile foundations were found to be necessary for all structures. Creosoted piles are used cut off at the general ground surface, and each one receives about 12 tons of the dead weight of the building.

Balconies.—The balconies consist of a slab of concrete supported by beams, one end of which rests on the wall of the building and the other on independent columns. These balconies were designed for concentrated and uniformly distributed live loads and are provided with expansion joints, as are also the buildings. In most cases the structures on each side of an expansion joint rest on a footing common to both, thus maintaining both at the same relative elevation in case of a settlement.

Compress Building.—The compress building is a one-storey structure about 230 ft. wide, 410 ft. long, and 22 ft. high. The roof is of the ribbed slab type, supported on beams from column to column in the direction of the length of the building. As will be seen from *Fig.* 6, alternate panels of this ribbed slab are raised along one edge, thus forming saw teeth.

Tie beams which can also act as struts were provided under the saw teeth at each column. These take any pulls or thrust caused by contraction or expansion of the building. The construction of the compress building was simplified by allowing in the design for pouring the nearly level portions of the roof and allowing them to set before pouring the inclined or saw tooth portions.

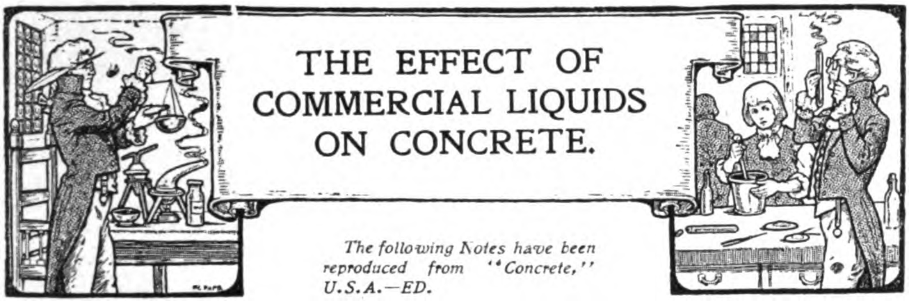
Wharf House.—The wharf house is 122 ft. wide and 2,000 ft. long, of which about 1,500 ft. is at present under construction. Both floors are reached by runways connected with the other buildings, and inclined elevators will be provided to transfer trucks and trailer trains from one floor to the other. *Fig.* 7 is a section through the building. Along the shore side is a 15-ft. covered receiving and handling platform, and on the river side a 45-ft. timber apron wharf. This is paved with creosoted blocks and carries two railway tracks and the lower rail for the wharf cranes. The second storey is 20-ft. less width, thus giving a platform from which cotton can be transferred by cranes direct to the ship's hold. The building is divided into 250-ft. sections by fire walls.

This building rests on pile foundations cut off at low-water level. These piles are capped with timbers, some of which are continuous, and maintain the desired relative position of the various clusters. Reinforced concrete spread footings rest on these caps and carry the superstructure. The columns to carry the first storey are connected in groups of four or six by a system of reinforced concrete X braces. The floors and roof of the wharf house are of the flat slab type, consisting of a slab of concrete supported directly on the columns without the use of beams or girders. Its great advantage is increased headroom and ability to adjust itself to slight settlements. In the design of the floor slabs the steel is arranged on the two-way system parallel to the sides of the panels and not on the four-way system, careful estimates having shown the two-way system to be more economical for the spans and loading existing.

Fig. 8 is a section through the second storey flat slab, and shows the arrangement of the bars.

Generally.—In addition to the cotton warehouses described in this article, the Board of Commissioners of the Port of New Orleans is constructing, adjacent to the cotton warehouses, a reinforced concrete grain elevator. Work was commenced upon this grain elevator in February of this year. Its capacity will be 1,000,000 bushels. It will have an unloading capacity of 24,000 bushels per hour from railway trucks and a shipping capacity to vessels of 96,000 bushels per hour, and it is hoped to deal with this in a later issue.

As already mentioned, the engineers for the whole of the works are Messrs. Ford, Bacon, and Davis, to whom we are indebted for the foregoing information and for the loan of the drawings and photographs here reproduced.



THE EFFECT OF COMMERCIAL LIQUIDS ON CONCRETE.

The following Notes have been reproduced from "Concrete," U.S.A.—ED.

THE Portland Cement Association, through the Institute of Industrial Research, Washington, D.C., has conducted a series of experiments to determine the effect of various commercial liquids on concrete tanks. In the case of each liquid both plain concrete tanks, 1 : 2 : 4, with trap rock aggregate, and concrete tanks with a neat cement mortar coat were used.

In addition to this a number of protective methods were tried with each liquid, in order to determine a practical treatment in case the concrete was proved unsatisfactory.

The materials tested were menhaden oil, linseed oil, rosin oil, 4 per cent. caustic soda solution, lard oil, tanning solution (formula not given), sulphate liquor, cider vinegar, sauerkraut, molasses, concentrate brine, and fatty acids from soap. The outstanding feature of the following summary of the tests is the fact that plain, dense concrete is in most instances equal or superior to any known special treatment.

MENHADEN OIL.

Material.—Menhaden oil.
Construction.—1 : 2 : 4; trap rock $\frac{5}{8}$ in. to $\frac{3}{4}$ in. wet mix.
Special Treatment.—None.
Length of Test.—Thirteen months to January 1st, 1913.
Number of Times Refilled.—Eight.
Effect of Material.—Uninjured. Small amount of lime in sediment. Acid value lowered. Quality improved.
Effect on Tank.—Uninjured.
Recommendations.—Safe to store in properly prepared 1 : 2 : 4 tanks. Plain concrete as good as or better than specially treated concrete.
Tests on mortar-faced tank showed same result.
Further tests were conducted with treated concrete, but showed no better results than plain concrete.

LINSEED OIL.

Material.—Linseed oil.
Construction of Tank.—1 : 2 : 4; trap rock $\frac{3}{8}$ in. to $\frac{1}{8}$ in. wet mix.
Special Treatment.—None.
Length of Test.—Thirteen months to January 1st, 1913.
Number of Times Refilled.—Eight.
Effect on Material.—Uninjured. Small amount of lime in sediment. Acid value lowered. Quality improved.

Effect on Tank.—Uninjured.

Recommendations.—Safe to store linseed oil in properly prepared 1 : 2 : 4 tanks. Plain concrete as good as or better than specially treated concrete.

Tests with mortar-faced tanks showed equally good results. Special treatment no advantage.

Rosin Oil.

Material.—Rosin oil.

Construction of Tank.—1 : 2 : 4 trap rock ⅝ in. to ⅛ in. wet mix.

Special Treatment.—None.

Length of Test I. I. R.—Eleven months to January 17th, 1913.

Number of Times Refilled.—Seven.

Effect on Material.—Uninjured. Slight increase in ash obtained upon ignition.

Effect on Tank.—Uninjured. Transparent gummy deposition sides and bottom.

Recommendations.—So far neither 1 : 2 : 4 concrete nor rosin oil are injuriously affected. Specially treated concrete no better than untreated.

4 per cent Caustic Soda.

Material.—Caustic soda solution 4 per cent.

Construction of Tank.—1 : 2 : 4; trap rock ⅝ in. to ⅛ in. wet mix.

Special Treatment.—None.

Length of Test I. I. R.—Twelve months to January 13th, 1913.

Number of Times Refilled.—Eight.

Effect on Material.—Uninjured. Sodium carbonate formed to some extent. This is true in any open container.

Effect on Tank.—Uninjured.

Recommendations.—Safe to store 4 per cent. solutions caustic alkali in properly prepared 1 : 2 : 4 tanks. Plain concrete as good as or better than specially treated.

A series of special treatments failed to show any preparation equal to plain concrete.

Lard Oil.

Material.—Lard oil.

Construction of Tank.—1 : 2 : 4; trap rock ⅝ in. to ⅛ in. wet mix.

Special Treatment.—None.

Length of Test I. I. R.—Eleven months to January 17th, 1913.

Number of Times Refilled.—Seven.

Effect on Material.—Supernatant oil uninjured. Limy sediment next concrete.

Effect on Tank.—Surface attack apparent. Coarse stone in aggregate exposed. Cement somewhat softened.

Recommendations.—Present results indicate 1 : 2 : 4 concrete not altogether satisfactory for storing lard oil.

Other tests with tanks coated with concrete paints and with oil-mixed concrete failed to show satisfactory results.

Tanning Solution.

Material.—Tanning solution (spent liquor from New England tannery).

Construction of Tank.—1 : 2 : 4; trap rock ⅝ in. to ⅛ in. wet mix.

Special Treatment.—None.

Length of Test I. I. R.—Thirteen months to January 1st, 1913.

Number of Times Refilled.—Eight.

Effect on Material.—Uninjured except for slight action of concrete on first charge, which darkens leather.

Effect on Tank.—Uninjured.

Recommendations.—Safe to store in properly prepared 1 : 2 : 4 tanks. Plain concrete as good as or better than specially treated. Tank should first be well tanned before introducing leather.

Concrete tank faced with neat cement equally satisfactory.

Sulphite Liquor.

Material.—Sulphite liquor.

Construction of Tank.—1 : 2 : 4; trap rock ⅝ in. to ⅛ in. wet mix.

Special Treatment.—None.

Length of Test I. I. R.—Thirteen months to January 1st, 1913.

Number of Times Refilled.—Ten.

Effect on Material.—Acid neutralised by lime in cement.

Effect on Tank.—Badly attacked. Coarse aggregate near surface laid bare and loosened. Action progressive.

Recommendations.—Not safe to store sulphite liquor in plain concrete.

Report April 24th, 1914.—The only satisfactory method of protecting concrete from disintegration by sulphite liquor which has been found is by surface treatment with a paint coat of blown-oil Gilsonite compound.* A concrete tank treated with such compound has now been used successfully for the storage of sulphite liquor for a period of fifteen months, and is at the present time in perfect condition. The suphite liquor readily attacks untreated concrete and no treatment other than that above noted has prevented disintegration.

Cider Vinegar.

Material.—Cider vinegar.

Construction of Tank.—1 : 2 : 4; trap rock ⅝ in. to ⅛ in. wet mix.

Special Treatment.—None.

Length of Test I. I. R.—Thirteen months to January 1st, 1913.

Number of Times Refilled.—Eight.

Effect on Material.—Acid neutralised by lime in cement.

Effect on Tank.—Quite badly attacked. Coarse aggregate near surface laid bare and loosened. Action progressive.

Recommendations.—Not safe to store cider vinegar in plain concrete.

Supplemental Report.—The same remarks relative to sulphite liquor are applicable to the tests made with cider vinegar. The blown-oil Gilsonite compound has now been in use for a period of fifteen months, and as the surface treatment caused no injury to concrete, coating or vinegar, it may be said that vinegar may safely be stored in concrete tanks if so protected.

Sauerkraut.

Material.—Sauerkraut.

Construction of Tank.—1 : 2 : 4; trap rock ⅝ in. to ⅛ in. wet mix.

Special Treatment.—None.

Length of test.—Six months to January 1st, 1913.

Number of Times Refilled.—Five.

Effect on Material.—Uninjured by concrete. Spoils, however, on protracted exposure to air.

Effect on Tank.—Uninjured.

Recommendations.—Safe to store in properly prepared 1 : 2 : 4 tanks. Plain concrete as good as specially treated.

Molasses.

Material.—Molasses.

Construction of Tank.—1 : 2 : 4; trap rock ⅝ in. to ⅛ in. wet mix.

Special Treatment.—Three coats special Pyramid paint† and one coat Bakelite varnish.‡

Length of Test I. R. R.—Seven months to January 8th, 1913.

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* Dissolve 100 parts by weight of Utah asphalt, Barber Asphalt Co. (Gilsonite), in 250 parts of turpentine. At ordinary temperature 24 hours will be required for perfect solution. Stirring should be resorted to. A perforated metal basket in which to suspend the broken lumps of asphalt in the solvent will accelerate solution. Add 5 parts neutral petroleum oil. Apply with a brush. Two-coat work is sufficient. Allow at least 24 hours for the drying of each coat.

† Pyramid Paint Co., Philadelphia

‡ The General Bakelite Co., N.Y.C.

Number of Times Refilled.—Four.

Effect on Material.—Uninjured.

Effect on Tank.—Uninjured.

Recommendations.—So far Bakelite varnish unaffected. Test promising.

At the end of a sixteen-months' test a concrete tank covered with two coats of Bakelite varnish has proved absolutely satisfactory for storing molasses. This is the only test that has been made in which neither the concrete, coating, nor molasses has been injured. It may therefore be said that molasses may be safely stored in concrete which has been properly protected by the application of two coats of Bakelite varnish.

Brine.

Material.—Concentrate brines from manufacture of salt.

Plant at which Tested.—J. C. Dickinson and Co., Malden, W. Va.

Construction of Tank.—Dimensions, length 160 ft., width 10 ft., depth 18 in. Built of 4-in. poplar plank, lined with 1 : 2 : 5 concrete 2 in. thick. Cross-expansion joints every 4 ft. Concrete coated with two layers of Gilsonite. Upon this is placed asphalt burlap fabric, which is covered with heavy coat of Gilsonite. Upon this is placed a 2-in layer of 1 : 2 cement mortar with cross-joints similar to first layer of concrete. Before setting this mortar is covered with 1½-in. facing of 1 : 2 cement mortar. Bottom joints are filled with Gilsonite.

Special Treatment.—Two coats of Bakelite A-15[2] applied on clean dry 1 : 1 mortar and baked; 1 lb. Bakelite to 8 sq. ft. second coat. Conditions unfavourable for work as weather was cold. Side joints caulked with oakum.

Length of Test.—Eleven months to February 14th, 1913.

Effect on Material.—Uninjured.

Effect on Tank.—Uninjured.

Recommendations.—Treatment with Bakelite so far satisfactory. In further construction work we believe that just as good results will be obtained by omitting asphalt felt covering with Gilsonite, and using instead a swab coat of a blown-oil Gilsonite compound (melting point 270 deg. F.) after painting with a priming coat of the same material thinned with gasoline. Then application of layer of burlap fabric and two swab coats of blown-oil Gilsonite. Then cement mortar and Bakelite treatment as described above.

Fatty Acids.

Material.—Hot fatty acids from soap.

Construction of Slab.—1 : 2 mortar.

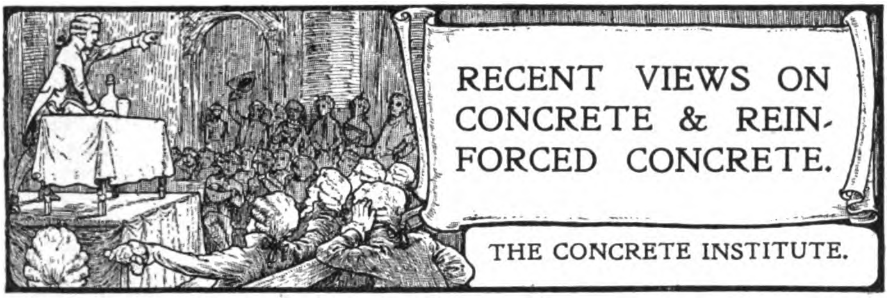
Special Treatment.—Surface treated with two coats Bakelite A-10[2] baked.

Plant at which Tested.—Fels and Co., Philadelphia.

Length of Test.—Seven months to January 24th, 1913.

Effect on Slab.—October 8th, 1912. Same condition as at first. No disintegration so far.

Recommendations.—Treatment so far satisfactory. Too early for final conclusions.



It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.—ED.

THE CONCRETE INSTITUTE.

THE CARE OF ANCIENT MONUMENTS.

By C. R. PEERS, Sec.S.A.

Chief Inspector of Ancient Monuments and Historic Buildings to H.M. Office of Works and Public Buildings.

A most interesting paper was read before the Concrete Institute last month on the preservation of ancient monuments, and we give below a short abstract, together with a summary of the discussion which followed. Owing, however, to the shortness of the abstract, many of the interesting points raised and examples given in the paper cannot be reproduced here. Mr. Peers, in the earlier part of the paper, dealt with some of the Roman buildings, and referred to the walls of the town of Caerwent, in Wales, and at Richborough, in Kent. By the courtesy of the Concrete Institute we are able to reproduce two of the illustrations shown in the paper.

INTRODUCTION.

It may well seem to members of this Institute that the problems which confront them to-day have little enough to do with the matters on which I propose to speak, and indeed the limitations of material under which the old builders worked confined their ideas within much narrower bounds than ours. But the art of construction is a very ancient art, and many of the results of modern science have been anticipated by rule of thumb centuries ago, to be forgotten and rediscovered in different surroundings. A knowledge of such things is essential in dealing with ancient structures, where a mind in sympathy with the methods and ideals of the past is the only sure guide to a right treatment. It will be obvious at first sight that this will limit our choice of expedients; we must rule our treatments which are convenient and advantageous enough in new works, but incompatible with the old. I hasten to add that I do not for a moment suggest that the results ot modern science are inapplicable to ancient buildings, or that we should use no processes which were not known to their builders. Far from it; our claim to be a generation which values its inheritance of history must rest on our employment of all the means which are at our disposal, for the preservation of that inheritance. But they must be used in the right way, and from this spring the limitations which must be observed. An ancient monument, speaking generally, has three precious qualities: its history, its beauty, and its educational value; in attempting to prolong its existence we must not obscure or destroy these qualities.

In a small building, where stresses are neither great nor complex, a weather proof wall face protecting a weak core will often serve well enough for the time, but the ruin or reconstruction of many of our mediæval buildings has followed the adoption of such a principle. Walls were pointed in tolerable lime mortar, but built in nothing but clay, and as long as the pointing was able to keep the weather out, they were able to do the work for which they had been designed. But if, through any settlement or stress, a fracture developed, the masonry had no power of resistance, but fell away and became fit for nothing but pulling down, for lack of sound walling to which to bond a repair. It will easily be seen that it is almost impossible to strengthen such a wall so as to prolong its existence appreciably, without destroying its character, considering that its character is the very source of its weakness.

Another evil, for which at present no adequate remedy has been found, is the decay of stone. This is a particularly important matter, as the loss of the surface of an ancient building, though not necessarily affecting its stability, is disastrous for its history and appearance. The causes of stone decay are various, but damp is an almost constant factor.

SOME EXAMPLES OF THE REPAIR OF ANCIENT BUILDINGS.

I shall now propose to invite your attention to some typical examples of the repair of ancient buildings, carried out during the last five or six years.

Richmond Castle.—I will take the repair of the east curtain wall of Richmond Castle, Yorkshire. This is part of the oldest masonry in the castle, having probably been built within ten years of the Norman Conquest. The site of the castle is a spur of rock overlooking the river Swale, and the levels fall quickly on the west, south and east. The walls are founded on the rock, except on the east side, where a section showed that below the surface soil there is a 9-ft. layer of brown clay resting immediately on 5 ft. of blue clay. Below this is a bed of gravel, 8 ft. thick, and again below the gravel more brown clay, the rock being only reached at about 30 ft. These beds

RICHMOND CASTLE.
Cracks between East Curtain and Fallen Tower.

are set with a considerable downward slope towards the east, and form a natural drainage line for the castle area, so that they are constantly wet, and the upper layer of brown clay tends to slide on the blue clay beneath it.

For reasons of defence it was necessary for the Norman builders to carry the east wall of the castle along this line, in spite of the unsatisfactory foundation, of which they were well aware. To counteract the tendency to slide they cut through the brown clay a trench 15 feet wide carried down to the blue clay, into which a number of wooden piles were driven. These were about 3 ft. 6 in. long by 3 to 5 in. in diameter, and were evidently cut on the spot, being of various woods such as birch, holly, etc. Where the blue clay was thin they entered the gravel below, but this was evidently by chance and there was no attempt to reach the gravel in every case. The object of the piles was to consolidate the foundation, the upper part of the blue clay being very soft from the constant draining of water over it; in some places the whole bed of the foundation trench was piled, in others only a narrow band of piles ran along its outer side, the rest of the clay being presumably considered hard enough for the work it had to do. How soon the wall began to fail it is hard to say, but an extant survey of 1538, when the castle was rather more than three and a half centuries old, mentions that part of it was then overhanging. The greatest stress came on the line of natural drainage, as might be expected, and probably within a century of the date of the survey mentioned the tower which here projected from the wall heeled over and tore away, causing great longitudinal rents in the masonry, the fractures following the line of the chases for the beams. The wall itself was similarly dislocated, and began to move downhill at the same time, leaning forward dangerously as it did so. At its extreme point of movement the wall has moved 4 ft. from its original line, and overhangs as much as 28 in. The tower has moved 6 ft. downhill, and but for some old underpinning would have fallen into the castle ditch.

The repair by the Ancient Monuments Department began in 1912. The origin of the trouble being the wetness of the foundation, the first step was to collect the water into a channel and prevent it spreading along the line of the wall. This carried away the greater part, leaving enough to keep the clay subsoil damp and so to prevent any shrinkage, but the more serious question of anchoring down the foundation of the wall remained to be dealt with. To underpin the wall was not enough without some form of buttressing, which, if only for appearance sake, could not be allowed to show above the ground level. Mr. F. Baines, the architect in charge, therefore decided to put in a line of sheet piling in front of the weakest part of the wall, at 3 ft. 6 in. from its outer face. The piles were 30-ft. steel interlocking piles, and this length was found to be more than enough to reach the underlying rock. These being driven, the clay and pebble foundations of the wall, with the layer of blue clay beneath, were removed in 4-ft. lengths and replaced by concrete bedded on the gravel and pinned up to the underside of the old lime-mortar-built masonry, a height of 14 ft.; this foundation was carried back for about three-quarters of the thickness of the wall, and brought out to the line of the piles; at the same time a bank of concrete, 7 ft. deep by 2 ft. thick, was set against the outer face of the piles to counteract their tendency to spring at the top.

To attempt to rebuild the overhanging wall tops was out of the question, as the history and authenticity of the masonry would have been entirely destroyed in the process, and it was also clear that the wall was massive enough, when properly strengthened, to resist the strain of the leaning stonework. The rents in the base of the wall, and the hollow chases left by the rotting of the bond timbers, were, therefore, filled in solidly with concrete, while the dislocated masonry of the upper parts was secured by bonding stones at intervals, the voids being filled in with loose stone which was afterwards solidified by grouting with a machine at a pressure of 30 lb.

In addition to the loss of a part of its fabric, there are minor losses, inevitable in the repair of any old building. Centuries of neglect have allowed the rain to soak into its walls and plants and bushes to grow upon them, thrusting their roots deep into the masonry and pushing the stones apart. The mortar has gradually yielded to damp and frost and crumbled to dust, or has fallen out, leaving the empty joints to act as channels for rain water. All decayed mortar and earth must be raked out of the joints to a depth sometimes of a foot to 18 in.; the roots must be pulled out, the voids filled and the facing masonry pointed to keep the wall waterproof. Very little of the old pointing, if it survives at all, will be sound enough to do its work, and as a result nearly the whole of the joints in the walls will be new, and until their newness has worn off the general effect will be far less picturesque than before. The surface of the mortar joint is therefore of great importance, and it may be well here to describe the practice of the Department in raking out and repointing. All pointing, except on horizontal surfaces and wall tops, is in lime mortar, hydraulic limes being used, as for example, in England, blue lias lime from Leicester or elsewhere; in Scotland, Arden lime; in Wales, Aberthaw lime. The sand is to be as coarse and sharp as possible, and in order to bring it to the surface of the joint it is the practice to spray the joints with water before the mortar is set, in order to wash away the particles of lime and leave the coarse grit exposed. If the joint is more than 3 in. deep, it is backed with cement mortar up to 3 in. from the face to avoid the drawbacks of the very slow setting of a large body of lime mortar. Cement pointing is to be avoided because of its colour and its hard and inelastic nature, and therefore greater tendency to crack away from the sides of the joint when set. On wall tops, however, and horizontal ledges it must generally be used, as lime mortar in such places is liable to get soaked with rain and in consequence to break up in frosty weather. If cement is used with a very coarse pebbly grit, breaking up its surface as much as possible, its ugly grey-white colour is less noticeable.

Jedburgh Abbey Church.—An important piece of work which was fortunately well advanced when the war broke out is the repair of Jedburgh Abbey Church. The danger here, and it was very considerable, arose from the building of the 12th century tower in the "core and facing" construction.

Jedburgh Abbey was founded by David I. of Scotland in 1118, when he was as yet only Prince of Cumbria, but was refounded by him in 1147, and it is to this latter date, or soon after, that the earliest parts of the present church belong. The church is

JEDBURGH ABBEY, May, 1914.

This photograph shows fractures on S. face of N.E. pier where the rubble casing was removed. This portion of the pier is in a crushed and very shattered condition. The fractures from the capital to the spring of the arch above are merely filled up with surface grouting.

cruciform with a tower over the crossing, and was originally designed with a short eastern arm of two bays and probably an apse, transepts with eastern apsidal chapels, and a nave of nine bays. The northern crossing arch with the north-east and north-west piers, and the masonry for some feet above the crown of the arch, being part of the original work, have failed under the weight of the later masonry, and have only been preserved to our time by the blocking of the arch as high as its springing with a solid stone wall. The old wall core is of very poor quality, a mass of unbedded rubble in weak lime mortar, and the crushing weight of the tower has come on the stone facings, which are only a few inches on bed, and as is so often the case with old masonry, taper inwards from their squared outer faces. The cause of the failure was clearly the weakness of the core; if it had been able to do the work of carrying the superstructure —a work which, it must in justice be added, it was never intended to do—the shallow facing stones would have served their purpose very well. The alternatives were to take down and rebuild the tower with stronger material, or to replace the old core with something better. There could be no doubt as to which was the appropriate treatment, when tested by the rule that the greatest possible amount of old work must be preserved, and the process adopted was to remove the old core piecemeal from the foundations upwards, and replace it with solid concrete. This was naturally a risky and difficult work, but the scheme devised by Mr. Baines, the architect in charge of Ancient Monuments, was carried through successfully and the new concrete core has been carried up to meet the 15th century masonry above.

Before anything could be done it was, of course, necessary to shore up the tower, the north, east and west arches being centred, and the north wall, which, as already said, was in the most unstable condition, steadied by shores from the north transept walls.

The process of re-coring was as follows:—A small section of facing stones at the base of one pier was carefully removed to a height and width just sufficient to allow access to the core within, and for greater security against possible movement of the face, screwjacks were inserted and tightened up to steel plates on the underside of the stones at the top of the opening and on the upper face of the stones at the base of the opening. With the core the danger of a fall of material was naturally to be feared directly any part of it had been hollowed out and removed. Steel plates 4 in. wide and ¼ in. thick were therefore provided, with one pointed end, which could be driven into the wall core and temporarily supported at the outer end, being tightened up with folding wedges as required. A start being made on one face of the pier, the core was removed over about half its area, in heights of a few feet at a time, and replaced by concrete, which was put down in layers, so planned and stepped that each additional layer should be overlapped and bonded to subsequent layers, avoiding any danger of a straight joint in the new filling of the piers. Steel rods were also used to tie the blocks together, being embedded in the concrete as it was laid in. The old core was removed up to the backs of the ashlar facing, the joints of which were thoroughly cleaned out and tamped in cement mortar at the same time. One side of the pier having been treated in this way, the other side was then taken in hand from below upwards, each piece of new core being filled in carefully to the line of that already in place, and the ashlar facing reset as the work went upwards. So the work was carried up into the haunches of the crossing arches, where the remains of the 12th century triforium passage were found built up in the heart of the wall. The 15th century builders had filled them in for strength, and it was reluctantly decided that it was unsafe to open them out again; they were therefore built up solidly in concrete.

It would be possible to multiply instances, but I hope that those which I have described will sufficiently show the application of the principles laid down at the beginning of this paper. In such a meeting as this it is not necessary to dwell on the absolute need of the best materials and the most careful workmanship; the members of your Institute can learn nothing from me on that head. But of all structures which come under our care to-day, a ruin needs the most painstaking treatment; being exposed on all sides to wind and weather, and weakened by the loss of much of its masonry, it exists in a condition for which it was never designed, and against which all our experience is not yet fully adequate to protect it.

Of all the lessons that the war has taught us, the greatest, perhaps, is that we should be well prepared for our future tasks, whatever they may be, and the making good of the losses inflicted on the historical monuments of the world will not be the least of such tasks.

DISCUSSION.

The President (Mr. F. B. Wentworth-Sheilds) said they had made something of a departure on that occasion, they had got out of the ordinary rut, so to speak, but he thought they would all agree that it had been a very successful departure, and they had been delighted to hear of the work carried out by Mr. Peers on old and well worn buildings. In all departments of life there was an enormous amount to be learned from history, and they were much obliged to Mr. Peers for telling them in so interesting a way of the work he had so ably carried out.

Mr. W. G. Perkins (District Surveyor of Holborn) said he had had a great deal to do with buildings in a ruinous and dangerous condition, but his function had been to condemn them to be taken down. Mr. Peers had borne out entirely what he had long maintained, that it was the habit of the old builders to have a facing of superior work, and then filling in with work of an inferior description. He knew of an instance where between two skins of 10½-in. brick-work the space had been filled in with chips and stones bonded together with builders' laths! He had also known cases where wooden posts were enclosed and surrounded by brickwork, the consequence being that when the wood decayed there was a subsidence. The cases Mr. Peers had mentioned were entirely in the country, but he wished to ascertain his opinion as to the effect of motor vibration if those buildings had been situated in towns. He quite agreed with the President as to that gathering taking them out of the usual rut, but the paper had been so interesting that they were fully justified in making the departure. It was his pleasure to move a vote of thanks to Mr Peers.

Mr. F. W. Troup, in seconding, said he had some experience of dealing with ancient buildings, and he was visiting Colchester when the work was being carried on. It had just begun and he felt very doubtful about the proceedings at the time, but there was no question that the Office of Works had taken the right course.

Mr. Archibald Scott, who was invited by the President to speak, said as a member of the Office of Works it would hardly become him to say anything as to the way in which the work of that Department was carried on. He had not much to do with ancient monuments, and to him the paper had been a sheer delight. What struck him most was the way in which the root of the trouble was got at immediately, and that there was no patching of any kind.

Mr. W. A. Forsyth said the country was very fortunate in having such an efficient Department. For many years they had suffered from the want of it. Now they seemed to be doing the work in a practical commonsense way, and they were especially fortunate in having men of skilled knowledge at the head of affairs. As an architect he knew what the work meant, and when they recalled what had been done in their own and other countries in the way of unsympathetic restoration they rejoiced at the change for the better. Speaking of the effect of iron in ancient buildings, he said it invariably caused great trouble in the way of disintegration and endless damage which often did not show for many years. He had recently visited St. Paul's Cathedral and seen the damage done by the rods and bolts put in by Christopher Wren. In the dome six months ago he saw an iron band running round near the top which had set up rust and caused considerable damage. That suggested something which was not outside the sphere of that Institute, viz., the use of reinforced concrete. He suggested that such buildings as St. Paul's Cathedral should be made accessible to ordinary students. He considered that there was a danger of using too much steel in reinforced concrete. With reference to re-pointing, he contended that the old pointing should not be hacked out as he noticed the Office of Works doing it at the Essex restoration they had seen illustrations of. He observed, however, that the walls were finished and seemed to be done well, but he would like to ask Mr. Peers how the tops were finished off? In regard to weak cores they had to remember that in the Eastern Counties the old builders were bound to use rubble, it was a practical necessity. Rubble cores were liable to settle, and nearly all the failures occurred in the early days of the buildings.

Mr. W. J. H. Leverton recalled that some years ago there was a discussion in the Press as to whether the restoration of ancient buildings was a subject for engineers and not for architects. Mr. Peers had knocked that on the head entirely, and had shown that a knowledge of history was required. In one case Sir Gilbert Scott had some bits of masonry put carefully away, and it was found that they formed the ancient shrine of St. Albans. But for his archæological knowledge they might have been broken up for use as cement. With reference to the rusting of iron in old walls, they were assured that there was not the slightest possibility of steel rusting in reinforced concrete. Were they sure of that? If not, there would be a terrible awakening later.

Mr. Ewart S. Andrews was fully in accord with all that had been said about the paper. It was just the kind of thing they wanted to get out of the ordinary ruts, and as an engineer he had enjoyed the subject very much. One thing that struck him forcibly was the sympathetic treatment which was so necessary for such work, and which had not been observed at all in the past. In many of their old cathedrals no attempt had been made by successive builders to follow the same style as the original. Perhaps half a window would be blocked out, and in many cases there seemed to have been a ruthless want of consideration for the work of others. The task of preserving ancient monuments was very necessary and valuable.

Mr. J. Ernest MacDougal, B.Sc. (Glasgow), added his tribute to the work of the institute, and said they had to bear in mind that the work they had heard of that evening dealt with architectural structures which needed the combination of (1) the historical antiquary; (2) the civil engineer; (3) the architect. He had been especially pleased at hearing of the work carried out by the Department, for he always had a feeling that often more harm was done than good by restoration, but after the lecture that evening he had come to the conclusion that they were fortunate in having such gentlemen engaged upon the work.

The President (Mr. F. E. Wentworth-Sheilds) said before calling on Mr. Peers to reply, he would like to make some observations. Mr. Leverton had cast a gibe at the civil engineer, and being a civil engineer himself he felt bound to stand up for his profession. He agreed that they should not employ civil engineers any more than they would have an architect for Quebec Bridge. But he recalled the fact that Sir Gilbert Scott when asked to repair the spire of Salisbury Cathedral, told the Dean and Chapter that though a knowledge of architecture was essential yet the knowledge of a civil engineer was also necessary, and he advised that one should be called in, and then between them they would repair the beautiful spire. He (the President) happened to be the son of the man who was called in on that occasion, and so the fact was imprinted on his memory. They might fairly say that the three excellent qualifications necessary for work of restoration were combined in Mr. Peers. As an engineer he had been interested in the paper, which not only treated the subject from the historic and æsthetic points of view and was deeply antiquarian, but it also dealt with the kind of buildings favourable to longevity. As had been pointed out, the great enemy of buildings was damp, and he had been impressed with that in Egypt, a rainless country. In the district where he was they only had one shower of rain in a year, and unfortunately he was away at the time. Practically there was no deterioration of buildings made from mud bricks, and he had been in a quarry from which stones were taken 2,000 years before, and there were tablets giving the history of the quarry in absolutely perfect condition with no sign of decay. In addition there were designs scratched on the stones still to be seen as clearly as when they were made. That showed how remarkably buildings would preserve in a dry climate. He referred to the fact that as yet no satisfactory solution had been discovered for the preservation of stone, as evidenced by the many experiments made with a view to preserving the stone in the Houses of Parliament. That was curious and interesting, if disappointing, and would be a most important discovery if they could in any way get stone and concrete absolutely watertight. In a very dry situation rust was unlikely to happen, and in very old concrete when cut to pieces iron rods had been found in perfect preservation. But there were circumstances in which steel embedded in concrete had rusted through damp air getting in. If some protective fluid could be discovered to prevent damp getting in there would be nothing to fear in that direction.

Mr. Peers, in responding, said he did not know of any building under their charge which was subject to motor vibration, which would be extremely difficult to combat once disintegration had set in. It was more a question of wind vibration they had to consider. With regard to digging and pointing he was against doing that, but there were cases where it was necessary, as in the Colchester restoration, where the pointing was in an appalling condition. To leave anything at all it was sometimes a case of having to destroy, and at Colchester it would have been of no earthly use leaving in the dusty deposits behind the pointing, the walls being so thoroughly weak in construction. As to the weather ravages the only way to prevent that would be to put a roof over the monuments and ruins, otherwise in time the effects of the weather was bound to destroy them. Egypt was, of course, remarkable for the way in which buildings were preserved. Walls with nothing but a face of wrought stones filled in with chippings thrown in without mortar, so that really there was no core at all, stood for ages, though they were hollow, and it was a wonder how they stood at all. But they all knew what an excellent thing was the absence of rain.

NEW WORKS IN CONCRETE

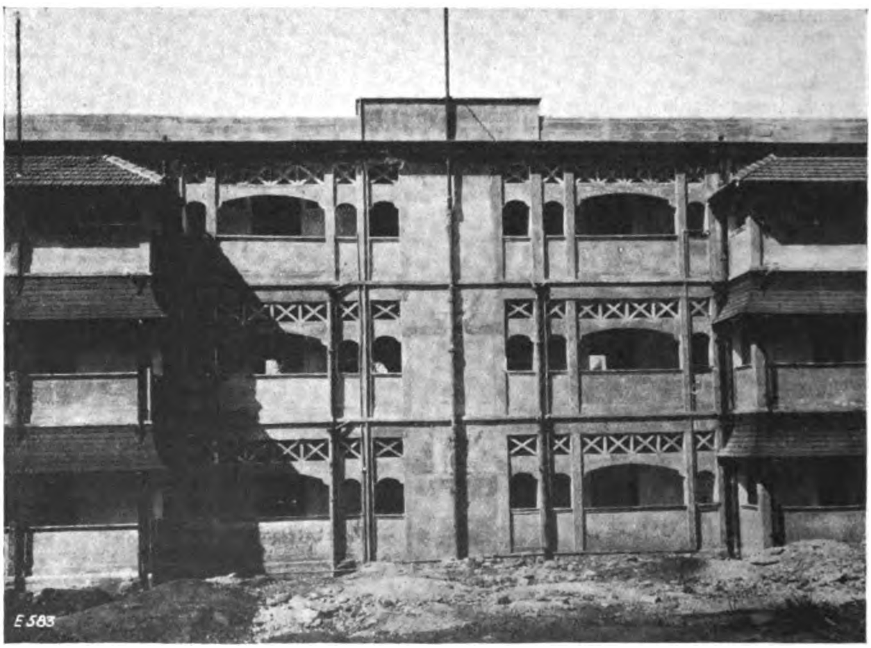
AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

CHAWLS FOR MILL WORKERS AT SPRING MILLS, NAIGAUM ROAD, DADAR, NR. BOMBAY.

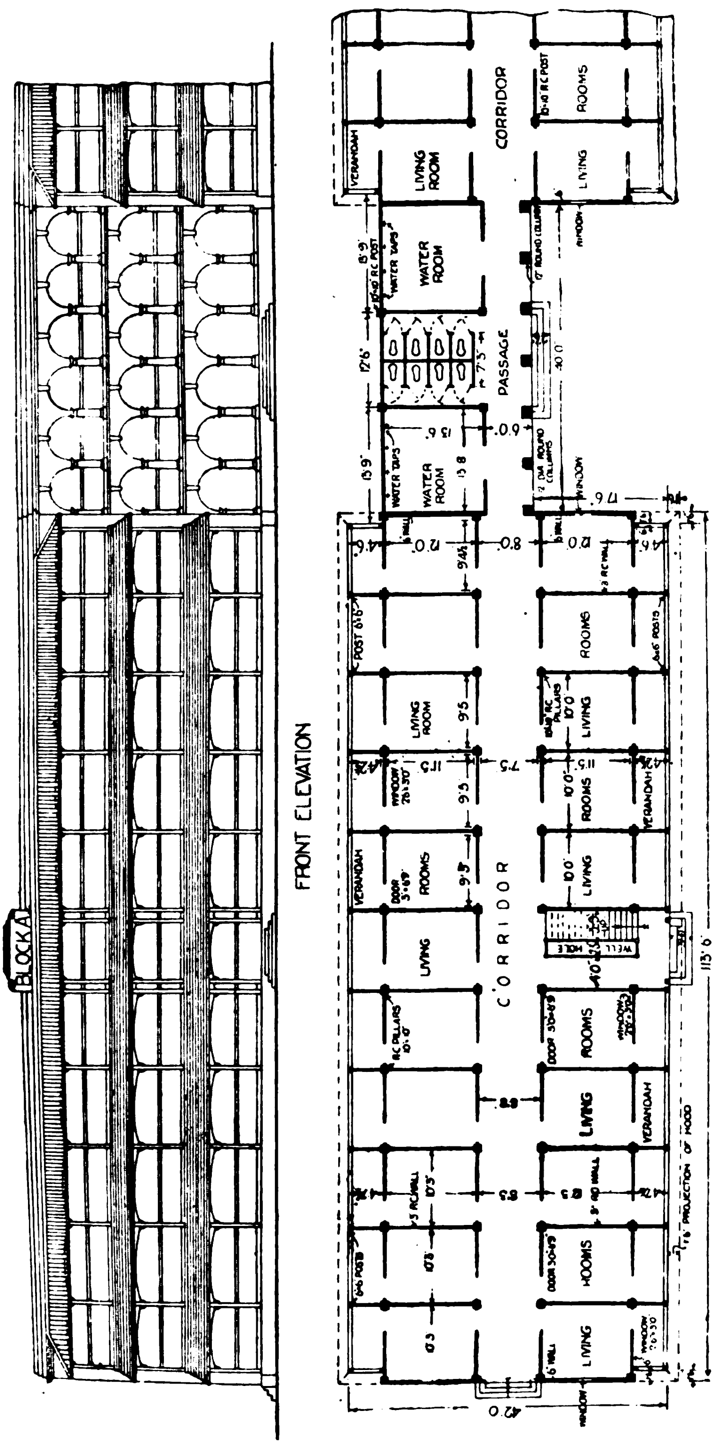
THE chawls described here are under construction to house mill hands of the Spring Mills, under an arrangement between the Bombay Improvement Trust and the Mill Owners' Association. The total estimated cost of these chawls will be £25,200 exclusive of the cost of the land. The work was begun in the middle of 1915, and at present Blocks A and B are completed, and the next three blocks are under progress. These buildings will provide accommodation for 2,000 persons, there being about sixty-three rooms to each block, each room housing four people.

The construction is wholly of reinforced concrete, the reinforcement consisting of round steel rods. The rooms are arranged in two rows, one at the front and the other



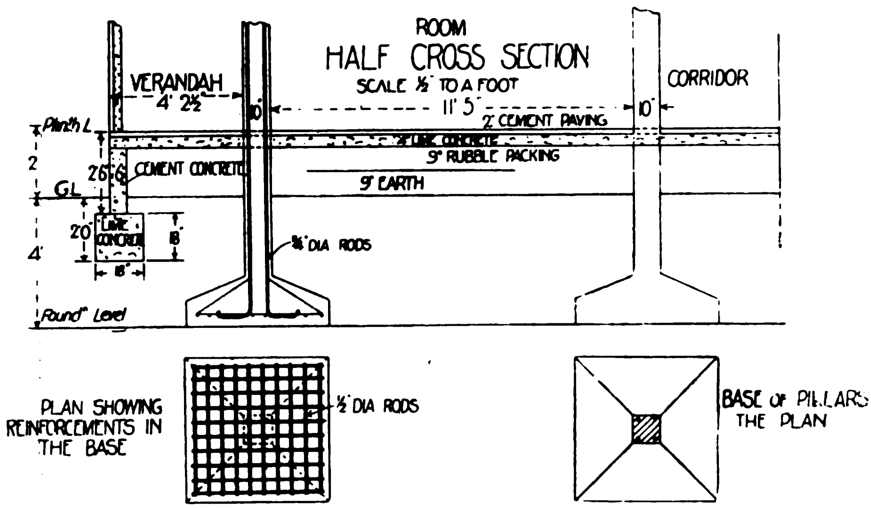
REINFORCED CONCRETE CHAWLS FOR MILL WORKERS, SPRING MILLS, NAIGAUM ROAD, DADAR, NR. BOMBAY.

at the back, with a central corridor 8 ft., and with a verandah 4 ft. 6 in. wide for every room at the back to serve the purpose of a kitchen and nahni. The rooms are 12 ft. by 10 ft. and 10 ft. in height. The pillars for the rooms are 10 in. by 10 in., reinforced with four rods ¾ in. diameter with spiral reinforcement of ⅛-in. steel wire. The foundation for pillars is 4 ft. 6 in. by 4 ft. 6 in. square filled in with cement concrete 9 in. deep, with a grillage of ½-in. steel rods at the bottom and then brought to 10 in. by 10 in. size at a height of 1 ft. 6 in. from the base. The height of floor is 10 ft. The beams are all of reinforced concrete, the reinforcement consisting of round mild steel rods

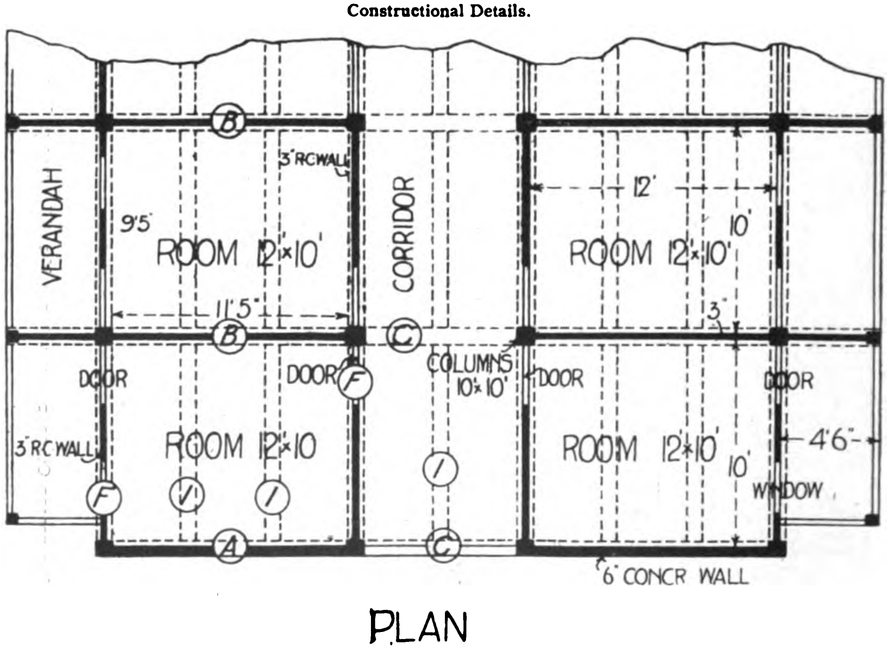


REINFORCED CONCRETE CHAWLS FOR MILL WORKERS IN INDIA, AT SPRING MILLS, NAIGAUM ROAD, DADAR, NR. BOMBAY.

and of expanded metal, for shearing at the end $\frac{1}{3}$-in. rods. The joists are also of reinforced concrete $4\frac{1}{2}$ in. deep. The beams and joists are all designed as T-beams, and while constructing, these beams and floors are filled in at the same time. The reinforcement for floors consists of $\frac{1}{2}$-in. steel round bars, placed 4 in. centre to centre with

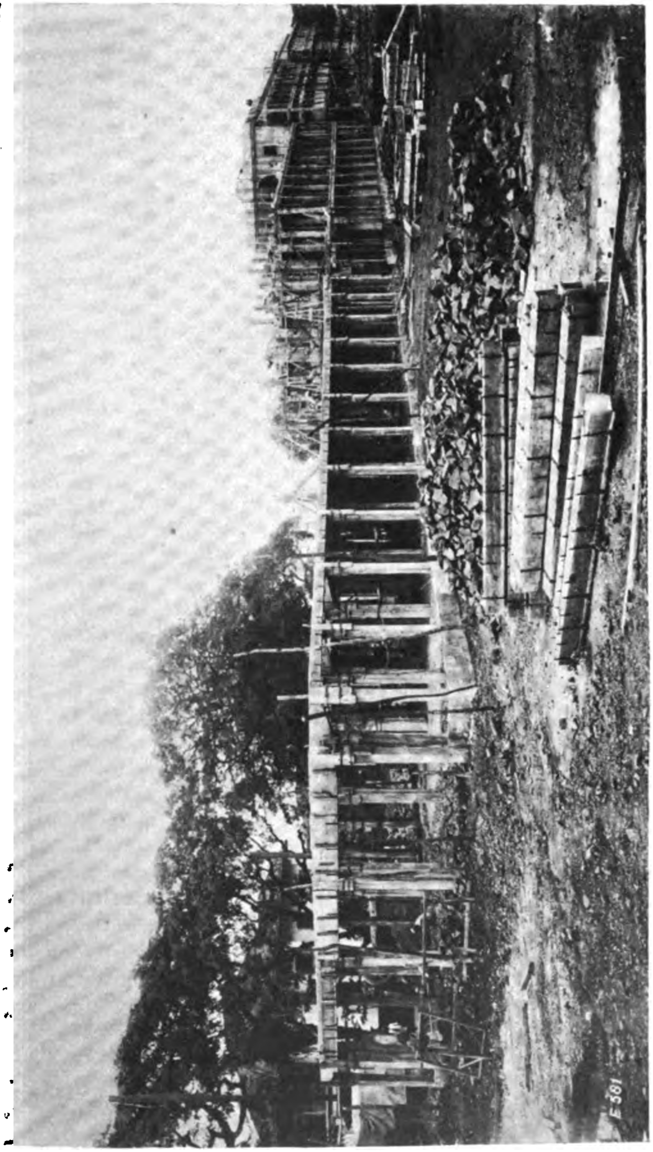


Constructional Details.



Reinforced Concrete Chawls for Mill Workers in India, at Spring Mills, Naigaum Road. Dadar, nr. Bombay.

transverse bars of the same size at 8 in. centre to centre. The flooring is $3\frac{1}{2}$ in. thick with effective depths of 3 in. The partition walls are constructed of reinforced concrete of 3 in. thickness with reinforcement consisting of $\frac{1}{8}$-in. steel wire, tied tight diagonally. In order to tie these wires for partitions, arrangement is made to keep the hooks in the beams and floors at the time of construction. The partitions are constructed solid to a height of 7 ft. with the upper 2 ft. closed with expanded metal, so as to facilitate through ventilation. The shutters consist only of teak wood, and are fixed with pivots working in a C.I. cap at the bottom in the floor and in a hole in the flat iron at the top. In the rooms arrangement is made to have two reinforced concrete shelves 5 ft. by 1 ft. by $1\frac{1}{2}$ in. thick, with pegs at the bottom to hang clothes on.

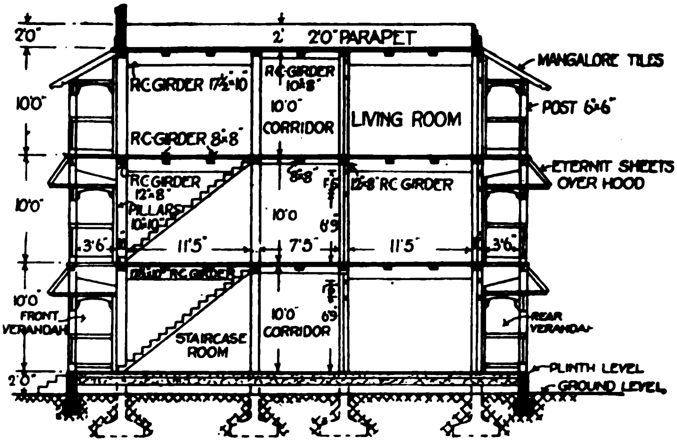


Buildings in course of construction.

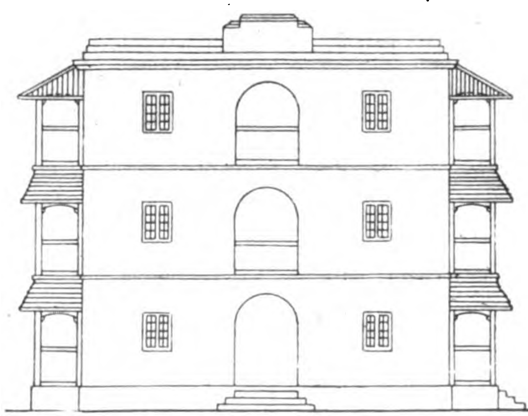
REINFORCED CONCRETE CHAWLS FOR MILL WORKERS IN INDIA, AT SPRING MILLS, NAIGAUM ROAD, DADAR, NR. BOMBAY.

The verandah at the back is divided by partitions at every room and is supported by 8 in. by 8 in. reinforced concrete posts with reinforcement of $\frac{3}{8}$ in. rods. The hood to the verandah consists of $\frac{3}{4}$ in. teak planks bolted to iron brackets, which in themselves are bolted to the beams at top and to the arch at the bottom. While filling in the beams and arches arrangement was made to put in bolts for this purpose at the proper place.

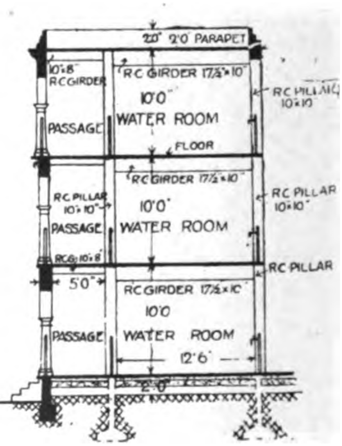
The lavatory block and bathrooms are placed between two blocks. There are four bathrooms, and taps are provided outside the baths. The W.C.s are constructed on intermediate water carriage system.



CROSS SECTION



SIDE ELEVATION



SECTION THROUGH WATER ROOM

Reinforced Concrete Chawls for Mill Workers in India, at Spring Mills, Naigaum Road, Dadar, nr. Bombay

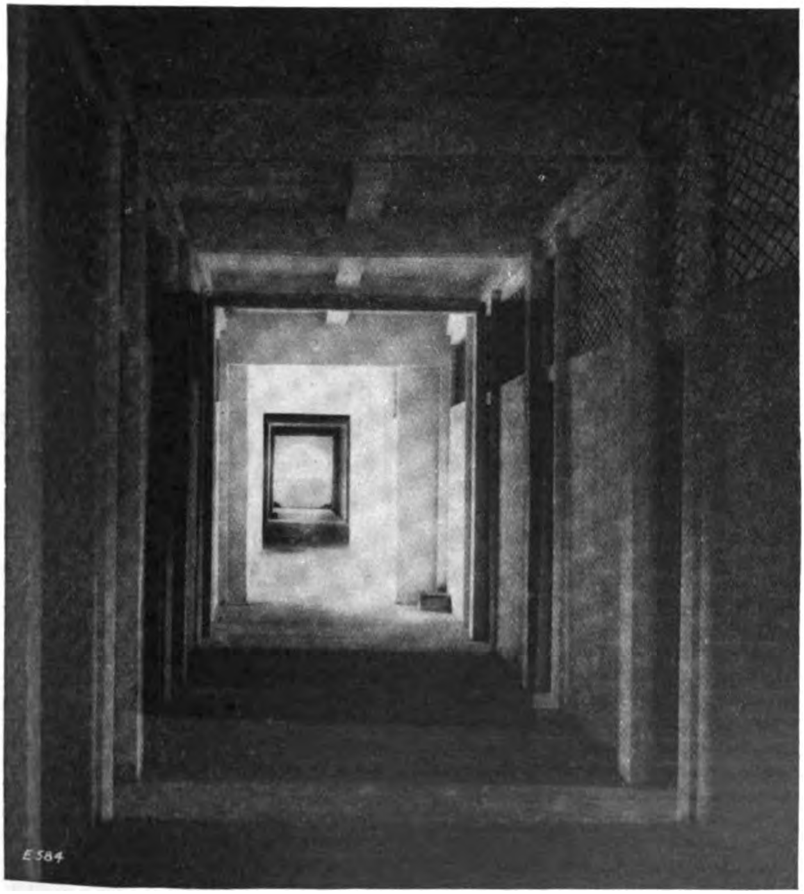
The roof and storage tank are perfectly waterproof, and no damp-proofing material had to be used. The verandah roof is of Mangalore tiles with battened joists of teak. The joists are supported in a concrete arch and fixed to it by bolts projecting from the arch at the top.

The roof is constructed in the same way as the floor, but a slope of 5 in. is given from centre of corridor to the sides. The parapet wall is also of concrete and is 2 ft. 6 in.

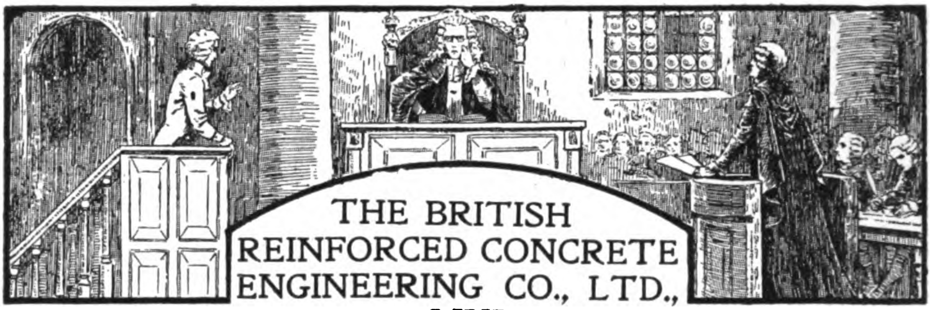
high. The front and side gables were filled *in situ,* with the letters carved in the centering.

The provision of the concrete mixer with hoist arrangement has proved a great economy in time and labour on this work. The mixing is thoroughly uniform, the whole floor, 113ft. by 42ft., could be easily filled in in two days, including all beams and joists, and including the staircase, which consists of reinforced concrete with angle iron to serve the purpose of hand rails. The staircase reinforcement consists of steel rods and expanded metal at the bottom. The steps are provided with L-iron at the nosing to prevent them from breaking off.

The plans for these buildings were designed by Mr. J. F. Watson, B.E., A.M.Inst. C.E. (at present serving with the Royal Engineers in France), and we are indebted for our particulars and illustrations to Mr. F. G. B. Hawkins, A.R.I.B.A., officiating Trust Engineer to the Bombay Improvement Trust.



View of Passage dividing the double row of rooms.
REINFORCED CONCRETE CHAWLS FOR MILL WORKERS IN INDIA, AT SPRING MILLS, NAIGAUM ROAD, DADAR, NR. BOMBAY.



THE BRITISH REINFORCED CONCRETE ENGINEERING CO., LTD., *v.* LIND.*

The following short notes on a legal action dealing with the Rights of Employees and Employers in Inventions may be of interest.—ED.

In this action the plaintiffs claimed a declaration that Letters Patent, No. 22,663, of 1914, granted to the defendant for "Improvements in ferro concrete linings for pits, shafts, tunnels, and the like," was their sole property, and that the defendant held it as trustee for them.

In support of their claim the plaintiffs alleged that at the time the defendant applied for the patent he was in their employment in the capacity of assistant engineer. As such he was directed by the plaintiffs to report on any enquiry received from the Powell-Duffryn Steam Coal Co. respecting the lining of the headings in their coal mine, and to design a suitable lining for the purpose.

The defendant alleged that he was not engaged as an assistant engineer but as a draughtsman, and that throughout his employment he carried out the duties of an ordinary draughtsman under the control of the plaintiffs' chief engineer. With reference to the Powell-Duffryn Co.'s inquiry, he devised various schemes, and while so engaged invented the method of supporting the roofs and walls subject to large compressional forces. He received no assistance from the plaintiffs' engineer or any other person in making the invention; and he denied that the plaintiffs were beneficially entitled to it.

The case was tried by Mr. Justice Eve who, in giving judgment, said the question to be decided was whether it was inconsistent with the good faith which ought to be inferred as an obligation arising from the contract of service, that the defendant should hold the patent otherwise than as trustee for the plaintiffs. It did not depend wholly upon the terms of the contract of service, regard must be had to the circumstances under which the invention was made. The terms of his employment obliged the defendant to place the best scheme he could at the disposal of the plaintiffs, and therefore they ought to enjoy the benefit of the patent. Accordingly, while expressly exonerating the defendant from any unworthy motive, he gave judgment for the plaintiffs with costs.

The case illustrates one phase of a comparatively little understood branch of patent law. Generally a patent granted to an employee is his sole property, the employer having no right to it at all.

Mr. Justice Byrne, in the case of *The Worthington Pumping Engine Co. v. Moore,* endorsed those cases which have established that the mere existence of a contract of service does not *per se* disqualify a servant from taking out a patent for an invention made by him during his term of service, even though the invention may relate to subject matter germane to and useful to his employers in their business; and that, even though the servant may have made use of his employers' time and servants and materials in bringing his invention to completion and may have allowed his employers to use the invention while in their employment.

If under such circumstances the employer were to take out the patent in his own name it would be bad and liable to be upset at any time on the ground that the grant was obtained on a false declaration and that the grantee was not the true and first inventor. And this would still

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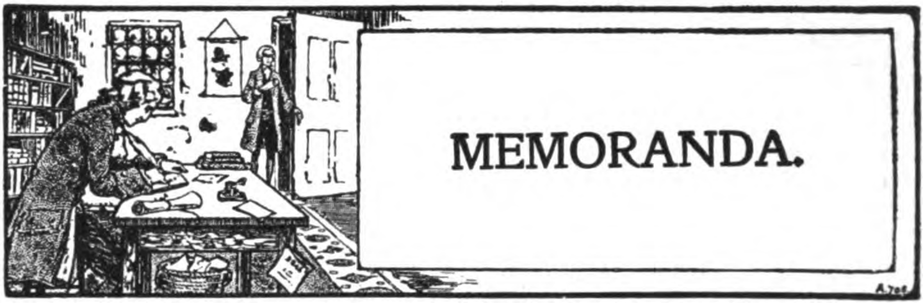
* Reported by Douglas Leechman, A.I.M.E., Barrister-at-Law.

be true even if the master directed the servant to make the invention, as witness, *In re Marshall and Naylor's Patent.* In this matter Marshall and Naylor were directors of a company and Wash was one of the workmen. Marshall asked Wash to invent a tap which, from supplies of steam and cold water, would give a delivery of hot, cold, or warm water as desired. Wash schemed out a tap, prepared the drawings and models, and perfected the device. Marshall paid him for overtime work on the models and then, in conjunction with Naylor, applied for, and was granted, a patent. Then Wash applied for revocation of the patent on the ground that he was the true and first inventor, and that the patent had been obtained in fraud of his rights. His application succeeded, and he was put in a position to have a patent granted to him in lieu of the one revoked.

But where the servant is from the nature of his employment bound to use his qualifications to the best of his ability in solving the problems arising in his employers' business, he is not entitled to patent for his own benefit such inventions as he may make under these conditions. *Edisonia, Ltd., v. Forse,* a case cited in the course of the hearing of *The British Reinforced Concrete Co. v. Lind,* is a good example of this aspect of the subject. Forse was employed by Edisonia, Ltd., first as a workman and then as manager of the department devoted to moulding the cylinders for phonograph records. While engaged in the latter capacity, Forse and the general manager took out, through the company's patent agent, and at the company's expense, two patents for improvements in the manufacture of the cylinders, the inventions having been made partly or wholly by Forse. The general manager did not claim any beneficial interest in the patents and assigned his share to the company. The company asked for a declaration that Forse held his interest in trust for them and made other claims which need not be dealt with here. Mr. Justice Warrington held that Forse was employed to do his best by his skill, knowledge, and inventive powers to improve the manufacture of the cylinders, that he made the inventions in the execution of his duty, receiving suggestions from the general manager, and that on the facts as to the taking out of the patents, apart from any general inference to be drawn as to his duty to the company, he was a trustee for the company. The declaration was, therefore, made.

Lastly, one may consider the position of the parties where the employer himself makes the invention, and then instructs assistants to work out the details. If the assistants make inventions which further the carrying out of the main invention they are the property of the employer. But if the main principle and object of the invention were not complete, or the assistant's discoveries were of wider application, considerable difficulties might arise. Each case would have to be decided on its own facts.



Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Reinforced Concrete Props for Collieries.—The cost of timbering on the main roads at Arley Colliery, near Coventry, always a very heavy item, became a factor for serious consideration when substantial advances in the cost of timber had to be met.

The trouble in the main roads is mainly due to "wet rot," this being particularly bad in the return, so that the timber had to be renewed at least every six months, and in certain parts of the road much more frequently.

Immediately upon the outbreak of hostilities Mr. E. C. Knox, colliery agent, decided to experiment with reinforced concrete, the outcome of which has been the evolution of a particularly serviceable prop.

The props, which are, of course, moulded on site, are 8 ft. long by 8 in. square, with the corners taken off. The reinforcement consists of twelve strands of wire rope, $\frac{3}{8}$ in. diameter, placed in four layers of three. The props are allowed from four to six weeks for seasoning, during which time they are well watered each day. The concrete is made of a mixture of three parts of granite chippings, one part of riddled red ashes, and one part of cement. The cost of a prop, with cement at 45s. 6d. per ton, is 1s. 9d., and the weight per foot 42 lbs.

The length of road was timbered with the cement props some two years ago, and so far no renewals have had to be made. A length of some 200 yds. of road has been timbered with the props, and the system is being extended as the wooden props require renewal *(from the "Colliery Guardian").*

Reinforced Concrete at Kingston Dock, Glasgow.—At a recent meeting of the Institution of Engineers and Shipbuilders in Scotland, Mr. P. D. Donald gave some interesting particulars regarding the construction of Kingston Dock since the fire in June, 1914.

The Trustees found themselves faced, as a result of the fire, with the question of a complete restoration of the dock, and, after various proposals had been considered, it was decided to reconstruct with concrete walls—thus avoiding the danger which had caused the fire—and to form the sub-structure of concrete deposited under water within lines of sheet piling.

This decision was reached largely because of the fact that the lower portions of the new front and middle piles at the South Quay were intact, and could be worked in with the new piling to form the face and back of the proposed concrete sub-structure.

The plan adopted for the South Quay included a line of new timber sheeting 10 in. in thickness and 35 ft. in length, driven in bays between the front main piles already in, and a line of temporary sheeting 6 in. in thickness and 32 ft. in length, driven between the piles of the middle row. The cut-off of the front sheet piling was at 3 ft. above low water.

By means of temporary divisions made with 6 in. sheet piles, pockets of suitable length, mostly of 64 ft., were formed. These were excavated by grabs to a depth of 21 ft. below low water and filled in with 6 to 1 concrete, deposited under water by means of wooden hopper boxes.

On the top of the new front sheeting and temporary sub-structure, at 3 ft. above low water, a granolithic string-course was laid. This course is 2 ft. 6 in. on bed and 18 in. in depth, and the face is curved outwards, so that the front upper edge projects 6 in. beyond the face of the sheet piling.

From the string-course upward the superstructure was formed in 7 to 1 concrete, with a facing 6 in. in thickness of granolithic concrete. The superstructure was built in lengths of about 64 ft., and it has a batten of three-quarters of an inch per foot. The thickness of the wall, which is 10 ft. at the top of the course, is reduced at the back by two steps of 21 in. and one of 18 in., so that it is 4 ft. at the underside of the cope.

The wall is finished with a concrete cope 3 ft. broad on the bed and 15 in. deep at the front. The cope blocks were moulded in lengths of 4 ft., and the front face and top surface have a facing of granolithic concrete 6 and 4 in. in thickness respectively.

At distances of 32 ft. concrete piers, 4 ft. by 3 ft., were corbelled out from the back of the quay wall, so as to form foundations for the steel columns of the goods shed.

The superstructure of the South Quay is typical generally of what has been done at the other quays, although there are differences in matter of detail. At the north-east corner of the dock, however, material of a difficult character was encountered, and this rendered necessary special designs in the sub-structure of the quay wall.

The extent of the work done subsequent to the fire may be expressed by stating that the permanent steel piling aggregates over 63,500 cu. ft. of timber, that the excavation under low water amounts to 13,500 cu. yds., the concrete in the sub-structure to 25,600 cu. yds., and the concrete in the superstructure to 15,700 cu. yds.

The reconstruction has been carried out to the designs of Mr. W. M. Alston, engineer to the Clyde Trust, and under his superintendence.

Armoury for Mounted Troops.—Reinforced concrete has been extensively used in the construction of a large armoury for mounted troops. The basement and ground floor of the building are of flat slab construction, with two-way reinforcements, and the upper floors are of beam and slab reinforced concrete, carried on steel girder beams spanning from wall to wall. The two most interesting items of reinforced concrete construction are the following:—The main east wall of the building, rising from the terrace level, is carried out over the flat slab on the base course, which is of concrete and reinforced for cantilever action. The balcony round the main riding hall is a continuation of the ground-floor slab, and juts out over the wall of the riding hall as a cantilever. It presents a perfectly smooth appearance on its underside, and is only 4 in. thick at the outer edge.

The bridge to the street is constructed of two segmental reinforced concrete arches 16 in. thick, and carries a deck slab approximately 9 in. thick.

The architect for the building was Mr. James E. McLaughlin.

Joint Committee on Concrete and Reinforced Concrete, U.S.A.—The revised report of the Committee has been published in the December proceedings of the American Society of Civil Engineers, and was presented at their annual meeting in January. Comparing it with the 1912 report, there are few changes in this revised issue. One of the notable differences is in respect of flat slab or girderless floor construction, a point not touched upon in the earlier report. The other points of importance touched upon include a statement as to the precautions necessary for good concrete work. Blast furnace slag is specifically not recommended for concrete aggregate, but, on the other hand, cinders are allowed in reinforced concrete slabs up to 8 ft. span.

Mixing.—In the manufacture of concrete the most definite change is the increase in the mixing period, for a machine mixer, from 1 min. in the old report to 1½ min. in the new for ordinary mixers and 2 min. for mixers of two or more cubic yards capacity. The need for good and thorough mixing is enlarged upon in some detail. The question of water content is touched upon, but definite instructions are avoided. An additional paragraph has been added on the necessary details of spouting concrete. In the paragraph on freezing weather, the use of salt is deprecated. For under-water concreting the drop-bottom bucket is also deprecated.

Design.—As regards design the following changes are noted :—

Under certain conditions the brackets are considered in span lengths of beams. The overhang width of T-beams is increased from four to six times the slab thickness. The load distribution on oblong slabs is changed in formula, though the new formula produces practically the same numerical results as the old. In continuous beams there is one minor change of coefficients.

Columns.—The section on columns has some changes, the first of which is that a definition of a column is changed so that it includes compression members in which the "ratio of unsupported length to least width exceeds about four" instead of as in the old report about six. The second change is that there is no reference whatever made to a hooped or banded column that has no longitudinal reinforcement, and the third change is that the unit stresses in hooped columns (with not less than 1 per cent. and not more than 4 per cent. of longitudinal bars) and (this is added) with hooping steel not less than 1 per cent. of the volume of the concrete shall have a unit stress 55 per cent. higher than for straight-rodded columns, provided the ratio of unsupported length of column to diameter of hooped core is not more than 10 (instead of 8 in the old provision). The old percentage was 45 per cent.

In the section on reinforcing for shrinkage and temperature stresses a paragraph has been added calling attention to the necessity for connecting the various parts of the frame of articulated structures in reinforced concrete.

Note.—With regard to the section on Flat Slab Design, we will reprint this in one of our next issues.

Registration of Business Names Act, 1916.—We are asked by the Press Bureau to draw attention to the fact that registration under the above Act commenced on February 22nd. The prescribed forms of application will be obtainable at the principal post offices gratis.

Any person who carries on a business *as sole proprietor must fill up the prescribed forms*, and applications must be made only on the forms provided through the post office. Those persons required to make a Statutory Declaration under the Act can also obtain the form for this purpose at the post office.

The fee 5s. is to be paid by affixing an adhesive stamp, and forms, when completed, must not be returned to the post office, but sent or delivered to the Registrar of Business Names, at 59, Russell Square, W.C.

As the reception and examination of applications will entail a considerable amount of work, it will be some time before Certificates of Registration can be issued.

Protection of Concrete in Cold Weather.—Experiments have been conducted at the Lewis Institute in Chicago to determine the effectiveness of manure as a protective covering for freshly-laid concrete, to prevent disastrous results in cold weather. In these tests slabs of concrete exposed to outdoor conditions were covered with 2, 4 and 6 in. of fresh manure obtained from a livery stable. The results proved that the 4-in. and 6-in. layers had high protective qualities and were sufficient to afford the concrete a protection against a drop of 25 or 26 degrees in temperature. The manure should not be allowed to come in direct contact with the freshly-laid concrete.

Tests of Concrete Specimens in Sea Water at Boston Navy Yard.—A paper, presented on January 3rd last, by R. E. Bakenhus, M.A., M.Soc.C.E., to the American Society of Civil Engineers, describes a test of twenty-four concrete specimens which were immersed in sea water for seven years. The object of the tests was to determine the action of sea water on concrete specimens of wet and dry consistencies, of various proportions of ingredients, and of different brands of cement, as well as the effect of special compositions.

The methods of mixing, analyses of the various cements, sand, and stone, and the conditions of the tests, as well as all other data having possible effect on the results, are stated in the paper. The information is given in tabular form where possible.

The specimens were examined at intervals of about one year, and record was made of their condition. The results of these observations have been tabulated, and show progressive deterioration of some of the specimens and remarkable durability of others. Recently the specimens were examined with great care, and graded in the order of durability. These results are also tabulated. Independent tabulations are made of the various tests originally planned, to ascertain in one case the effect of wet and dry mixture, in another case the effect of rich and lean mixture, and in others the effects of special brands of cement, and of using lime, Sylvester wash, etc., with the cement.

The results are interesting, and seem to show, briefly:—

(*a*) That the 1 : 1 : 2 mixture is superior to the 1 : 2½ : 4½, and that the 1 : 2½ : 4½ is, in turn, superior to the 1 : 3 : 6.

(*b*) That the wet mixtures are superior to the dry.

(*c*) That the effects of magnesia or alumina in varying proportions are not very marked, and follow no apparent law, although the two most durable specimens are those lowest in alumina content.

(*d*) That extra care in mixing produced decidedly beneficial results.

(*e*) That hydrated lime was of no benefit, but rather a detriment.

(*f*) That the addition of Sylvester wash was harmful; and

(*g*) That the addition of clay to the cement had a slightly beneficial result.

The deterioration occurred between high and low water, and was most marked at mid-tide. Above high water there was little deterioration, and the same is true, but to a less marked extent, of the concrete continually submerged.

The experiments are not sufficiently extensive to warrant drawing final conclusions in all cases, unless confirmatory evidence is available. In utilising the results, the limitations of the tests and local conditions should be taken into account.

Bristol.—The Corporation has under consideration a scheme for bringing water from Cheddar at a cost of £300,000.

Colombia.—The Municipal Council of Bogota has been authorised to raise a loan up to £1,000,000 for the improvement of the municipal tramway and aqueduct, etc.

HOW TO MAKE
CONCRETE ROOFING TILES.

The following notes on how to make concrete roofing and flooring tiles will probably be of special interest at the present time, when other materials generally used for roofing and flooring are difficult and expensive to obtain.—ED.

INTRODUCTION.

HAVING described the machinery, moulds, etc., necessary for the manufacture of concrete blocks, we now propose to deal with the moulds and machinery, and also the making of concrete roofing tiles. For these products it is necessary to have a very sharp, fine, clean aggregate, and also one which is practically non-porous. There are many different shaped concrete tiles now in use, but we propose to deal only with a few of the most popular.

MATERIALS.

The most suitable material for the manufacture of concrete roofing tiles is sharp sand, but finely crushed clinker, free from all dust and impurities, has been used with success, and has in its favour the fact that it makes a lighter tile than sand, or other aggregate. Finely crushed granite and stone chippings, etc., are also suitable.

Grading Materials and Mixing, etc.—The aggregates for concrete roofing tiles must be clean, free from loam, sulphur, and all other impurities, such as were referred to in the "Cleansing of Aggregates," in the article on Concrete Blocks (*October issue*, 1916).

As before mentioned, the most suitable aggregate for this purpose is sand. If from a pit, it should be well washed, to free it from every particle of loam it may contain. It should be a good, coarse, sharp sand, and should pass a $\frac{1}{8}$ in. mesh sieve. If clinker is used it should also pass a $\frac{1}{8}$ in. sieve and must be of very sharp texture, while other aggregates—as, for example, fine granite, fine stone chippings, etc., etc.—would be quite suitable, providing they are quite free from dust and other impurities.

The mixing of the materials for tiles differs somewhat from the mixing for concrete blocks. The proportions are stronger and the mixture is made wetter.

The mixture is composed of $2\frac{1}{2}$ of aggregate to one of cement. This must be thoroughly mixed, as described under the heading of "Mixing" (*see October*, 1916). After it has been thoroughly mixed, the water should be applied from a fine rose can, and the mixture should be turned about while the watering process is taking place. It must not be made sloppy, but just wet enough so that, when a shovel is drawn over the mixture, the water rises to the top. If the mixture is too wet, the tile will lose its shape upon being taken from the mould, and should it not be wet enough, the tile will be weak when finished. But the right consistency will soon be found after one or two experiments and tests, and this is one of the best ways of gaining experience, providing one has sufficient knowledge to undertake the tests in a proper manner.

MACHINERY AND MOULDS FOR THE MANUFACTURE OF CONCRETE ROOFING TILES.

Machines and moulds for roofing tiles are of a somewhat different construction to the machinery and moulds used for concrete block making, and so a detailed description is necessary.

As there are several types in common use in this country, it will be well to take the general principle upon which all tile machines are made.

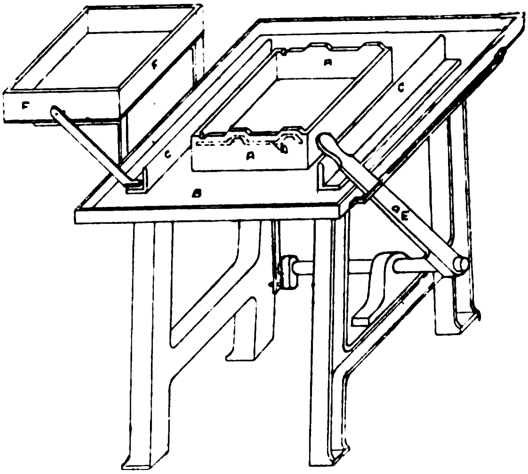


Fig. 1. A Roofing Tile Machine.

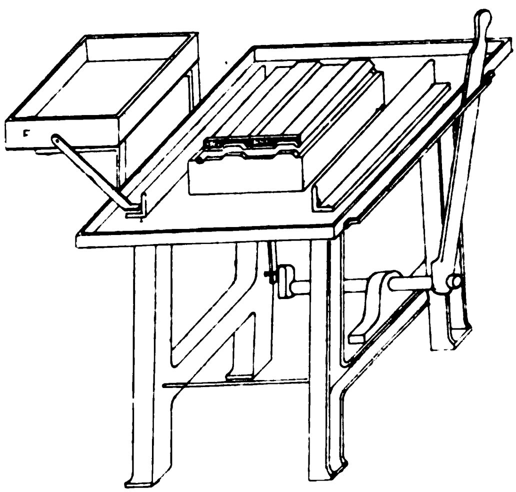


Fig. 2. Showing Tile ready to be taken away.
How to Make Concrete Roofing Tiles.

In *Fig.* 1 a general view of a roofing tile machine is given. (*A*) shows the mould box in position. (*B*) is the table to which the mould box is fixed. (*C*) is the guide for the strickle or striker which forms the top of the tile. (*D*) is represented by a dotted line, and is the position of the pallet when ready for a tile to be made. (*E*) is the handle or lever for raising the pallet and tile out of the mould after the tile is made. This lever is connected to a shaft upon which a crank is fixed, and this raises a plate which has four columns fixed to it. (*F*) shows the colour box, from which the glazing material is applied, and further reference will be made to the working of the machine later on in this article.

This illustration is only intended to show the general principle of the working of a roofing tile machine, but there are several different makes of these machines, and illustrations of them have appeared in the pages of this journal at different times. *Fig.* 2 shows the same machine after a tile has been made with the tile raised out of the mould box ready to be taken and placed upon the racks to dry. *Fig.* 4 shows a complete mould for making half round ridge tiles. These are made by hand. *Fig.* 3 illustrates the pallet upon which they are made. *Fig.* 5 is the strickle, and this works upon the edge of the ends marked *A* on *Fig.* 4. *C* is the pallet, while *B* forms the thickness of the sides of the tile. The whole of this mould is made of iron. The operation of making the tile is described later on.

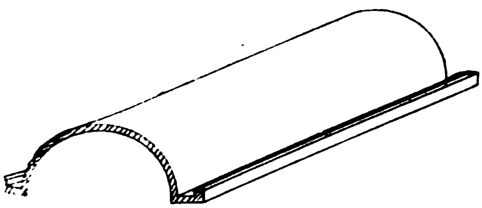


Fig. 3. Pallet for Ridge Tiles.
HOW TO MAKE CONCRETE ROOFING TILES.

Before leaving the subject of machines it would perhaps be well to refer here to the question of the glazing of the tile. To mix the colour and the cement properly it is necessary to mix it by machinery. The machine for this consists of an iron drum, which revolves with a central shaft to which it is fixed. Inside the drum several (turned) iron rollers are placed. As the drum revolves round, the rollers roll round the side of the drum, and grind and mix the colour and the cement together. Of course, the colour and cement can be very well mixed by hand, but this is an expensive method, as the time it takes to get the colour uniform throughout adds exceedingly to the cost of the tile.

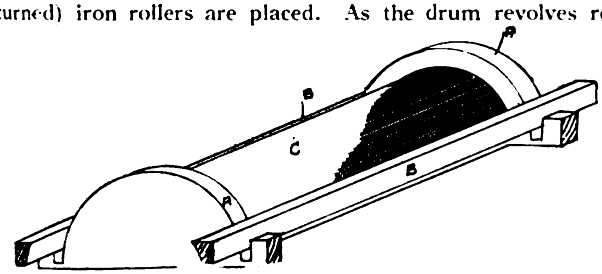


Fig. 4. Mould for Ridge Tiles.
HOW TO MAKE CONCRETE ROOFING TILES.

MAKING CONCRETE ROOFING TILES.

Before dealing with the actual making of the tiles, the mixing of the colour and the cement must be referred to. The amount of colour required for glazing largely depends upon the colour itself, but if light or middle red oxide is used, it will be necessary to mix 1 of colour to about 10 of cement. This can be mixed in a colour-machine such as referred to in the last paragraph, or it can be mixed by hand. If it is mixed by hand it will be necessary to sieve it through a very fine mesh sieve, which will greatly help in getting uniformity of colour throughout. It should be noted that the colour and the cement are measured by weight and not by bulk. Now we will assume that all is ready for making the tiles. The colour-box is filled with the mixture of colour and cement. The first operation is to place the pallet in the mould-box, and then shovel some concrete (gauged as before mentioned) on to the pallet. This is tamped down with a tamper, as shown in *Fig.* 6, which is made of hard wood. Then the strickle is run over the surface of the concrete until the tile is the shape of the strickle and of the required thickness. The thickness must always be the same if the strickle is worked down to the guides,

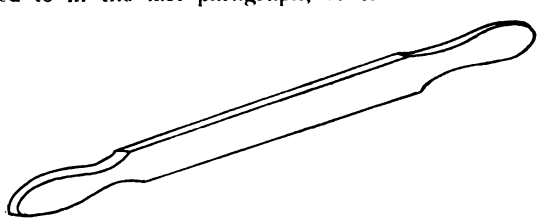


Fig. 5. Strickle or Striker for Ridge Tiles.
HOW TO MAKE CONCRETE ROOFING TILES.

or the tiles will not lay flat or be at all neat when fixed. But with a little practice this is easily done without any special effort. When the tile is of the required shape and thickness, the colour-box is moved from its table on to the mould-box, and the colour is applied. This is done either by giving the colour-box a sharp tap or by drawing a specially bent piece of wire fixed in a handle, and similar to *Fig.* 7, over the bottom of the colour-box. This will give an even thickness of colour over the surface of the tile. After the colour has been applied the colour-box is removed back on the table arranged for it (the box being so arranged with iron guides that it always fits on the mould-box and upon its table in exactly the same place, so that it is practically an instantaneous movement). Next the strickle is run over the coloured surface, which gives a kind of glazed appearance to the tile. The next operation is to put the top locking-piece on. For this a small box is arranged to fit over the tile, and this allows the rib to be put on to the tile, as shown in *Fig.* 8. The box is filled with concrete, and is tamped down, care being taken not to tamp too hard to alter the shape of the tile where the joint is made. The surplus material is scrapped off the top of the box, and the box is removed. The tile is then ready to be taken from the mould. To release it from the mould-box the lever *E* is pushed back, and this raises the tile out of the mould. The tile is then resting upon the pallet (which forms the underneath side of the tile, and thus must be the exact shape of the under side of the tile), and this allows it to be "handled" quite easily. It is then taken from the machine and placed upon racks (*see Fig.* 9), upon which it rests for three days, when it may be taken from the pallet and stacked. It must always be borne in mind that the tiles must be kept from the sun and draughts when they are first made; if not fine cracks will be noticeable on the surface of the tile, and if these should develop the tile will not be waterproof. It may seem to the reader to be a long operation to make these tiles, but after a man has got into the way of making, he will not have any difficulty in turning out 200 to 250 tiles in a day of ten hours. After the tiles are put into stacks they should be watered every other day for ten days to a fortnight. On no account should they be used for at least six weeks or two months after making.

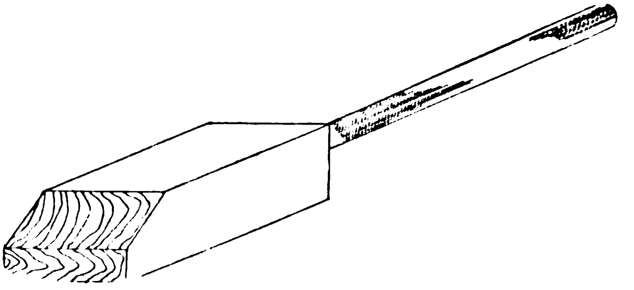


Fig. 6. Tamper.
How to Make Concrete Roofing Tiles.

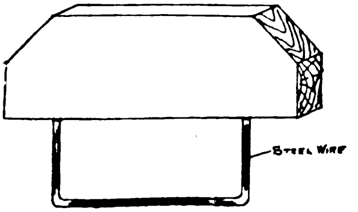


Fig. 7. Colour Sprayer.
How to Make Concrete Roofing Tiles.

Fig. 10 *to* 14 show some different types of concrete tiles in use; while *Fig.* 15 illustrates, in section, the sideways interlocking of the tile in *Fig.* 10. *Fig.* 16 shows how the ends of the same tile also interlock. The benefit of this type of tile is that when a roof is set out and the battens are fixed so as to work the tiles to show all alike, these tiles will slide down, and thus, to all appearances, shorten themselves. This is illustrated in *Figs.* 17 and 18. *Fig.* 20 shows the tiles lying on the battens to the full extent of their length, while *Fig.* 19 illustrates the same tiles on a roof where the length of the rafter will not allow the whole length of the tile to be used, and thus the tiles have either to be cut or shortened in some way or other. In this case, if the tiles were cut, the interlocking and weather-proofing design of the tiles would be destroyed.

When making ridge tiles the mixture is the same as for making roofing tiles, but the operation is slightly different. The material is placed upon the pallet in the mould and is tamped down with a tamper (see *Fig.* 6). When the material is fairly solid the strickle (*Fig.* 5) is worked over the surface until the tile is to the shape of the ends of the mould. Then the colouring material is applied from a small sieve and the strickle is again run over the surface. This has a tendency to give a glaze to the surface of the tile. The tile is now finished and the sides *A* and *B* of the mould can be removed, thus leaving the tile exposed and resting upon the pallet. It can then be taken away and placed upon a rack, as before described, until hardened, which will be about three days, and the remarks before made about stacking and using also apply to ridge tiles. Hip tiles are made upon the same principle, but in some cases the designs are slightly different. *Figs.* 21 and 22 show two types of ridge tile.

Fig. 8. Section of Tile showing Locking Piece.

How to Make Concrete Roofing Tiles.

It will be found that, where suitable material can be obtained, the manufacture of roofing tiles will be a thorough business proposition, it being possible to compete in price with any clay tile of similar design and then show a good profit for the manufacturer. The weight of a square (10 ft. by 10 ft.) of concrete roofing tiles is about 7 cwt. to 8 cwt., or about 5 to 6 lb. each. Of course, different designed tiles may weigh more or less, but this is about a fair average of the tiles illustrated in this article. Perhaps it will be of interest to mention that concrete tiles made in the form of slabs 3 ft. by 2 ft. by $1\frac{3}{4}$ in. thick were tried for roofing at Croydon about 1880, but were found to be rather heavy, and as they were reinforced and thick ($1\frac{1}{2}$ in. in the thinnest part), it was also found that they could not be used with economy and convenience.

The advantages of concrete roofing tiles are that they harden with age, the interlocking and perfect weatherproof design make a neat and sound roof at a minimum outlay. Being lighter than clay tiles or slate when fixed in position, it is possible to do

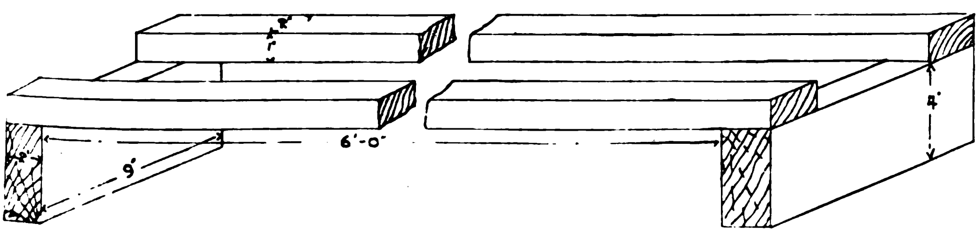
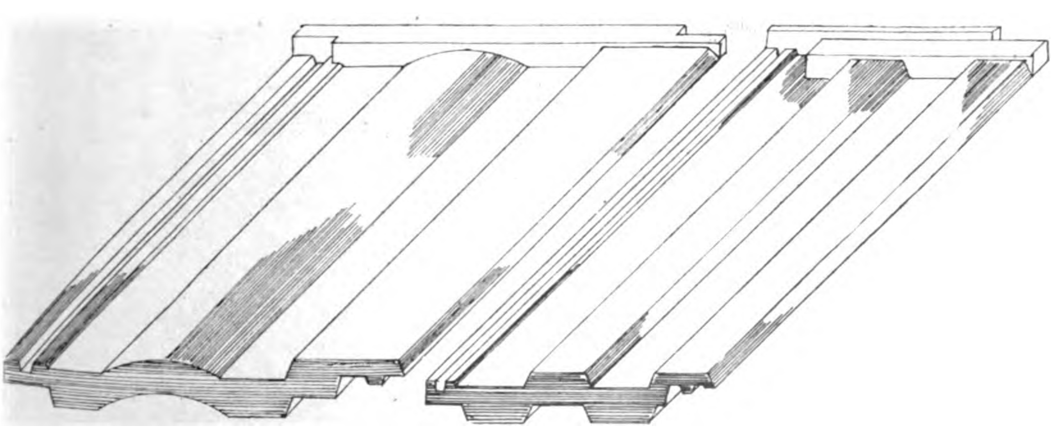


Fig. 9. Detail of Drying Racks.



Figs. 10 and 11. Interlocking Tiles.

How to Make Concrete Roofing Tiles.

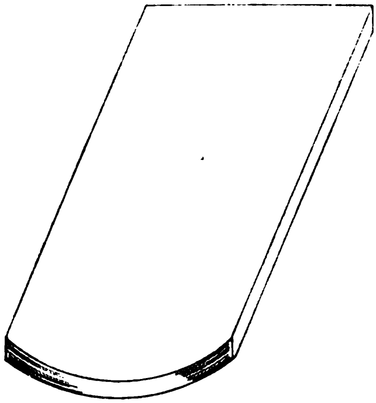


Fig. 12. Another Type of Concrete Tile.

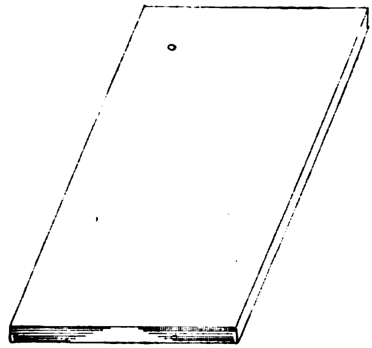


Fig. 13. Concrete Tile as used in Sweden

HOW TO MAKE CONCRETE ROOFING TILES.

with less rafters than are usually used for slates or clay tiles, and thus a further saving is effected. Many roofs in different parts of the country have been roofed in with concrete tiles, and have been very successful in all ways, as regards cost, appearance, and also strength.

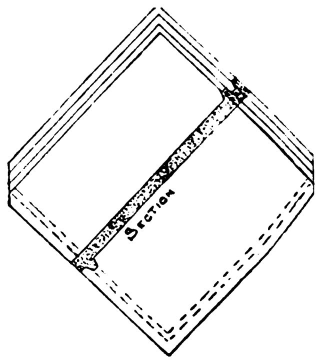


Fig. 14. Another Type of Roofing Tile

CONCRETE FLOORING TILES.

For making concrete flooring tiles which have a flat surface and are one colour throughout, a machine similar in general detail to the one shown in *Fig.* 1 is suitable. A different mould box must be fitted to the table of the size required for the tiles. This mould box should have cuts in it so that steel cutters may pass through to form half quarters and half diagonal tiles. This obviates a lot of cutting when fixing the tiles and also saves unnecessary waste.

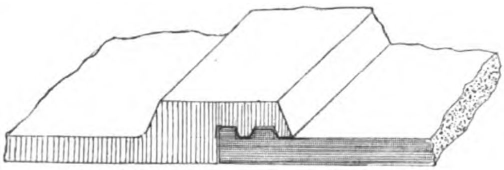


Fig. 15. Cross Section of Tiles as per Figs. 10 & 11.

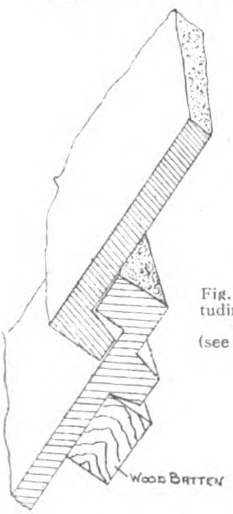


Fig. 16. Longitudinal Section of Tiles (see Figs. 10 & 11)

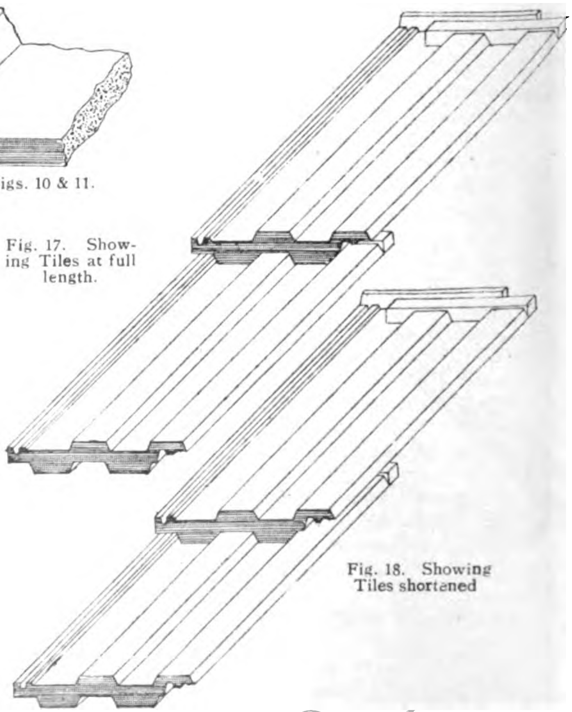
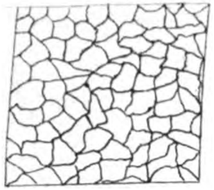
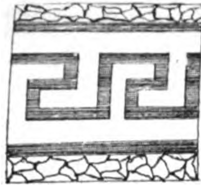


Fig. 17. Showing Tiles at full length.

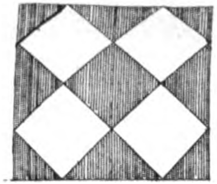
Fig. 18. Showing Tiles shortened



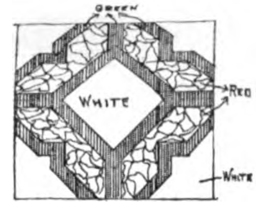
Plain Tile Rough Face
Fig 23



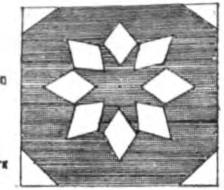
Border Tile
Fig 24



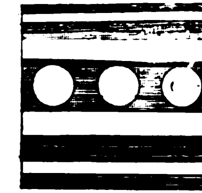
Two Colour Tile
Fig 25



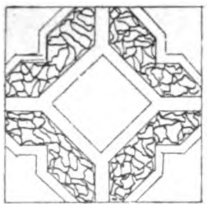
Three Colour Tile
Fig 26



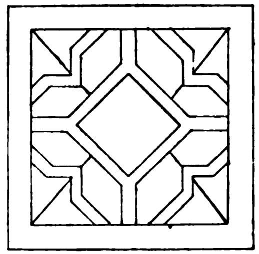
Three Colour Tile
Fig 27



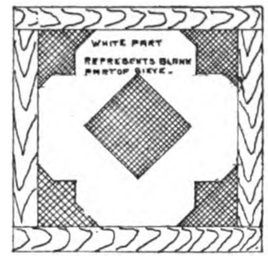
Two or Three Colour Tile
Fig 28



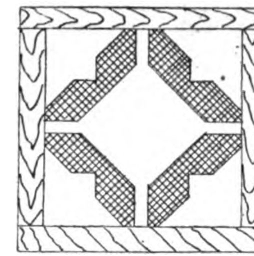
Matrix for Tile see Fig 26
Fig 29



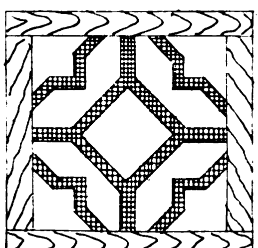
Stencil formed with Thin Brass. Fig 30.



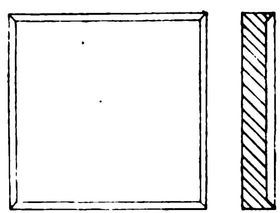
Sieve for White Colouring
Fig 31



Sieve for Red Colouring
Fig 32



Sieve for Green Colouring
Fig 33



— Die Plate - Fig 34 - Section —

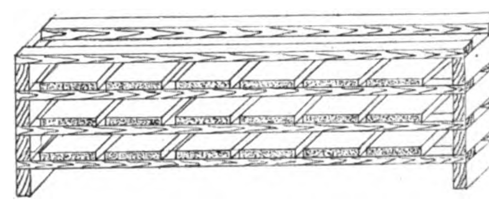


Fig 22. Pile of Racks with Floor Tiles Drying

Concrete Mosaic Tiles.
(Description of these will appear in next issue.)

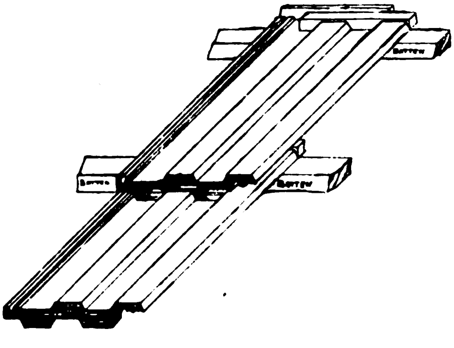


Fig 19.

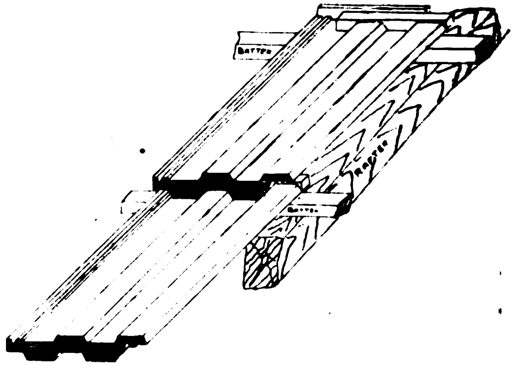


Fig. 20. Showing Tiles at full length on batten.

How to Make Concrete Roofing Tiles.

The mixture for flooring tiles requires to be a little stronger than that for roofing tiles, as hard wear has to be taken into consideration. With roofing tiles it will be noticed that only the face surface of the tiles is coloured, but owing to the greater wear it is necessary to colour flooring tiles throughout. The surface of the flooring tiles is finished in exactly the same way as described for the making of roofing tiles.

It must always be remembered that the colour must be mixed with the sand before adding the cement. Then take 2¼ of coloured sand and mix with 1 of cement. A weaker mixture should never be used as the tiles would soon show the wear. It should be noted that the materials for flooring tiles must be clear and sharp, free from loam, dust, or other impurities such as have been referred to earlier in this article. A knife is used for glazing or finishing the surface of the tile. This knife is made of polished steel. After the tile is made it is placed upon the drying rack (see *Fig.* 9) and left to harden off. When hardened off it can be stacked and well watered. *Fig.* 22a gives a view of a pile of racks with the tiles lying on them hardening off. With this method of arranging the racks no time is wasted as would be the case if fixed racks were used. When racks of this type are used, they can be placed around the machine and filled up, and time is thus saved walking to fixed racks and back.

It will also be interesting to add that after the tiles are hardened off, if they are placed in a tank of water for a few days this will greatly increase their strength.

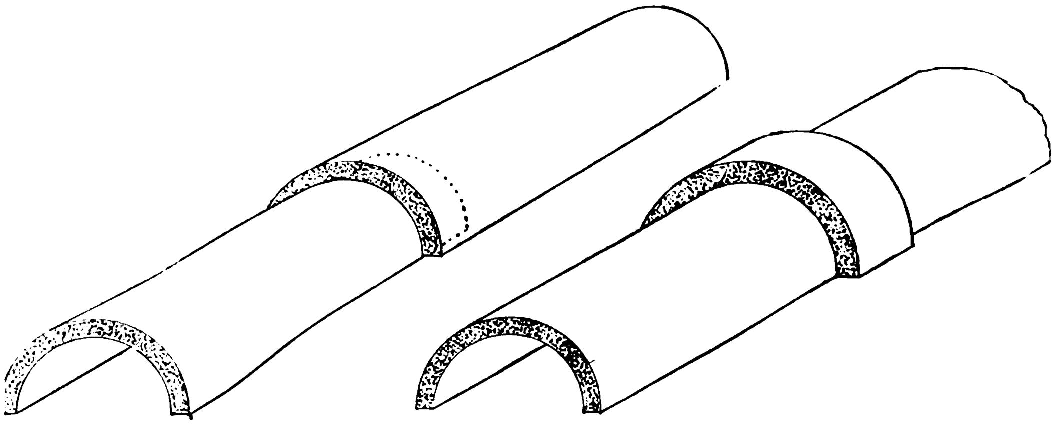


Fig. 21. Ridge Tiles Interlocking.

Fig. 22. Ridge Tiles with loose piece for covering joint.

How to Make Concrete Roofing Tiles.

(*To be concluded.*)

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APRIL 1917. VOL. XII. No. 4.

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ISSUED MONTHLY

CONTENTS.

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Interior of Cold Store (fifth floor, showing roof.)
NEW REINFORCED CONCRETE BUILDINGS AT THE PORT OF LONDON.
(For description see page 181.)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XII., No. 4. LONDON, APRIL, 1917.

EDITORIAL NOTES.

THE EDUCATION OF THE ARCHITECT.

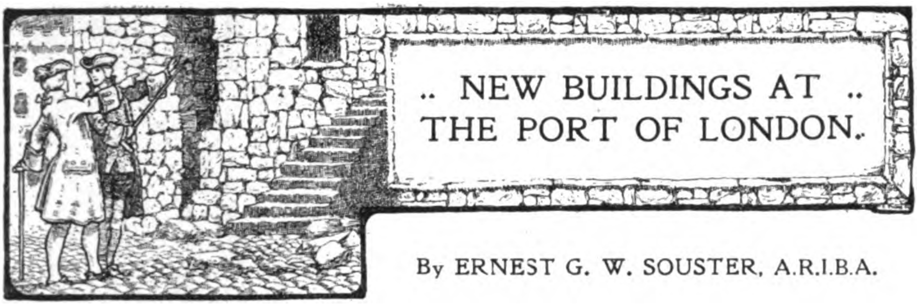
ALL who have been interested in the advancement of concrete and reinforced concrete among the architectural profession have long realised the extraordinary ignorance on matters scientific which is unfortunately met with among a large number of architects and surveyors, and especially amongst those architects who claim to be artists, but appear to neglect professional business and the technical aspects of their vocation generally, with deplorable results as far as the practicability and cost of their structures is concerned.

We thus note with considerable interest that a Conference has been held, under the auspices of the Royal Institute of British Architects, to consider the question of the Education of the Architect, and much has been said that claims close consideration and attention. Of the many speeches or addresses at this Conference (which has, so far, held two meetings) there is one which ably summarised the position from a point of view shared by many of our readers. We refer to the opinions expressed by Mr. H. Kempton Dyson, the Secretary of the Concrete Institute, who, whilst specialising on the purely scientific aspects of concrete building and structural engineering, is not unsympathetic to the claims of Art. No one is more likely than he is to have realised the lack of technical and scientific knowledge amongst architects, although of course there are notable exceptions.

We give Mr. Dyson's words below as reported, without abbreviation and without further comment, as they sum up the position in a most useful manner:

> "Mr. H. Kempton Dyson considered that if the ideals of Professor Lethaby and his school of architectural thought were followed in architectural education we should no longer feel that architecture was not occupying its proper place in modern civilisation. Professor Lethaby had long urged architects to study the art and science of building, and to be sure of the fitness before expressing themselves in the mannerisms of the past. The cry is that the engineer and the surveyor are usurping the place of the architect. Two favourite apophthegms of the engineer are to quote the late Prince Consort of Queen Victoria, who is reported to have said: 'If I wish to talk about a thing I send for an architect; if I wish to get it done I send for an engineer,' and the American who said that 'An engineer is a man who can do for one dollar what any fool can do for five.' These remarks express two common ideas among the ignorant

public—namely, that an engineer is superior to an architect because he does what is wanted and he does it cheaper. Now that ought not to be. Building work requires to be organised and controlled by an architect if it is to be completely efficient. The misunderstanding of the qualifications of the architectural profession by our Government Departments has resulted in the loss of millions of pounds sterling and the prolongation of the war. The amateur and the quack have rushed in, and contractors have been given practically *carte blanche* in building operations. Architects have been pushed on one side to make way for a crop of self-styled factory specialist designers, who are in many cases incompetent. Some firms who seek to furnish constructional schemes to architects advertise to provide factory owners with complete designs without the intervention of an architect, and employ architectural draughtsmen with that object. The architectural profession might, with advantage, protect itself as the medical profession has done against the quack. It should ostracise those trade firms of so-called constructional specialists in steel and reinforced concrete, and the contractors who deal direct with clients without the intervention of an architect. Selection on price alone results in inefficiency. Architects should only co-operate with other professional men, such as engineers, and not become associated with contractors and others commercial firms, as they do when they accept schemes from them. The education of the architect in the past has been lacking in that it has not made of him a scientific man. The student need be none the worse an artist because he has a knowledge of the many branches of science required by an engineer to achieve success—namely, mathematics, chemistry, physics, mechanics, business economics, and ethics. Scientific training will make him precise, systematic, able to analyse and synthesise. The ideal to strive for is that architecture should be so expert a profession that a layman would no more dare to interfere with the work of the architect than with the work of the engineer. It should be impossible to get an efficient building so economically from anyone as from an architect. Greater attention should be given to the study of details of professional practice. Why does this Institute so seldom have papers read on experiences in everyday professional practice? Building construction has not been taught properly. The teacher should begin with a course in science—mathematics, chemistry, physics, mechanics, properties and manufacture of materials—and then show how the various details have arisen by the application of the fundamental principles in the endeavour to fulfil the function. Why not have art studied both as a science and an art? That is to say, why not study it in theory and in practice? The theory has been too much neglected, with the result that architects too often lack originality. With all who are engaged in the creative professions, such as architecture and engineering, imagination and inventiveness should be trained and encouraged."



.. NEW BUILDINGS AT .. THE PORT OF LONDON.

By ERNEST G. W. SOUSTER, A.R.I.B.A.

By the courtesy of the Chief Engineer of the Port of London Authority, we are able to publish the following interesting particulars of recent reinforced concrete work at the Port of London.—ED.

SINCE the Port of London Authority was established in 1909 many and great improvements have been effected, and the new Port of London bids fair to be second to none in its capabilities for handling both passengers and goods traffic of all kinds.

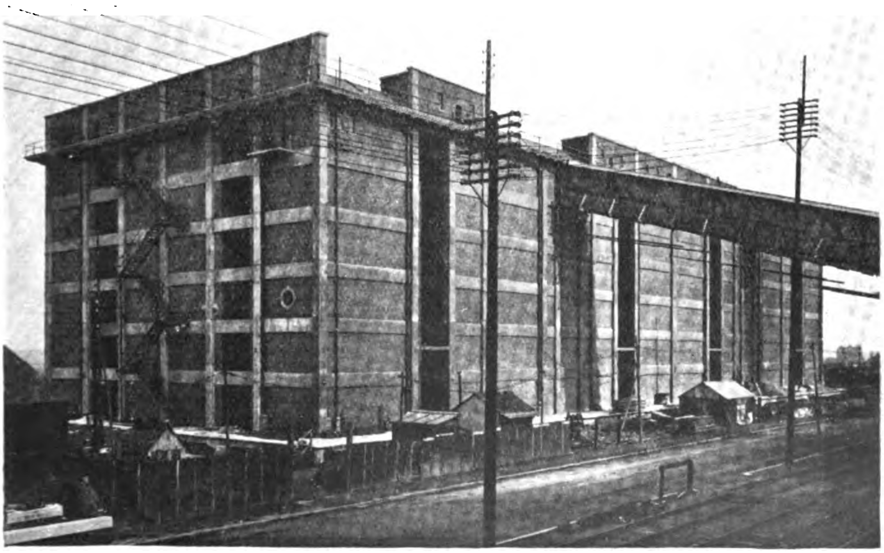


Fig. 1. Exterior View of Cold Store.

NEW REINFORCED CONCRETE BUILDINGS AT THE PORT OF LONDON.

Besides alterations and additions to the dock basins and adjuncts, buildings of the many types that are necessitated by the kinds of merchandise dealt with have been, and are still being, erected. The three buildings in connection with the Royal Albert Docks, which are here illustrated, are interesting, as they show

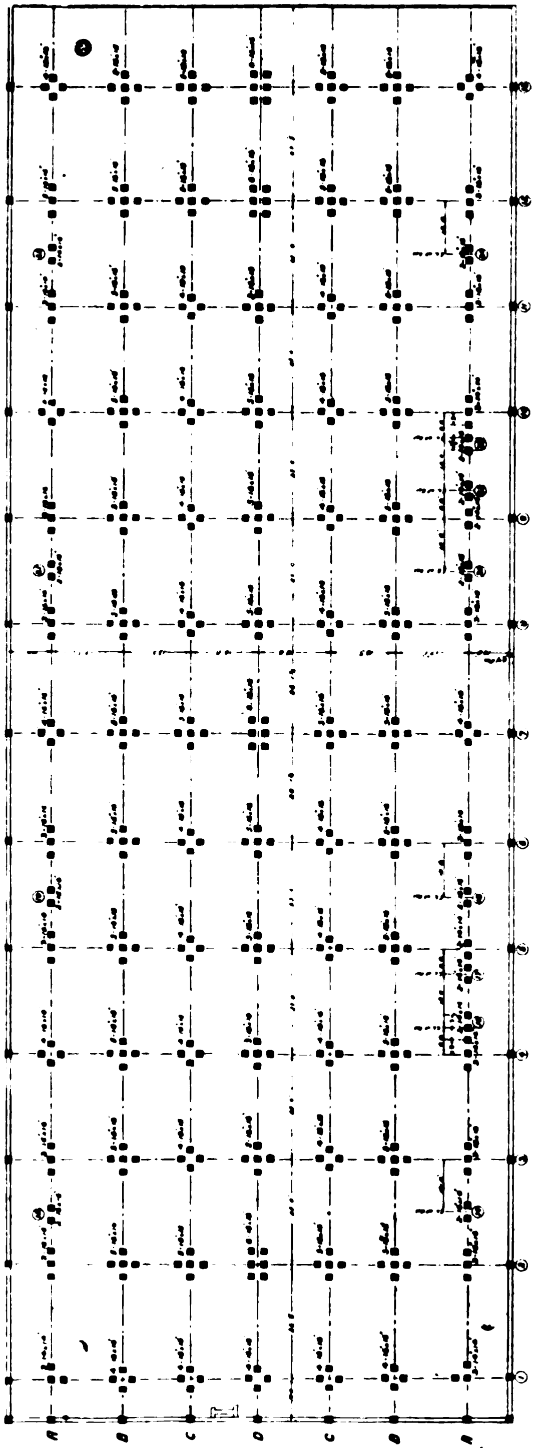


Fig. 2. Foundation Plan of Cold Store.

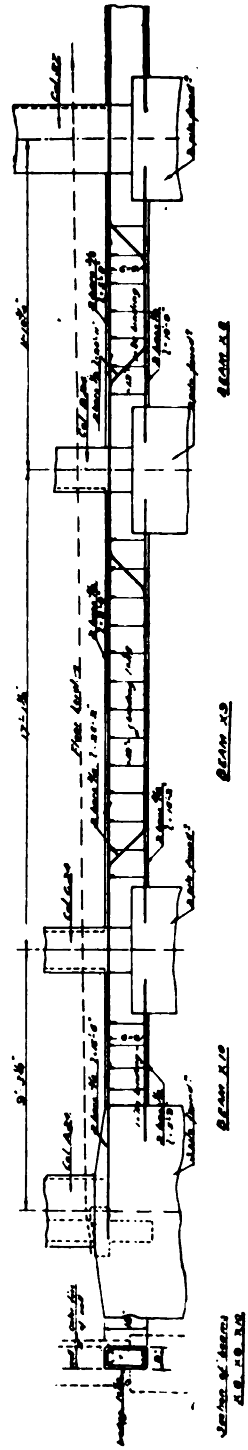


Fig. 3. Detail of Foundations for Transit Shed.
New Reinforced Concrete Buildings at the Port of London.

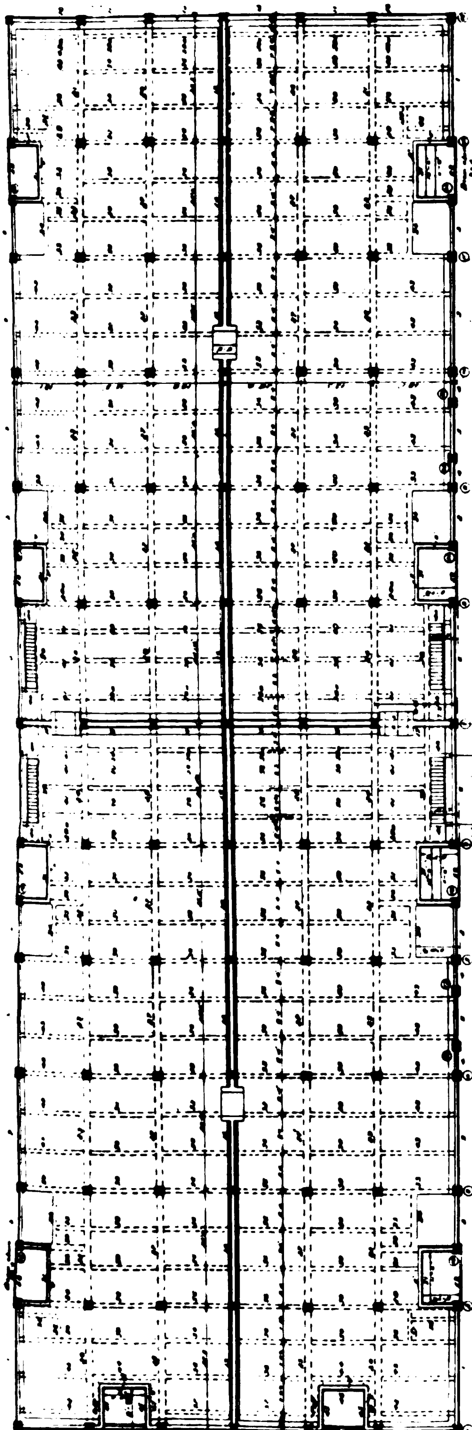
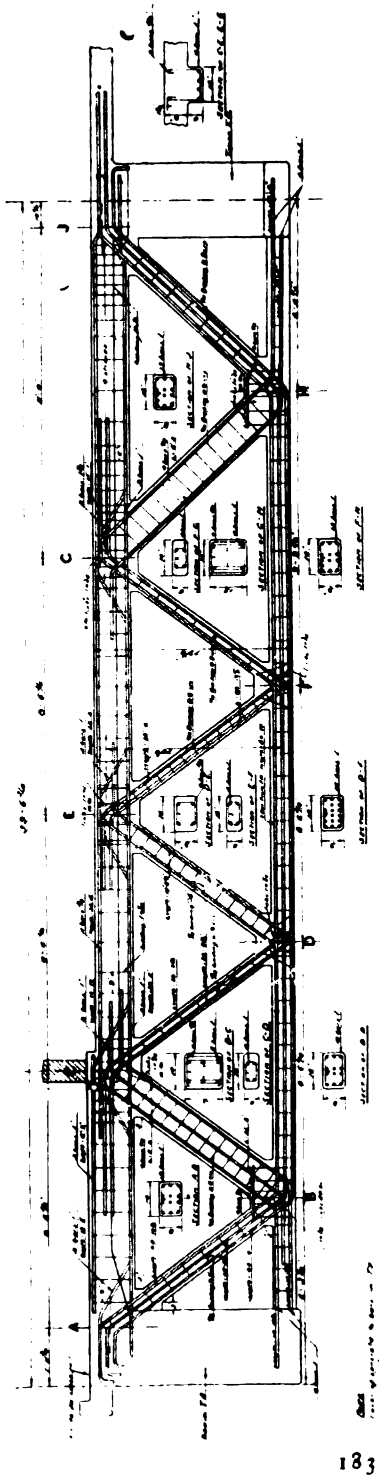


Fig. 4. First Floor Plan--Cold Store.



TRUSS T7

Fig. 5. Truss over Tra sit Shed Cartway

NEW REINFORCED CONCRETE BUILDINGS AT THE PORT OF LONDON.

how reinforced concrete is being widely used for purposes where, a few years ago, structural steel would undoubtedly have been employed.

The buildings comprise:—(*a*) Cold store; (*b*) transit and cold sorting shed; (*c*) refrigerating station, and all three of them are carried on pile foundations, the piles being of reinforced concrete about 30 ft. long and of sections 12 in. by 12 in., 14 in. by 14 in., and 16 in. by 16 in.

THE COLD STORE.

Fig. 2 shows the foundation plan of the cold store and indicates the principle upon which the piling is arranged for the three structures.

The cold store is 307 ft. long and 100 ft. wide and consists of ground and

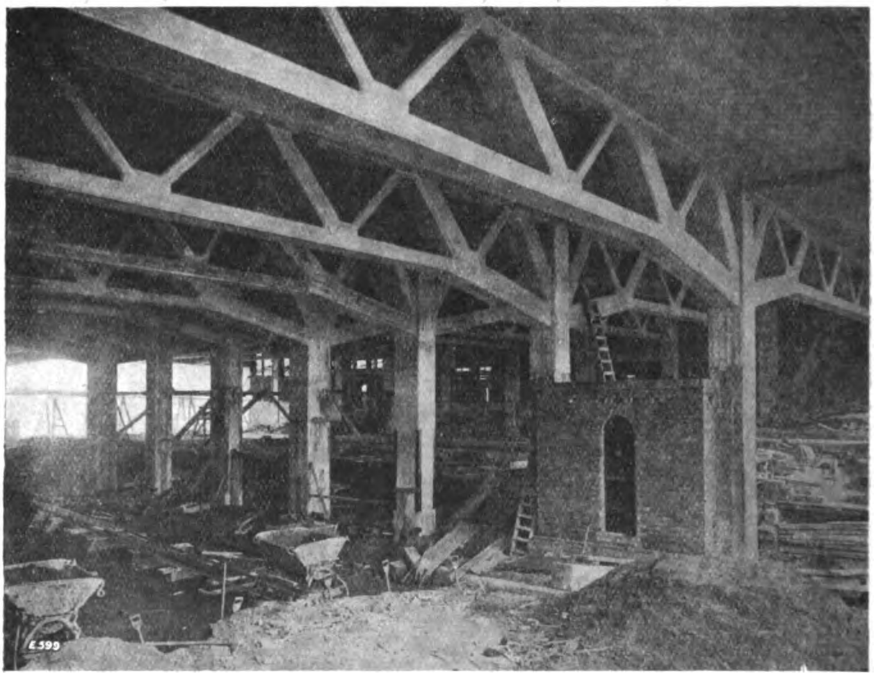


Fig. 6. Cartway in Transit Shed.
New Reinforced Concrete Buildings at the Port of London.

five floors over, totalling 62 ft. 6 in. from level of ground floor to underside of the lower flange of the truss containing the roof principals, which will be afterwards mentioned.

The construction of the building is really a framework of reinforced concrete columns and beams with brick panel wall fillings for external and cross walls, and a feature of interest is the large openings which run through several stories. (See *Fig.* 1.)

The building is set out on a basis of bays 25 ft. long, except the end ones, which are 27 ft. 5 in., and the two central ones, which are 26 ft. $1\frac{1}{2}$ in. long.

Transversely the building is in six bays, the outer ones 18 ft. 1 in. from column faces to centre of columns, 15 ft. 5 in. centre to centre of adjoining ones, and the two central ones 16 ft. 6 in. wide.

Upon the pile foundations 40 in. by 14 in. reinforced concrete beams run longitudinally through the building (except the central one, which is 40 in. by

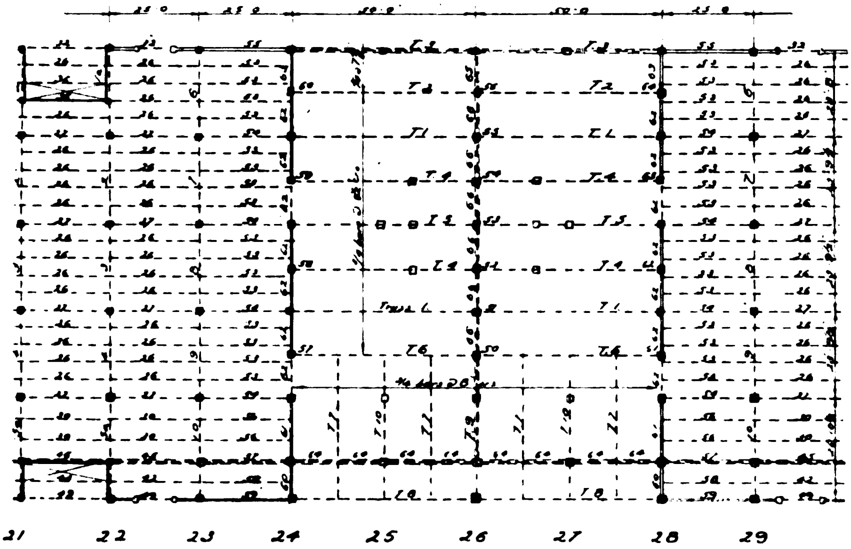


Fig. 7. Part of Ground Floor Plan of Transit Shed showing Cartway. (The dotted lines indicate beams of first floor.)

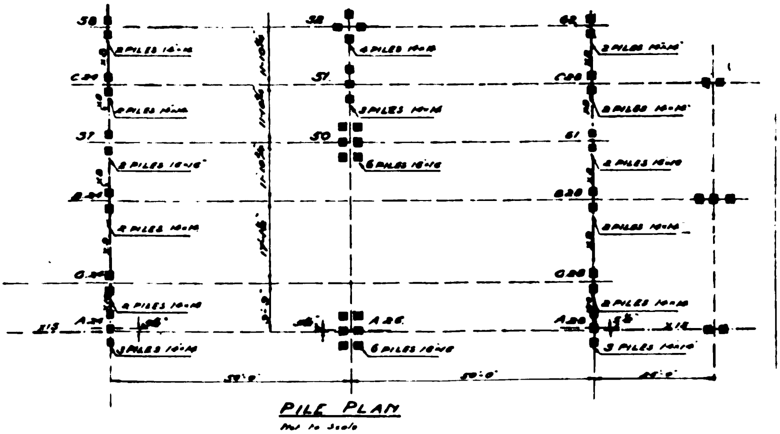
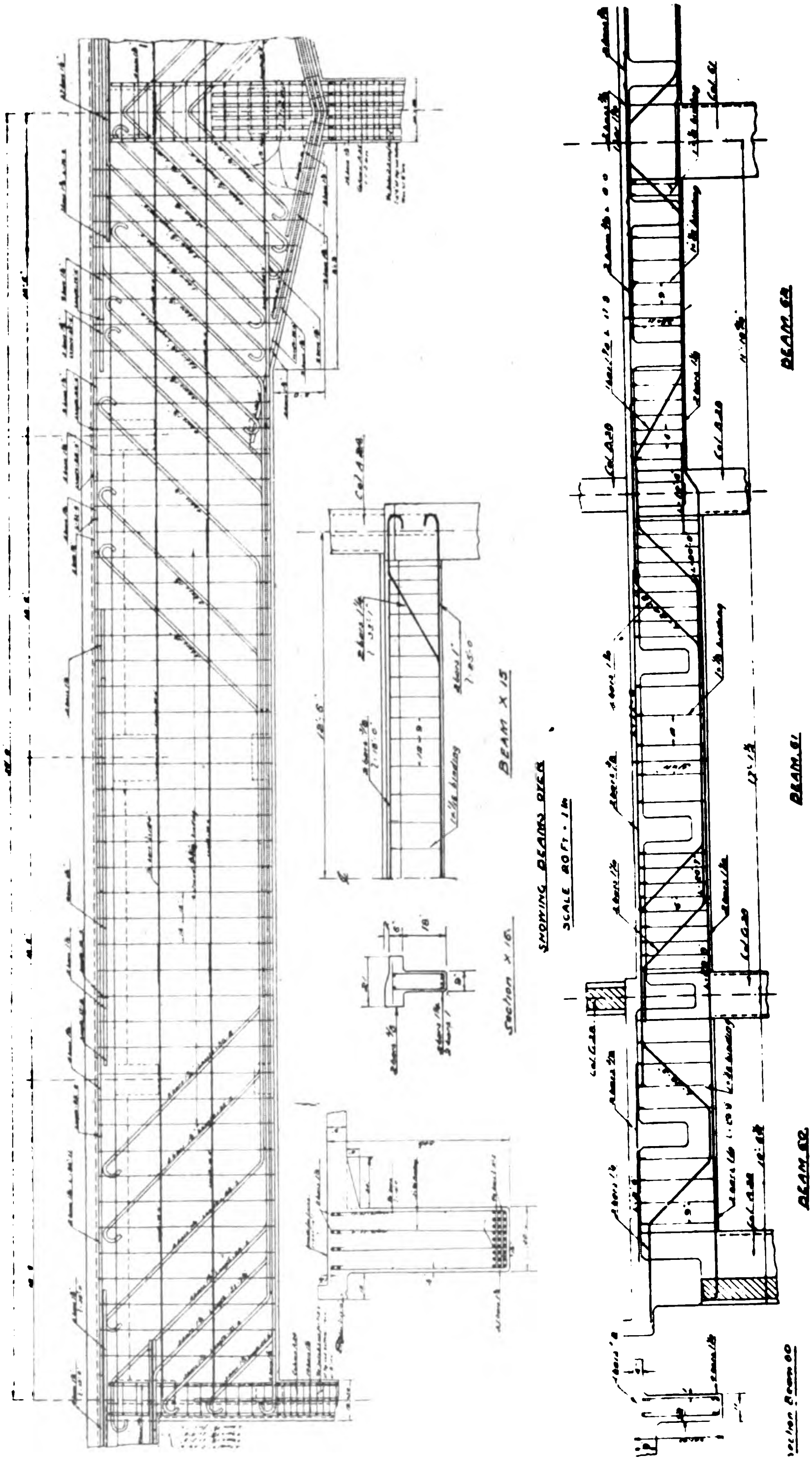


Fig. 8. Ground Floor Plan Details—Transit Shed Foundations to Cartway.

New Reinforced Concrete Buildings at the Port of London.

16 in.) and connect together the bases of the columns; and between these are 18 in. by 9 in. secondary beams supporting and stiffening the floor slab.

The columns on ground floor are 24 in. by 24 in., and reduce regularly floor by floor to the fourth floor, where they are 18 in. by 15 in. The main beams are generally 30 in. by 18 in. with 16 in. by 10 in. secondary beams. In



Figs. 9 and 10. First Floor Details—Transit Shed.
New Reinforced Concrete Buildings at the Port of London

this building it is necessary to maintain an even temperature throughout, and to effect this timber has been used for the first, second, third, and fourth floors, which consist of 5½ in. by 4 in. battens ¾ in. apart resting on the beams already mentioned, and the whole floors are designed to carry 2 cwt. per super foot.

Fig. 4 shows the first floor of the whole building and indicates the division of the structure into sections and the general arrangement of beams, lifts, etc.

The fifth floor consists of a 4 in. slab, and except for the central row of columns carried up to receive the roof beams is free of all obstructions.

The roof to the building over this floor is formed by a series of eight steel saw-tooth principals, designed as two lattice beams 50 ft. span each, supported by the outer wall beam and a 16 in. by 9 in. beam over the central row of columns. An illustration of this floor is given in the frontispiece.

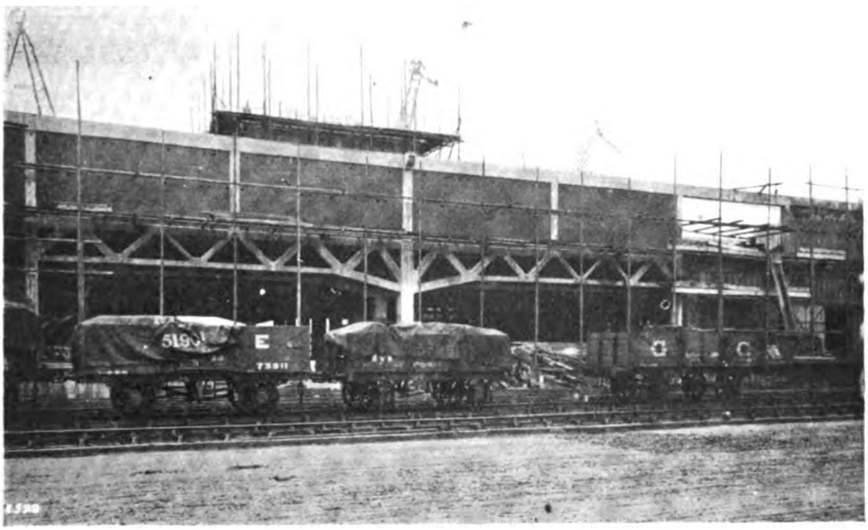


Fig. 11. Transit Shed during Construction.
NEW REINFORCED CONCRETE BUILDINGS AT THE PORT OF LONDON.

Another interesting feature is the balcony on either side of the building at the roof level. This projects 3 ft. 9 in. beyond the wall face and is of reinforced concrete built out from the main beam, finishing the top floor and supporting the roof trusses.

THE TRANSIT SHED.

The transit and cold sorting shed is 1,100 ft. long, 123 ft. wide and 47 ft. high.

This building is also designed on a unit basis with columns and beams of reinforced concrete and with brick filling for the necessary walls. *Figs.* 7 and 8 show a detail of part of the pile foundation for this building and also details of the ground floor construction, and it may be of interest to state that the whole area of the upper floor is designed to carry a superimposed load of 3 cwt. per super foot.

The portion of the structure that at once attracts attention is the cartway area which cuts through the centre of the building. This opening is 100 ft. wide, divided into two sections by a series of reinforced concrete columns which support beams 50 feet span carrying the floor above. These beams are of two types. Those adjoining the dock basin are of solid construction, 7 ft. deep and 2 ft. 6 in. wide, and carry crane loads of 33 tons in addition to the load of the structure. A detail of these beams is shown in *Figs.* 9 and 10.

Fig. 5 is a typical example of the remaining beams to the cartway area, which are of Warren girder type.

THE REFRIGERATING STATION.

The refrigerating station is 140 ft. long by 50 ft. wide and 30 ft. high, and consists of a reinforced concrete framework of columns and beams encased with brickwork and with brick filling for the walls.

The structure, as already mentioned, is carried on piles, and is designed for a superimposed load of 2½ cwt. per super foot on the roof slab which forms the bottom of a tank.

The chief point of interest is the main beams carrying the roof slab. These beams are in single spans of 45 ft., are designed of the Warren girder type, and are shown in *Fig.* 12.

The total estimated cost of the works, including the insulation, refrigerating machinery, conveyors, lifts, etc., is £475,000.

The whole of the work to the three buildings has been to the designs and under the supervision of the Port Authority's Chief Engineer, Mr. C. R. S. Kirkpatrick, M.Inst.C.E., the Resident Engineer being Mr. A. Binns, M.Inst.C.E. The reinforced concrete work has been designed by the Indented Bar and Concrete Engineering Co., Ltd., of Queen Anne's Chambers, Westminster. Indented bars have been used throughout as the reinforcement.

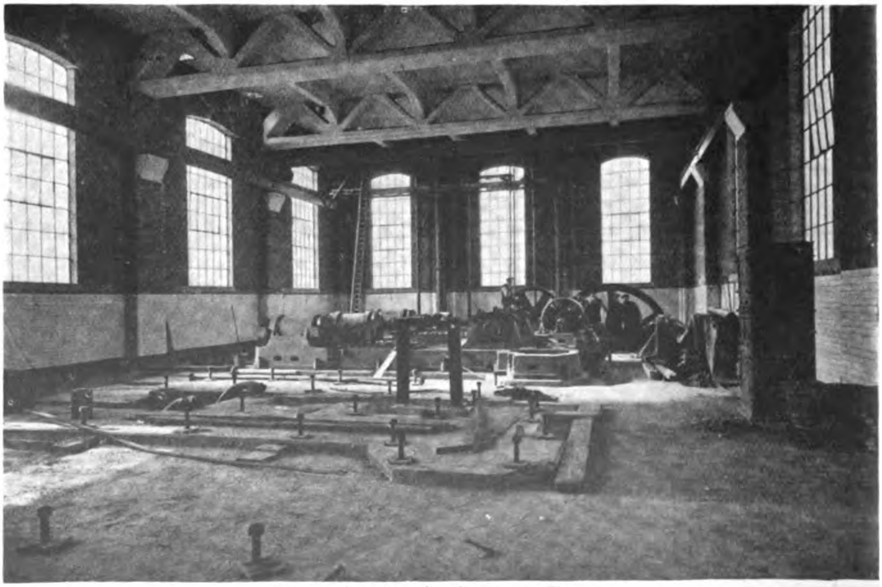
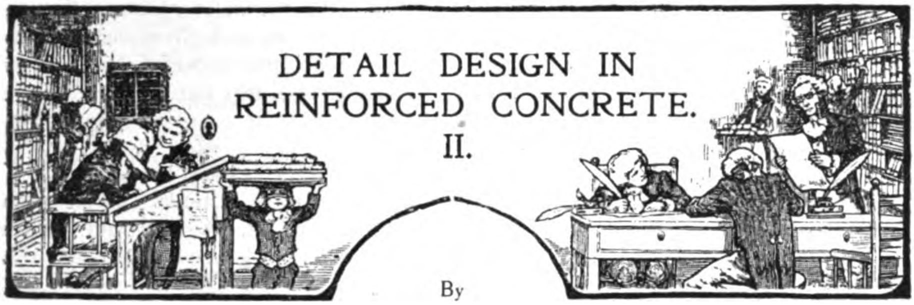


Fig. 12. Interior of Refrigerating Station.

NEW REINFORCED CONCRETE BUILDINGS AT THE PORT OF LONDON.



DETAIL DESIGN IN REINFORCED CONCRETE. II.

By

EWART S. ANDREWS, B.Sc.Eng., M.C.I.

Continued from February issue.—ED.

DESIGN OF FLOOR OF A WORKSHOP BUILDING (*contd.*).

Design of Secondary Beams.—The secondary beams are of 25 ft. span, and carry 9 ft. width of floor. The proposed section of these beams is 7 in. broad and 17 in. projection from the under side of the slab.

In general, where considerations of head-room do not hamper us, $\frac{1}{12}$ to $\frac{1}{18}$ span gives us a basis for determination of depth of beams. We then have

$$\text{Load carried from slab} = 1{\cdot}55 \times 25 = 38{\cdot}7 \text{ kips}$$

$$\text{Own weight} = \frac{17 \times 7 \times 25}{1000} = 3{\cdot}0$$

$$\text{Total} = W = 41{\cdot}7 \text{ kips.}$$

$$\text{Centre Bending moment} = B_c = +\frac{Wl}{12}$$

$$= \frac{41{\cdot}7 \times 25 \times 12}{12} = 1042 \text{ kip-in.}$$

$$\text{End Bending moment} = B_e = \frac{Wl}{10}$$

$$= \frac{41{\cdot}7 \times 25 \times 12}{10} = 1249 \text{ kip-in.}$$

For the centre section we have to design the section as a T-beam, but at the ends where the slab is on the tension side, we have to design as a rectangular section.

Reinforcement at Centre.—The next point to decide is the breadth (b) of slab which is available. In accordance with regulation **82**, this must not be greater than

(a) ¼ span—*i.e.*, 6·25 ft.

(b) Distance between rib centres—*i.e.*, 9 ft.

(c) Twelve times the slab thickness—*i.e.*, 5 ft.

whichever is least.

In our case, therefore, 5 ft. or 60 in. is the maximum breadth permissible. For calculations, we will take the effective depth $d = 5 + 17 - 2 = 20$ in. *Fig.* 6 shows a diagram which is very useful in T-beam calculation.

$$\text{In our case } \frac{R}{bd^2} = \frac{B}{bd^2} = \frac{1042 \times 1000}{60 \times 20 \times 20} = 43{\cdot}4$$

$$\text{Slab-depth ratio} = s_1 = \frac{5}{20} = 0{\cdot}25$$

Running in horizontally from 43·4 on the left-hand scale of *Fig.* 6, until we meet the vertical through ·25 on the bottom scale, we notice that the intersection comes just above the boundary line marked "rectangular beams," and just below the curve marked $c=400$. This shows that the stress in the concrete is well within our allowable limit $c=600$. We then proceed to determine the lever-arm, by running vertically upward from our point of intersection, until we come just between the boundary line and the corresponding curve marked $c=400$ on the upper curves; we then run out horizontally on to the size scales, reading $a_1=0{\cdot}912$.

Then area of tensile reinforcement required $A=\dfrac{B}{ta_1d}=\dfrac{1042}{16\times 0{\cdot}912\times 20}=3{\cdot}58$ sq. in.

From Table 1 we see that $6-\frac{7}{8}\phi$, giving $A=3{\cdot}61$, will be suitable. These we will arrange in two rows of three bars. By regulations **141** and **58**, the covers of these bars must be, at least, 1 in., and their distance apart must be $\frac{1}{2}$ in. vertically and 1 in. horizontally.

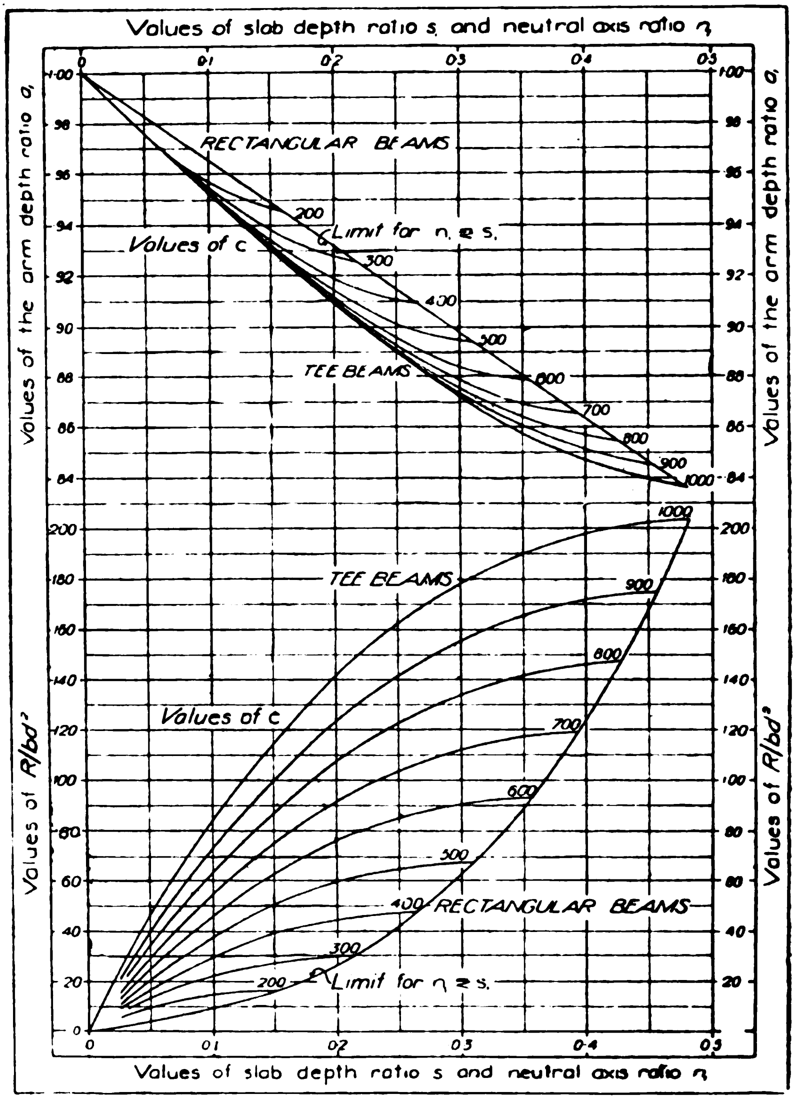


Fig. 7. Diagram for T-Beam design.

DETAIL DESIGN IN REINFORCED CONCRETE.

$\therefore$ minimum breadth $= 4 \times 1 + 3 \times \frac{7}{8} = 6\frac{5}{8}$ in.

Maximum effective depth $= 5 + 17 - (1 + \frac{7}{8} + \frac{1}{4})$

$= 19\frac{7}{8}$ in.

We have assumed 20 in., the difference in the results of the calculation being negligible.

Before proceeding further with the calculation, we will check whether the proposed breadth is sufficient from the point of view of end shear.

By regulation **66**, $\frac{S}{b_r d}$ shall in no case exceed 180 lb. per sq. in. for 1 : 2 : 4 concrete (b_r=breadth of rib of T-beam). The value of d at the end where the shearing force S is greatest, will be 23 in. for the intermediate secondary beam. We will take $S = \frac{41 \cdot 7}{2} =$ 20·8 kips.

$$\therefore \frac{S}{b_r d} = \frac{20 \cdot 8 \times 1000}{23 \times 7} = 125 \text{ lb. per sq. in.}$$

This is within the allowable limit.

Reinforcement at Ends.—For the end sections we have to provide for a bending moment of 1249 kip-in. on a rectangular beam, which is 7 in. broad, and in the case of the intermediate secondary beams, is of 23 in. effective depth. The depth in the pillar secondary beams, where a greater splay is permissible, is 27 in., so we must calculate separately. For intermediate secondary beams $\frac{B}{bd^2} = \frac{1249 \times 1000}{7 \times 23 \times 23} = 337$

It is clear from *Fig.* 3 that this is considerably in excess of the value that can be obtained by tension reinforcement only, so we must provide compressive or bottom reinforcement as well.

This is governed by regulations **61** and **62**, according to which we may either stress the compression steel at m times the stress in the concrete at the same level, or may neglect the concrete altogether, and stress the compression reinforcement up to 16,000 lb. per sq. in.

As a general rule, it may be taken that whenever $\frac{B}{bd^2}$ exceeds 150 it is more economical to neglect the concrete altogether.

The lever arm in the present case will be $23 - 2 = 21$ in.

$\therefore 16Aa = B = 1249$

$$\therefore \text{Area of steel required at top and bottom} = A = \frac{1249}{16 \times 21}$$

$$= 3 \cdot 71 \text{ sq. in.}$$

We will adopt $7 - \frac{7}{8}$ in. bars, giving $A = 4 \cdot 21$, because as we shall see later in designing the main beam the bottom steel will have to pass through that of the main beam, and a will have, therefore, to be slightly reduced. For the pillar secondary beams $d = 27$, and $a = 25$

$$\therefore \text{Area of steel required at top and bottom} = A = \frac{1249}{16 \times 25}$$

$$= 3 \cdot 21 \text{ sq. in.}$$

We will adopt $6 - \frac{7}{8}$ in. bars, giving $A = 3 \cdot 61$.

Shear Reinforcement.—The design of the shear reinforcement is a question which often presents difficulty to engineers, and it is, moreover, a matter of very great importance.

We will at this stage explain that the failure which would take place if adequate shear reinforcement were not provided is strictly a tension failure ; it is due to the diagonal tension induced by the shearing force. The shear reinforcement will therefore be stressed in tension and not in shear, however it be arranged.

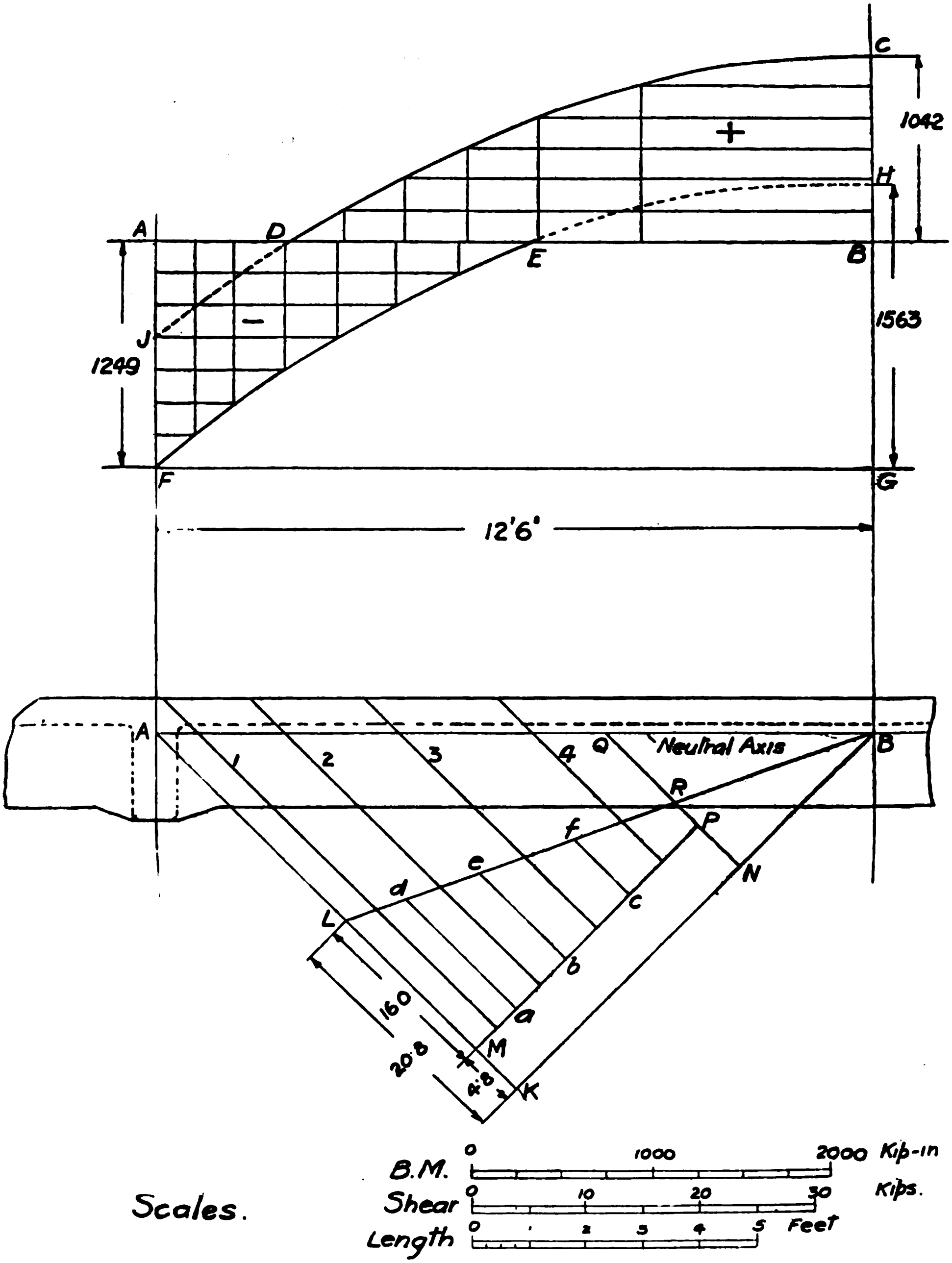


FIG. 8.

We will give the detail calculation for the shear reinforcement and arrangement of bars for the intermediate secondary beams.

Shear reinforcement is governed by the following regulations :

64 states that the shear taken by the concrete only shall be calculated on the compressed area of the web or on the web area for a depth equal to the arm of the resistance moment of the beam.

65 states that if the shear is carried by the concrete only, the ends of 50 % of the tensile reinforcing bars shall be inclined across the neutral plane of the beam and shall be carried through a depth equal to the arm of the resistance moment or the whole of the bars shall be carried through to the ends of the beam.

66 states that if the shear stress in the concrete alone exceeds the permissible stress (60 lb. per sq. in. for 1 : 2 : 4 concrete) the *whole of the shear* shall be provided for by the web reinforcement and in no case shall $\frac{S}{b_r d}$ exceed three times the shearing stress (*i.e.*, 180 lb. per sq. in.).

67 states that the web reinforcement shall :

(1) Be spaced according to the distribution and intensity of the shearing stresses but the distance centre to centre shall not exceed the arm of the resistance moment (a).

(2) At least extend from centre of tensile reinforcement to centre of pressure of concrete.

(3) Be passed under or around the tensile reinforcement or be otherwise secured thereto.

(4) Be hooked at both ends or equally effectively anchored.

68 states that bent up tensile reinforcement which is carried through a depth equal to the arm of the resistance moment may rank as shear reinforcement.

We have in addition to keep in mind regulation **62**b, which states that when compression reinforcement is stressed up to 16,000 lb. per sq. in. anchors must be provided at distances apart not greater than 6 inches and not greater than 8 times the diameter of the anchored bar.

We will first calculate the distance between which by the regulations no special shear reinforcement is required.

By regulation **64** we have :

$$\frac{S}{b_r a}=60$$

$$\therefore \text{ In our case } S = 60\, b_r a$$
$$= 60 \times 7 \times \cdot 912 \times 20$$
$$= 7{,}660 \text{ lb.}$$
$$= 7\cdot 66 \text{ kips.}$$

The shear at the ends is 20·8 kips and at the centre is 0 (zero), the span being 25 feet.

$$\therefore \text{ No web reinforcement is required for a distance } = \frac{7\cdot 66}{20\cdot 8} \times \frac{25}{2}$$
$$= 4\cdot 6 \text{ feet each side of the centre.}$$

Stirrup or vertical shear reinforcement.—Since we have stressed the compression reinforcement up to 16,000 lb. per sq. in. we must, as explained above, provide anchors not more than 6 in. apart. We will use these anchors as part of the shear reinforcement and will take ¼″ stirrups or links of the shape shown in *Fig.* 9.

The shear which these links are capable of resisting is given by the formula $S=\frac{Ata}{p}$

where A = area of stirrups (sq. in.).
t = tensile stress (16,000 lb. per sq. in.).
a = arm of resistance moment (in.).
p = pitch of stirrups (in.).

$$\therefore \text{ In our case } S = \frac{2 \times {\cdot}0491 \times 16{,}000 \times 18{\cdot}2}{6}$$

$$= 4{,}800 \text{ lb. approx.} = 4{\cdot}8 \text{ kips.}$$

The remainder of the shearing force must be borne by the bent-up bars, the spacing of which we will now proceed to determine.

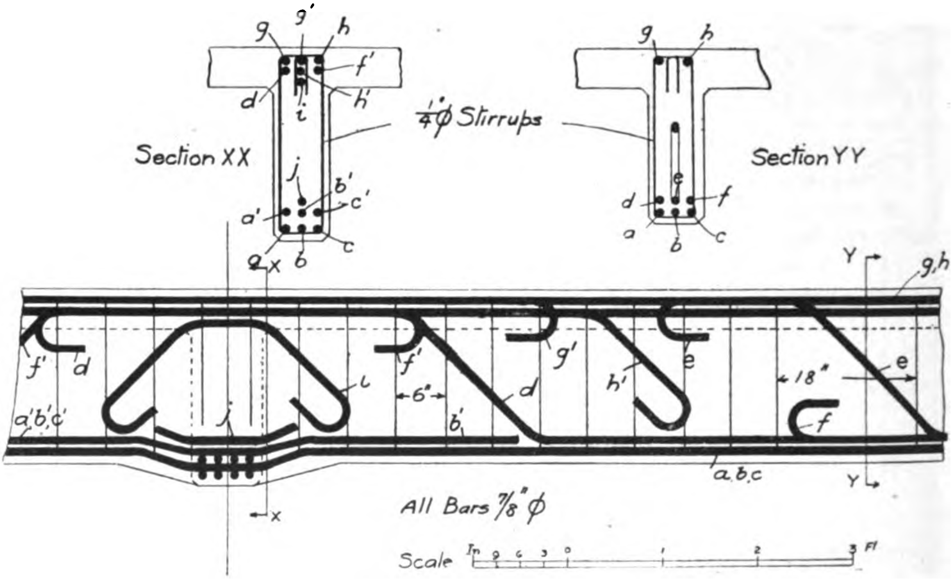


FIG. 9.

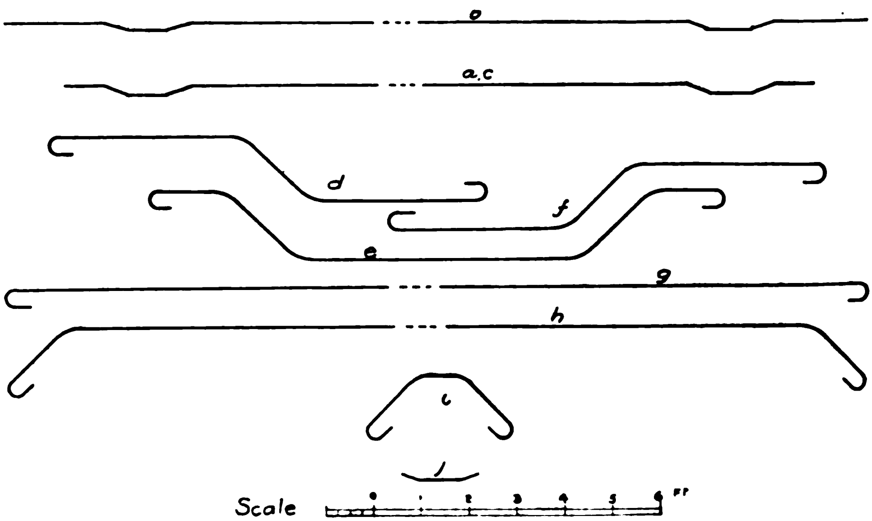


FIG. 10.

Shear reinforcement from bent-up bars.—In bending up the bars we consider the shear diagram, keeping an eye at the same time on the bending-moment diagram to ensure that we do not bend up bars beyond the point where they are required for the bending moment.

The B.M. diagrams for $+ve$ and $-ve$ moments are shown on the upper portion of *Fig.* 8.

At the support end we set down AF to represent 1,249 kip-in. and at the centre of the span we set up $GH = \frac{Wl}{8} = \frac{41 \cdot 7 \times 25 \times 12}{8} = 1{,}563$ kip-in. and draw a parabola passing through F and having vertex at H, the portion EF representing the $-ve$ B.M. to be considered. Since this is carried by 7 bars we draw 7 horizontal lines at equal vertical distances apart and project their intersections with the parabola vertically on to the base AB, thus obtaining points at which successive bars may be stopped off.

For the $+ve$ B.M. we set up $BC = 1{,}042$ kip-in. and draw a similar parabola CDJ, the portion CD being employed for the + B.M.; this is similarly divided into 6 strips because there are 6 bars at the centre.

A common method of determining the spacing of the bent-up bars is to draw from the points A and B on the neutral axis at the end and centre of span lines AK, BK at 45° to the neutral axis and to set up KL to represent the end shear of 20·8 kips. At the point N, where NR represents 7·66 kips, which is the shearing force that the concrete alone may resist, we draw a line NQ at right angles to KB; then BQ gives the distance from the centre in which no shear reinforcement is called for, this coming equal to 4·6 ft. as previously calculated.

Now set up KM to represent 4·8 kips which the stirrups can carry and draw MP parallel to KB.

The tensile strength of each ⅞ in. φ bar $= tAs = 16 \times {\cdot}601 = 9{\cdot}62$ kips.

Then we choose a length Ma so that the area $MLda$ is equal to $tA_s a = \frac{9 \cdot 62 \times 18 \cdot 1}{12} = 14 \cdot 5$ (a being brought into ft.).

If we take $Ma = 1$ ft., this condition will be satisfied, and the centre line of the trapezium $MLda$ gives, when produced across the beam, the centre-line of the first bent-up bar 1.

We next choose the length ab so that the area $adeb = 14 \cdot 5$ and thus get the centre-line of the next bent-up bar 2, and so on, proceeding to the point where shear reinforcement is no longer required.

The above partly graphical method is commonly followed in practice; if it is preferred to work by direct calculation we may proceed as follows:

By the formula (explained in Appendix VI. in the R.I.B.A. report of 1911):

$$A_s = \frac{Sp}{ta\sqrt{2}}$$

where S is the shearing force where the given bar crosses the neutral axis.

p is the distance between the mid-points of lengths on the neutral axis where successive bars cut.

A_s = Area of shear reinforcement bar.

t = tensile stress in bar (16,000 lb. per sq. in.).

a = arm of resistance moment (lever arm).

We can calculate p for given values of S, A_s, a, t. Some amount of trial and error is, however, necessary, since S has to be taken at the point where the shear reinforcement cuts the neutral axis, and this must be first assumed.

Detail arrangement of bars.—We are now in a position to proceed to the detail design of the reinforcement as shown in *Figs.* 9, 10. There are several ways in which the bars may be arranged in detail, and it sometimes requires a good deal of manœuvring to get a satisfactory arrangement, particularly if we are restricted as to the lengths of bars which are available.

It is very necessary to scheme out the arrangement of the bars on the drawing board and to give full instructions on the drawings ; to avoid confusion on the diagrams, which have here to be reduced considerably in scale, we have omitted many dimensions from the drawings, but on the working drawings full dimensions should be shown, and a schedule of the overall lengths of all bars before bending should also be given. Time thus spent in the drawing office will be amply repaid by saving of time on the job and —more important still—saving of serious mistakes in the work, seeing that the workmen never realise the importance of accurate placing of the reinforcement.

Three of the bottom bars *a*, *b*, *c* go right through and continue beyond the support, the three corresponding bars, a^1, b^1, c^1, from the previous span combining with them to give 6 bars at the support ; the seventh bar *j* is a short bar whose length is determined from the B.M. diagram on the upper part of *Fig.* 8.

For the top reinforcement we take two bars *g*, *h* right across the span ; this is not essential from the regulations, but it is desirable as giving a support for the stirrups and for taking the reverse bending moment, which would extend nearly right across the span if alternate spans only are loaded.

The dimensions of the hooked ends of the bars are determined by regulation **48** (b) ; their inner diameter must be 4 times the diameter of the bar (3½ in. in our case), and the length of the straight portion beyond the curve must also be 4 times the diameter of the bar.

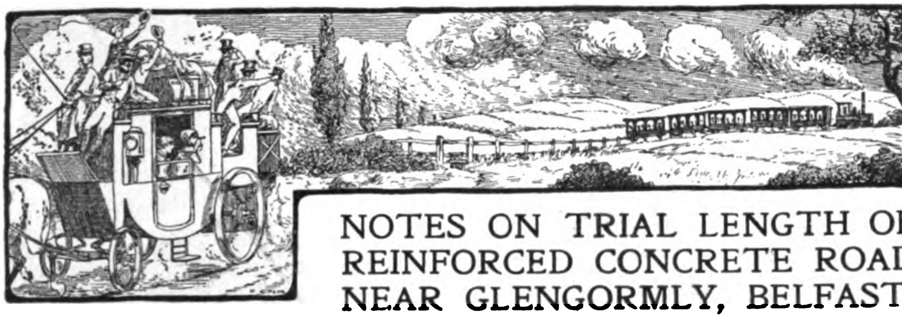
The first inclined shear bar is given by the bar *i*, which provides the seventh bar in the top reinforcement at the support ; the second bar *d* is obtained by bending up the bar *d* from the bottom reinforcement, this bar continuing beyond the support as shown ; the third is given by bending down the bar h^1 which comes through from the previous span and extends right across it ; the fourth bar *e* is obtained by bending up from the bottom and extending horizontally along the top for a short distance.

The shapes of the various bars employed in the beam are shown in *Fig.* 10, separated from each other to save confusion.

A consideration of *Fig.* 8 will show that the bar 4 will resist an amount represented by more than the area *fcRP*, and we have therefore shown in *Fig.* 9 the spacing of the stirrups to increase from a point just before the bar *e* to 18 inches. As we have already explained, it is not essential to provide any shear reinforcement between the points *B* and *Q*, but we favour the continuance of the stirrups at 18 in. apart right across the beam to the corresponding point on the opposite side of the centre. The stirrups help to secure the proper truss action of the beam and are also desirable in view of the fact that some isolated loads may be placed on the floor near to the centres of the beam.

The design of the shear reinforcement for the pillar secondary beams will be similar, but will vary in detail at the ends on account of the additional haunching which is available at the pillars.

(To be continued.)



NOTES ON TRIAL LENGTH OF REINFORCED CONCRETE ROAD NEAR GLENGORMLY, BELFAST.

We are indebted to the County Surveyor of Belfast, Mr. D. Megaw, A.M.Inst.C.E., for the following particulars.—ED.

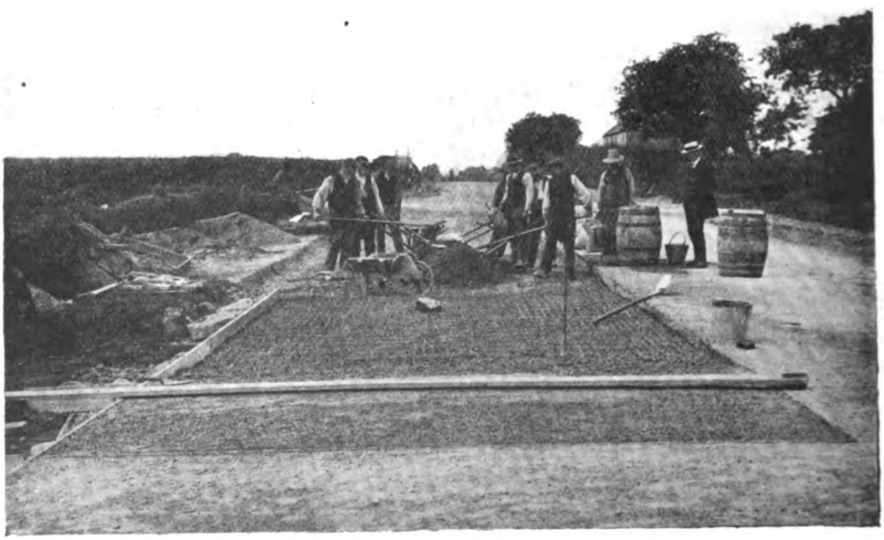
In August, 1915, a short length of reinforced concrete road was laid in the Belfast rural district about four miles outside the Belfast borough boundary; the length was one of three experimental lengths on a portion of the Antrim main road where maintenance has always proved to be difficult and expensive on account of the boggy nature of the subsoil.

The width of the carriage way—30 ft.—is above the average for country roads, and there is a footpath 6 ft. wide on the N.E. side of the road, as well as a grass verge of about the same width on the S.W. side.

In the execution of the work the specification for the Kent experimental length No. 4 (*b*) was followed, with the exception that the concrete, instead of having a uniform thickness of 6 in. all over, was made 7½ in. thick at the middle of the road, reducing to 6 in. at the sides. The road was laid in half-widths, and each half-width in 10-yd. lengths.

One half of the old road crust was scarified and sufficient of the crust removed to give a formation of the proper contour and at the proper level. On the formation bed so prepared a 2-in. layer of concrete was laid, and on this was placed the reinforcement, which consisted of the British Reinforced Concrete Engineering Co.'s fabric (Regd. No. 9), laid longitudinally with 4-in. overlap where the separate sheets joined. These sheets are in 6-ft. widths, so that at the centre of the road, to avoid exceeding the half-width, it was necessary to bend back the central sheet of reinforcement until the second half-width of concrete came to be laid. On account of the sheets overlapping, the reinforcement did not come quite to the edge of the 30-ft. width of concrete, but the width outside the reinforcement was given an extra thickness of 3 in. underneath, being 9 in. thick for a width of 12 in.

On top of the fabric the upper layer of concrete was immediately laid and carefully tamped, to bring it to the specified thickness when the surface was finished off by men who used contour boards, which ensured that the surface had the proper contour and crossfall. The concrete surface was then covered with a 2-in. layer of damp sand until the concrete had thoroughly set, and there was an interval of fifteen days before traffic was permitted on the new surface. When traffic was turned on the first half-width the second half-width was carried out in the same way; after the bottom 2-in. layer of concrete was laid the central



Views showing Concrete Road in course of construction at Glengormly, near Belfast.

sheet of fabric that had been turned back at the edge of the first half-width was now turned down and the other two sheets laid in position.

Each half-width was done in 10-yd. lengths separated from one another by ½-in. boards that were later replaced by short creosoted slips grouted in pitch that served as expansion joints; the laying of these parting slips was somewhat troublesome.

When the full width of concrete had set and was thoroughly dry, the surface was tar-sprayed; owing to its absorbent nature this required tar at the rate of 1 gall. to 2 sq. yds.; the tarred surface was then coated with clean chips.

The specified crossfall, 1 in 50, seems to be rather less than is advisable; in the present case a crossfall of 1 in 45 was given, but probably a somewhat greater fall would be better.

Except for slight adjustments at the crossjoints the work has proved quite satisfactory.

A traffic census on the Antrim road, near the Sandy Knowes Cross roads, where the length which has been described was laid, gave a total of 416 tons per day. The length of the concrete road is 48 lineal yds.

Details of the cost per sq. yd. are as follows:—

	s.	d.
Labour	1	9·4
Reinforcing fabric, No. 9	1	2·3
Portland cement, at 50s. 4d. per ton	2	3·7
Broken stones, at 3s. 10d. per ton	1	1·7
Horsework	0	1·6
Sundries (parting slips, etc.)	0	4
Total cost per sq. yd. ...	6	10·7

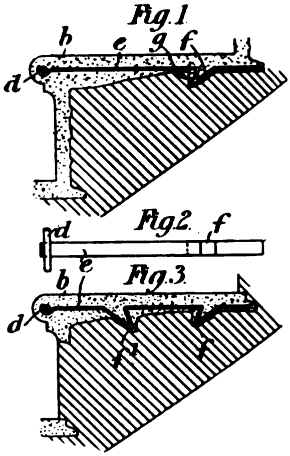
The cost would not be justified on county roads unless in exceptional cases.

[With regard to the statement that the cost of this road, *i.e.*, 6s. 10·7d., "would not be justified on county roads unless in exceptional cases," it must be remembered that the cost of all material for road making, labour, cartage, etc., has considerably advanced from the figures that prevailed in pre-war days. Guernsey stone has risen about 65 per cent., and we are informed that the cost of a granite macadam road, with foundation, on present prices would be 7s. to 7s. 6d. per yd. super, and possibly more. Whatever difference there may be in the initial cost between a water bound macadam road and one properly constructed of reinforced concrete, the annual maintenance cost of the former is very expensive when compared with the upkeep of a concrete highway.—Ed.]

RECENT BRITISH PATENTS RELATING TO CONCRETE.

We propose to present at intervals particulars of British Patents issued in connection with concrete and reinforced concrete. The last article appeared in our issue of December, 1916.—ED.

Repairing Stair-treads, etc.—*No.* 12,409/15. *J. H. Bennett,* 253, *Putney Bridge Road, Putney, S.W. Accepted June* 22/16.—This invention has reference to the repairing or renovating of stair-treads by embedding a metal rod in the nosing and combining with this rod a bar passing under the bar and extending backwards to the underside of the riser of the next step above, both rod and bar being covered in concrete; this method is described in Specification No. 271/10.

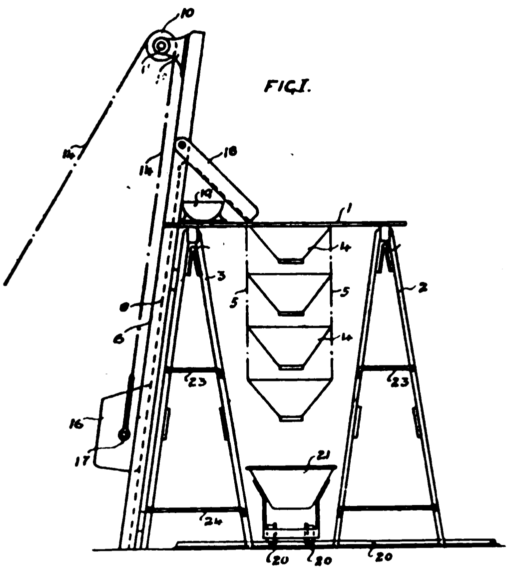


According to the present invention, the bar is provided with a cranked or downwardly projecting portion to prevent it from moving outwards.

The concrete or cement facing *b*, forming the new tread, has the rod *d* arranged in the nosing, and the bar *e*, which engages under the rod *d*, has in one form, *Figs.* 1, 2, a cranked portion which is placed in a recess *g* formed in the old tread, forward movement of the bar *e* being thus prevented.

In a modified construction, *Fig.* 3, the bar *e* is formed with two cranked portions, *f*, *f*', inclined in opposite directions, and thus preventing movement in either direction.

Concrete Mixers.—*No.* 14,891/15. *J. Hunt and M. Lawless,* 22, *Heans Lane, Dundee, N.B. Accepted October* 23/16.—This invention comprises improved means for charging concrete mixers of the inverted cone type to enable the mixers to be erected above the ordinary ground level. A platform (1) is supported by trestles (2, 3), the inverted cones (4) connected by chains (5) being supported from the platform. Inclined guides (6) are bolted to one trestle and carry slide bars (8), which terminate a short distance above the platform.



A rope pulley (10) is carried on a shaft supported by brackets on the guides, and guides a rope (14), to one end of which is secured a tip bucket (16), the other end being attached to a suitable winch or winding engine. The pivots (17) of the tip bucket are so placed that when the latter reaches the top of the slide bars (8) it overbalances and discharges its contents down a shoot (18) into the top cone. This shoot is pivoted on the guide (6), so that it may be turned up out of the way when not in use; when this has been done the bucket discharges into a receptacle (19).

Rails (20) may be laid between the trestles to take a tip wagon (21), into which the mixed concrete may be discharged; the trestles may be hinged and provided with stays (23, 24).

Reinforced Beams, Arch Ribs, etc.—No. 16,888/15. *W. S. Armstrong, Alexandra Villa, Kilmailing Road, Cathcart, Glasgow. Accepted December 1/16.*—Reinforced beams, arch ribs, etc., are constructed in accordance with this invention of metallic lathing which is covered with Portland cement or other hard-setting

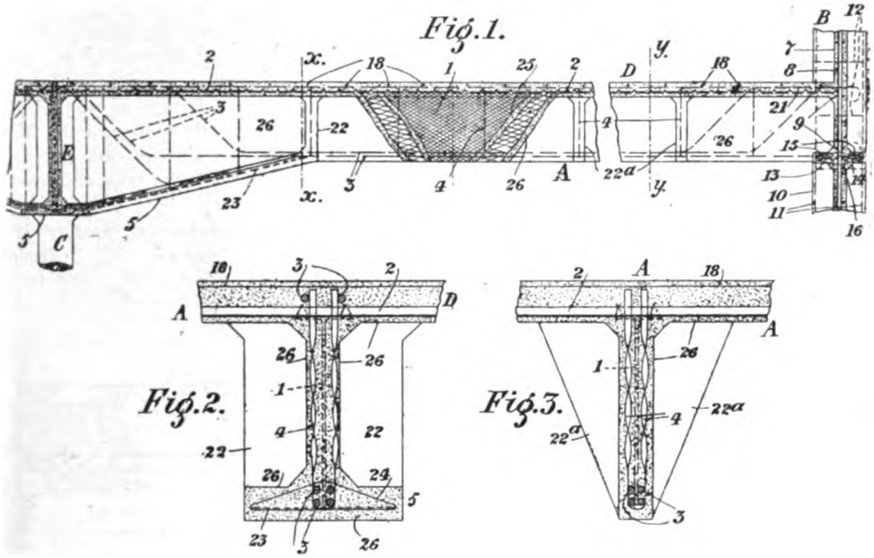


Fig. 1. Fig. 2. Fig. 3.

plaster, after having reinforcing rods bent near supports to resist shearing forces and secured in position by wiring or clipping on to the lathing.

The beam *A*, *Fig.* 1, is supported by the wall *B*, and by a column *C*, and has metallic lathing, 1, the floor, *D*, being provided with lathing, 2. The lathing, 1, is covered with two coats of cement plaster, 25, 26. The shear bars, 3, are bent up as shown, and stirrups, 4, are provided at intervals. Towards the continuous end a compression flange, 5, is formed, having metallic lathing, 23, and wire binders, 24; gussets, 22, 22a, *Figs*. 2, 3, are provided at intervals.

The aim of the invention is to dispense with formwork.

Metal Formwork for Concrete Buildings.—*No.* 13,711/15. *R. Wilson*, 116, *Collins Street, Hobart, Tasmania. Accepted September* 27/16.—Metal formwork

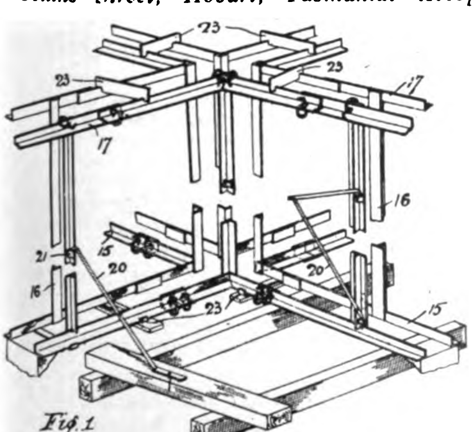


Fig. 1

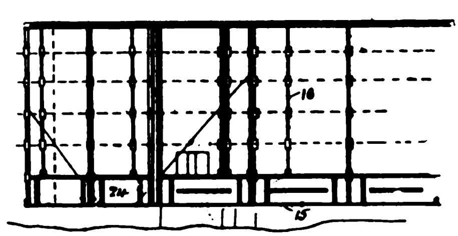


Fig. 3

in accordance with this invention comprises horizontal angle bars (15, 17) along the upturned legs of which notched vertical T bars (17) are supported at intervals;

struts (20) are employed, consisting of hooked bars engaging angle brackets (21) packed out from the T bars.

The open spaces between the T bars are filled with sheeting frames (24), to which sheet-iron is riveted to form a plane surface; the corners of the frame are provided with legs, which are bent to come behind the flange of the T bar and thus present a flush surface, and are secured by wedges engaging the brackets (21). The framework is held at the requisite distance apart for casting the walls by means of riding pieces (23).

In constructing cavity walls, cavity boxes are arranged between the sheeting prior to casting, and may be made collapsible to facilitate their removal. When the concrete is set, the sheeting frames are removed by knocking out the fixing wedges and lifting the frames clear; they are then secured higher up and casting is proceeded with.

Metal Formwork for Concrete Structures.—*No.* 14,611/15. *E. LeBas, H. T. Garvie and C. L. Evenette, Dock House, Billiter Street, London E.C. Accepted October* 15/15.—Metal plates for use as formwork in concrete structures are formed

Fig. 1.

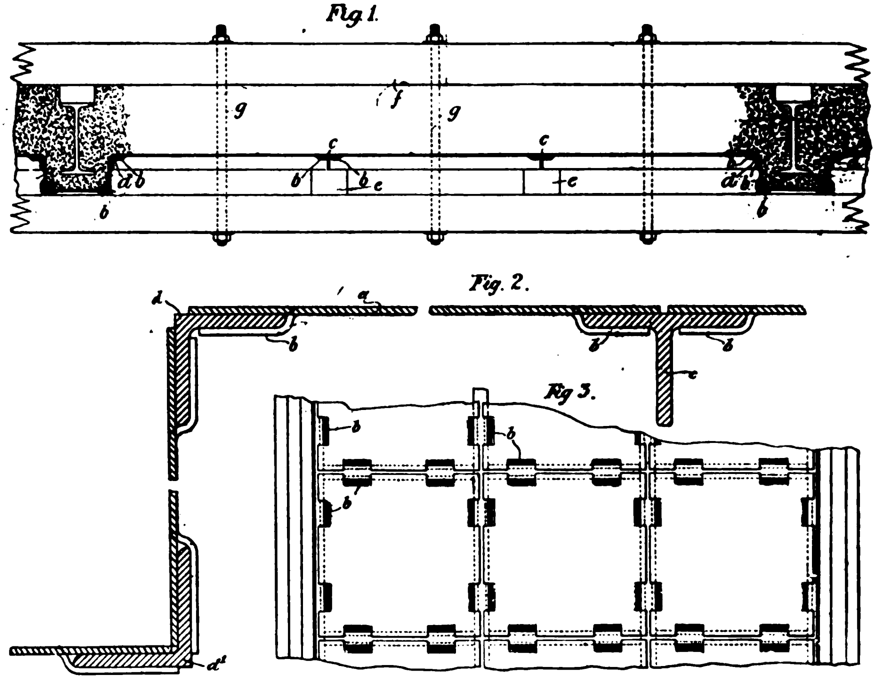


Fig. 2. Fig. 3.

in accordance with this invention with narrow integral clips stamped up from the plates at intervals, so as to engage with L, T, and like supports; the clips may also be so formed and spaced upon the plates that they may interlock with each other.

In *Figs.* 1-3 the clips, *b*, are shown engaging L and T bars, *d, c;* the bars, *c*, rest on temporary timber bars, *e*, which rest, in turn, upon timber frame bars, which are suspended as usual from upper frame bars by means of suspenders, *g*, during the construction of the floor, the suspenders being subsequently removed.

The construction is also applicable to dished plates or plates of curved or arched form.

Holding Reinforcement in Place during Concreting.—*No.* 15,834/15. *T. J. McDowell,* 231, *Strand, London, W.C. Accepted November* 9/16.—A metallic flat or like bar, *H*, is provided, having the two end portions bent at a right angle, adapted to fit over the mould or casing. Secured to the under surface of the metal bar are two plates, *M*, forming a bracket. The two plates project into the mould and depend from this metal bar in parallel relation the one to the other, and are each secured to this bar by angle flanges.

Recesses or slots, *I*, are formed in the edge of each plate, adapted to receive the wires or like reinforcement, *G*. Holes are formed through the bar in a suitable position above the recesses, and between the plates, and hooked bolts, *B*, are fitted through the holes, the hook being turned in the same direction at each end. A screw thread on the shank of each such bolt is fitted with a washer and flynut, *E*.

The supporting bar for the device is fitted over the mould, so that the parallel plates project downwardly into the mould, the reinforcement is then clamped

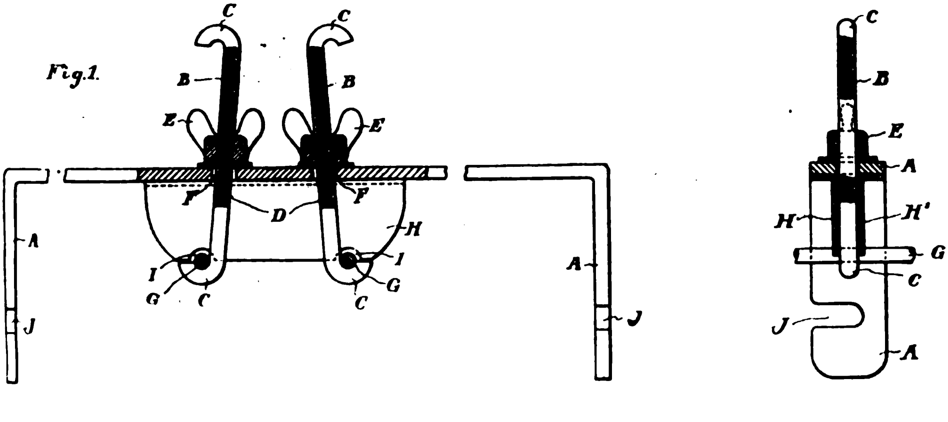


Fig. 2.

between the hooks and the recesses cut in the edges of the depending plates, the nut and washer being screwed down until each hook holds the bar, rod, or wire against its corresponding recess. The concrete is then filled in round the reinforcement.

When the filling in has been completed, and the concrete is still in the plastic state, the flynuts are unscrewed; each hooked bolt is then pushed down slightly and is then turned half round—that is to say, to approximately 180° relatively to its former position, so as to release it completely from engagement with the reinforcement, and the device is then withdrawn from the concrete. A slot may be provided in order to secure the bar, *H*, on the outside of the mould if desired.

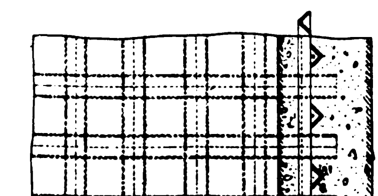


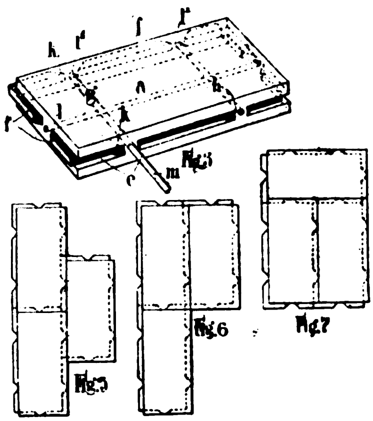
Fig. 1.

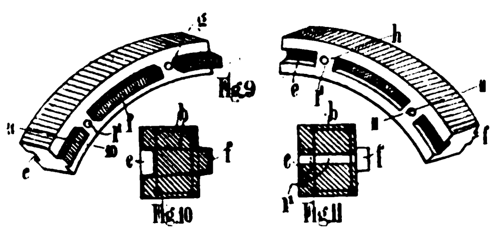
Reinforced Concrete Strong-rooms.—No. 102,588. *S. Binns, Cross Street, Manchester. Accepted December* 14/16.—This invention consists essentially in the particular arrangement of two or more layers of angle bars, the layers in the walls being alternately arranged vertically, horizontally, or diagonally, so that the sides of each bar present a surface inclined to the face of the wall.

In the walls one layer is arranged vertically with the angle bars, *A*, and the adjacent layer with the bars horizontally, the distance being then conveniently 6 in. In the arrangement shown in the drawing the angle bars of one layer are placed facing those of the adjacent layer, but they may be arranged back to back.

Reinforced Concrete Slabs.—No. 102,805. *D. G. Somerville, 120, Victoria Street, Westminster, London, S.W. Accepted December* 28/16.—The present invention consists in a reinforced concrete slab, one side and one end of which are longitudinally grooved and the other side and end of which are longitudinally ribbed, the ribbing being interrupted by recesses and the grooving by bridging pieces, and both ending flush with the body part of the slab.

In the case of a flat slab, *Figs.* 3, 5-7, suitable for forming ceilings, flooring, or walling, the rectangular slab, *a*, is formed of concrete, in which a suitable metallic reinforcement is embedded. In one of the sides, *c*, and in one of the ends, *d*, grooves, *e*, are formed, whilst on the other side c^1, and on the other end d^1, ribs, *f*, are constructed. The relative arrangement of the grooves and ribs is such that on respectively opposite sides a groove in one will be opposite to, and correspond with, a rib on the other. When fitting a number of blocks or slabs together the ribbing, *f*, on one will engage the grooving, *e*, in the adjacent face of another block or slab, and *vice versa*, and to prevent any sliding movement between the adjacent faces the





ribbing is interrupted at the part, *g*, and the grooving is filled in by bridging pieces, *h*, to constitute keys or interlocking means.

Instead of the slabs being flat they may be curved or formed with flats (*Figs.* 9-11) in order to be built together to form a lining, a circular structure, or rounded corners, and so forth. In the example shown interlocking will occur on the longer sides and not at the ends, but ribs and grooves may also be applied on the ends if so desired.

In order to secure more completely a number of slabs together, holes, l^1, are preferably provided, which extend through the slab, and through which holes a tie rod, *m*, may pass, which remains permanently therein, cement grouting and the like being used to fill any clearance between the holes and the rod.

THE NEW REINFORCED LIGHTHOUSE AND THE OLD IRON LIGHTHOUSE, BRANDYWINE SHOAL, U.S.A.

BUILDING A CONCRETE LIGHT-HOUSE ON BRANDY-WINE SHOAL.

The following interesting particulars and illustrations of the design and construction of a reinforced concrete lighthouse to replace a 60-year-old iron lighthouse in Delaware Bay, have been taken from an article in "Engineering News," by Mr. T. J. Rout, U.S.A. Lighthouse Inspector, Philadelphia, Penn. —ED.

BRANDYWINE SHOAL is about 2½ miles long, running parallel with the main ship channel of Delaware Bay, and is 11½ miles north of Lewes, Del. At this point the bay is 16 miles wide and the site has little protection against storms. The nearest harbour is at Lewes, and the nearest land is at Cape May, 7 miles distant, the Delaware shore of the bay being 9 miles away. The site has a submerged depth of 8 ft. at mean low water, and the tides have a mean rise and fall of 6 ft., with a current velocity of 3½ miles per hour. The original structure on the site was an iron-frame lighthouse on screw-piles, erected in 1850 at a cost of $53,000 and the first of its type in the United States. The wrought-iron piles had deteriorated to such an extent that it became advisable to build a new structure near by rather than to attempt repairs. Accordingly, in 1911 Congress appropriated $75,000 for a new lighthouse. Work was started in 1912 and completed in 1914. A one year guarantee by the contractor expired in October, 1915.

Preliminary test borings made at the site showed very hard sand to a depth of 60 ft., and then a hard blue mud for 10 ft. more, the extent of the borings. For this condition a design was prepared consisting of a pneumatic caisson foundation 35 ft. in diameter and 37½ ft. high, built of 1¼-in. cast-iron plates, the whole supporting a cast-iron superstructure. At the first letting no bids for the complete structure were received. Bids were again invited under the same plans and specifications, but it was stated that due consideration would be given to proposals for a reinforced-concrete structure, the bidder to furnish detailed plans and specifications.

Two bids for a complete structure were received, one for an iron structure, and the other from the Interstate Construction Co., of Mobile, Ala., for a reinforced-concrete structure. This latter was accepted.

As shown in the details in *Fig.* 1, the lighthouse is a cylindrical structure with a footing section of a cellular caisson cast on shore and floated into place, where it was bedded on timber piles and pinned to place with concrete piles. The superstructure, of decreasing circular sections, is of reinforced concrete built in place. It consists of a three-story circular concrete dwelling,

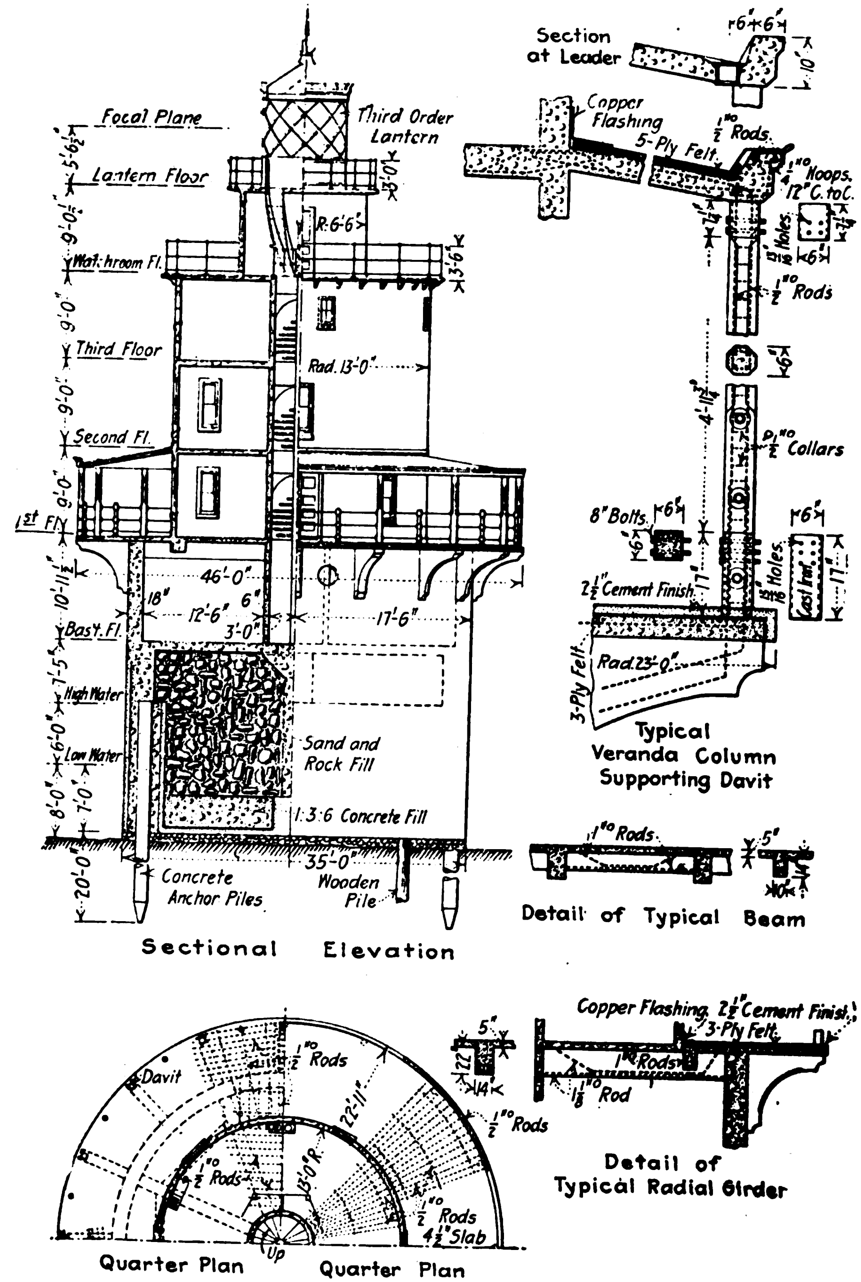


Fig. 1. Construction Details.
Brandywine Shoal Lighthouse

26 ft. in diameter, supporting a circular watchroom and a standard third-order lantern. The circular walls of the superstructure are 6 in. thick, reinforced with ½-in. rods, 12 in. c. to c. in both directions.

The first floor consists of a 5-in. slab reinforced in both directions by ½-in. rods and supported on eight radial 14 by 22-in. beams. At this level a balcony extends entirely around the lighthouse. The balcony floor is supported on sixteen 12-in. brackets, while its roof is supported by sixteen 6 by 6-in. concrete

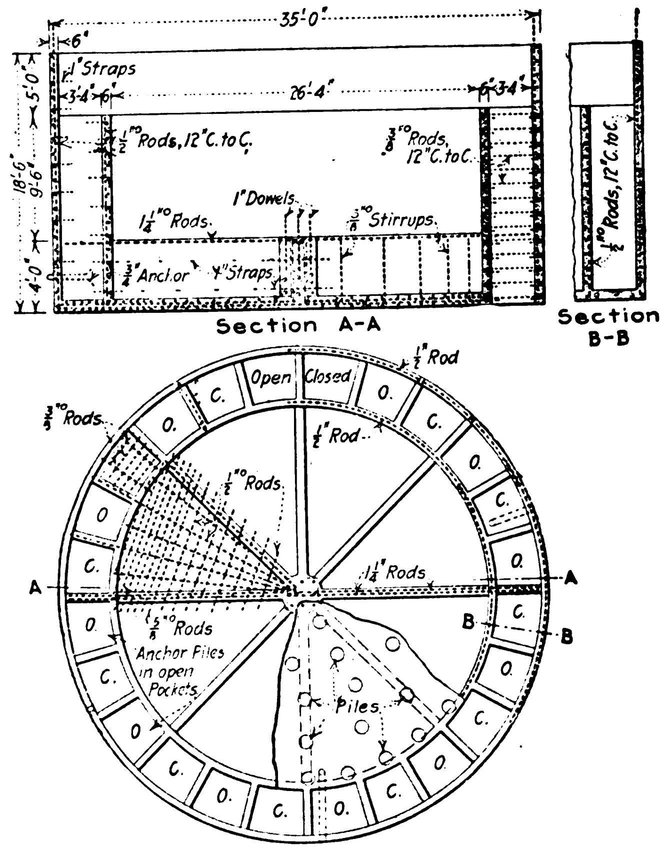


Fig. 2. Details of Reinforced Concrete Caisson Foundation.
Brandywine Shoal Lighthouse.

columns. The upper floors consist of a 6½-in. slab reinforced in both directions by ½-in. rods. All were designed to carry a live-load of 200 lb. per sq. ft. together with the dead-load. There is a balcony with iron railing at the level of the third and lantern floor.

The balcony floor slabs were covered with a three-ply tar and felt roofing, and this waterproofing was covered with a 2½-in. layer of cement mortar. The inside floors were finished with a ½in. coat of asbestos composition flooring. Room is provided for the lantern and foghorn machinery in the basement, and quarters for three men are in the upper stories.

BUILDING AND PLACING THE FOUNDATION.

The concrete foundation shell (35 ft. in diameter and 18½ ft. high) was erected on a launchway on the beach at Lewes, Del. It contained 104 cu. yd. of 1 : 2 : 2 concrete, 11,400 lb. of steel reinforcement, and weighed about 225 tons. Details are shown in *Fig.* 2. The shell consisted of circular inner and outer walls, each 6-in. thick, spaced 3 ft. 4 in. apart. An 8-in. concrete floor extended to the inner circular wall only. This floor was reinforced on the upper side by eight 10-in. by 3-ft. 4-in. radial beams. The outer and inner

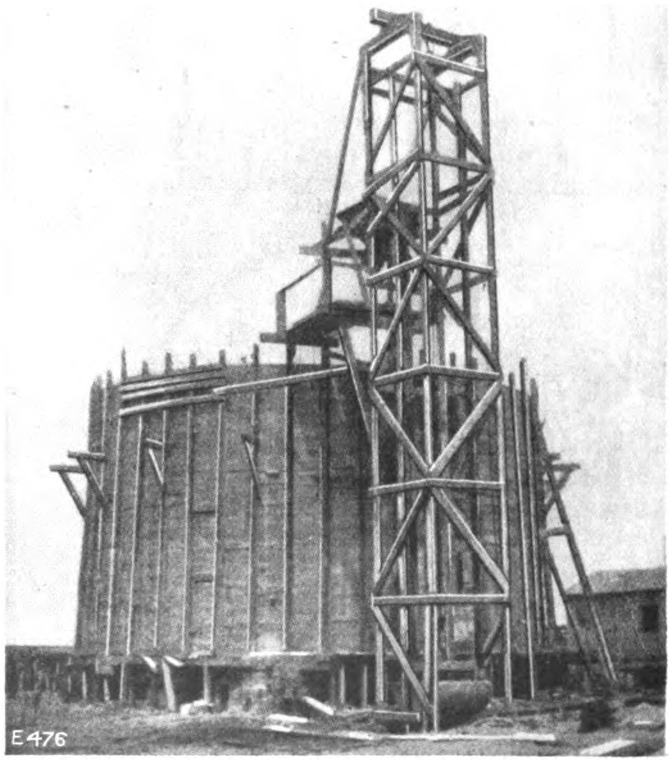


Fig. 3. Building the Foundation Caisson.

BRANDYWINE SHOAL LIGHTHOUSE.

circular walls were joined together by twenty-four 6-in. radial partitions. Each alternate pocket thus formed was sealed at the bottom with an 8-in. floor, the other pockets remaining open. The reinforcement for the bottom consisted of two layers of plain iron rods ½ in. to ⅝ in. in diameter, spaced 6 in. to 12 in. on centres. The walls were reinforced by vertical and horizontal ½-in. rods, 12 in. on centres. The forms were of ⅞ by 8-in. horizontal boards, well nailed to 4 by 4-in. upright studs, spaced about 22 in. on centres.

While the concrete work was in progress on the shore a working platform was erected by the contractor at the site to accommodate the storage of materials and to facilitate the work. It was supported on thirty-five piles driven 7 ft. into the sand. Its deck was 1,100 sq. ft. in area and was 9½ ft. above mean high water (*Fig.* 5). In addition to this, the contractor was allowed to use the platform around the old lighthouse. On this were erected the quarters for workmen, the hoisting engine, pumps, water tanks, concrete materials, etc.

After these preliminaries seventy-four pine bearing piles were driven at the site. Each pile was calculated to carry about 20 tons, had a penetration of

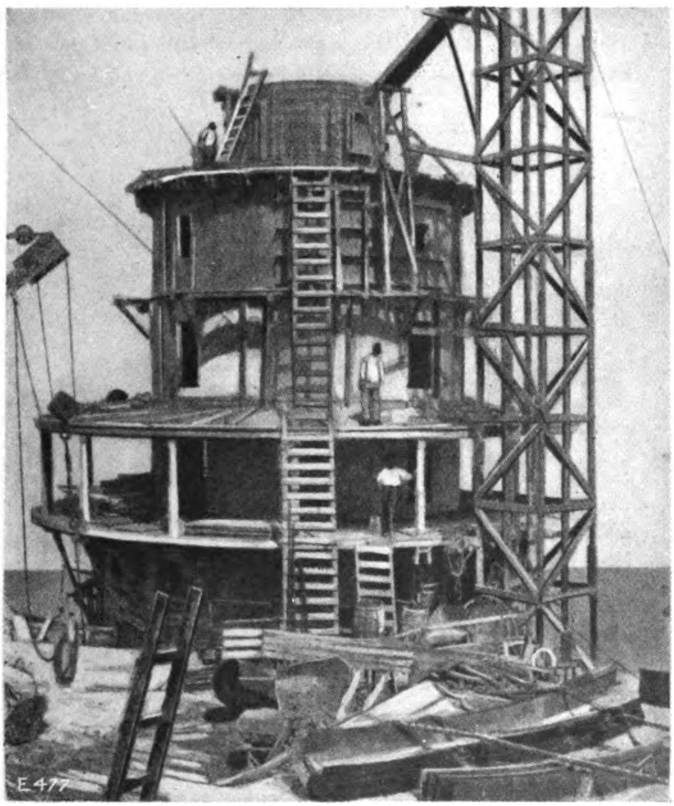


Fig. 4. The Superstructure under Construction.
Brandywine Shoal Lighthouse.

20 ft., and terminated 1 ft. above the top of shoal. All were driven by means of a jet, the water being supplied through a 2-in. hole reduced to a ¾-in. nozzle and furnished under high pressure by a duplex piston pump provided with its own boiler. A 2-in. pipe was screwed about 5 in. into the head of each pile to guide it and hold it in a vertical position. By means of an engineer's level and a file mark on the 2-in. pipe the elevation of the top of the pile could be determined. In this manner the piles were jetted to the exact depth required, thus eliminating the services of divers. Near the centre of the foundation,

when the piles were close together, it was found that in jetting one pile down, another would rise. This trouble was overcome by lashing the 2-in. pipe follower to the falsework.

When the foundation had been prepared the shell was launched at Lewes in the same manner as a vessel. On account of a sand shoal, it struck on the bottom in 5 ft. of water at low tide, and it was necessary to dredge a cut in order to float it. Before the shell was launched the open pockets were floored with 2-in. planking to exclude the water. In launching three of these were damaged and allowed the water to come in. This gave the shell quite a list.

A tug, by means of a 13-in. hawser, towed the shell to its destination. It weighed about 225 tons, had a draught of 9 ft. 2 in. and a freeboard of 9 ft. 4 in. It was towed around the west end of the inner (or old) Delaware Breakwater, thence to the eastward around the south end of the outer break-

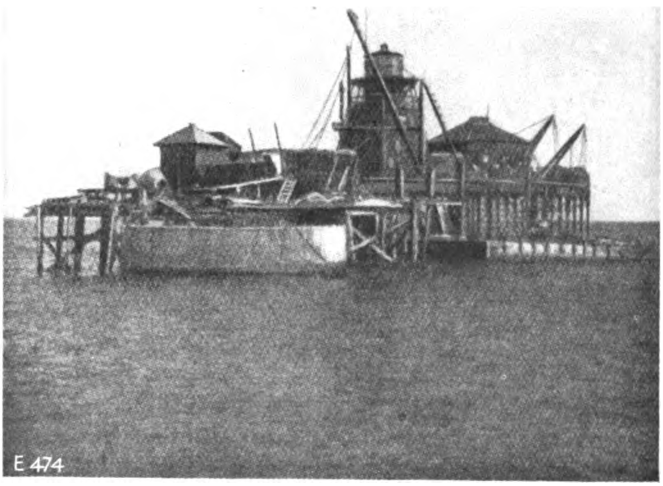


Fig. 5. Work in Progress, showing Foundation Caisson, Working Platform, and old Lighthouse.

water, thence northward to the site. The total distance travelled was 14 miles, which was covered in four hours. For the first three miles the towing was against the tide, and slow progress was made; but after passing the outer breakwater, better speed was maintained on account of flood tide. There was a slight swell on, and at times the shell had a freeboard of only 7 ft. (*Fig.* 6). However, no water came inside it.

At high-water-slack the shell was floated into place and sunk upon its pile foundation by means of sea-cocks. To pin the structure down, twelve 16 by 16-in. concrete anchor piles, 34 ft. long, were driven in place through the open pockets. Each of these piles had a penetration of 20 ft. into the sand, weighed about 4½ tons, and was calculated to carry 55 tons. They were put in place by means of two water jets. After the piles were in place the bottoms of the pockets were sealed by depositing concrete in bags. The water was then pumped out, and the pockets were filled with concrete deposited in air.

Concrete was also deposited in the closed pockets; after this the water was pumped out of the foundation and the space up to the tops of the radial beam was filled with concrete. Above this level and up to the basement floor excepting the water tank the fill consisted of sand and stone.

The twelve anchor piles, made of 1 : 1½ : 3 concrete, were cast on shore. The reinforcement consisted of a ¾-in. rod in each corner. The forms for two piles were erected parallel with each other and 16 in. apart. These piles were poured, the forms were then removed, the sides of the two piles well greased, and a third pile was poured in the space between the other two. Three others were made in the same manner on top of the lower three. The lower end of each pile was pointed, and the upper end was provided with a heavy iron ring for handling purposes. After the foundation was made secure at the site in November, operations were suspended for the winter. The work was resumed

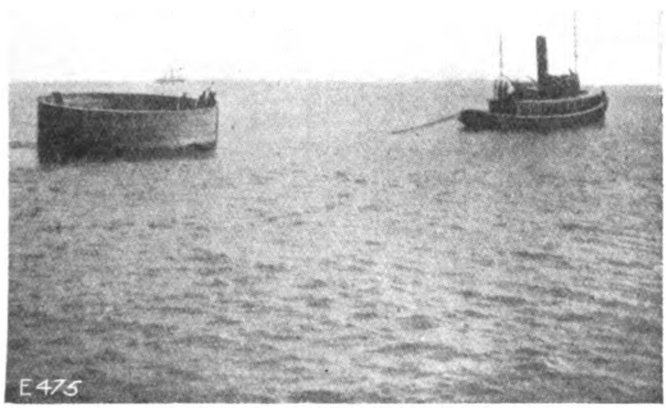


Fig. 6. Towing the Caisson to the Site.
BRANDYWINE SHOAL LIGHTHOUSE.

the next May. The summer was devoted to the construction of the upper works. All material had to be brought in by barge and stored to the extent possible on the working platform and old lighthouse. Fresh water was used in mixing the concrete, and had also to be brought out from shore. The view in *Fig.* 4 shows the progress of this superstructure work.

The lighthouse is the first one of its kind in the United States located on a submarine site. Although the idea was novel, the success of the work justified the acceptance of the design, and it has demonstrated the suitability of this form of construction for open-sea lighthouse work. In this instance the structure not only was completed for a less sum than would have been required for a corresponding lighthouse of iron, but is lighter, was more rapidly built, and will not cost as much to maintain.

The work was done under the direction of the Lighthouse Service of the United States Department of Commerce.

Experience in the United States regarding the Necessity of Employing Suitable Aggregates.

Having regard to the recent experience in London, the data and opinions obtained from the United States are a useful contribution to the subject.—ED.

In our last issue we referred to the high resistance which reinforced concrete had shown under very severe conditions, and on the next page will be found an extract from a paper read by Sir Aston Webb, R.A., before the Insurance Institute of London, regarding the fire referred to.

We have now received a report on a fire which occurred last year in America in a reinforced concrete building which produced some significant results and confirms what has been stated so often that much care must be devoted to the selection of aggregate. The report is by Professor Ira H. Woolson, Consulting Engineer to the Committee on the Construction of Buildings, National Board of Fire Underwriters, U.S.A.

The building in which the fire took place had seven stories and a basement; it was 52 ft. by 90 ft., with a single longitudinal row of columns. It was erected in 1909 and appears to be of satisfactory design in view of the knowledge of the subject at that time and the quality of the concrete appears good upon inspection. The damage to the building was all out of proportion to the severity of the fire.

The report discusses in detail the damage done to the building, from which are drawn a number of conclusions which merit careful study. The fact was pointed out that in several instances the fire was communicated through concrete walls by very small openings. Three-inch and four-inch pipe holes communicated the blaze from story to story, and in at least one instance a one-inch hole in a fire wall communicated the fire to materials stored on the opposite side of the wall. The report says:—

"Air and gases in combustion in a burning room are under more or less pressure due to rapid expansion caused by heat. Under certain conditions they will be forced through very small openings and if their temperature is 1,000° F. or over, which quickly obtains in a fire of any size, they will ignite almost every inflammable object they touch. This fact is extremely important, but, unfortunately, often overlooked."

The greatest lesson to be drawn from this fire is, however, the necessity for the careful selection of aggregates for work destined to be fire resisting. The coarse aggregate used was a gravel composed largely of quartz rock. It is believed that excessive expansion of this rock augmented in some cases by the presence of oversized aggregates, is mainly responsible for the damage. Discussing this subject, attention is called to an investigation made by Mr. Woolson in 1905-1907 on the thermal-conductivity of concrete mixtures. This report said:—

"Although the thermal-conductivity of the gravel concrete was fully as low as that of the trap, it must nevertheless be condemned as a first-class fire-resisting mixture. All the specimens of gravel concrete tested were badly disintegrated by the heat. The gravel specimens would crack and crumble in pieces when the trap and cinder specimens under similar treatment would remain firm and compact. These results are in complete confirmation of those reported last year which were received by some of the membership with considerable scepticism. The writer is convinced that concrete made from this particular gravel is not reliable as a fire-resisting material. Whether other grades of graved would give equally unsatisfactory results is a matter for investigation.

"The cause of this failure of the quartz mixture is not easy to locate. The most plausible reason seems to be the relatively large coefficient of expansion of the quartz. It is about twice that of feldspar, which is one of the predominant minerals in trap rock. Clark's "Constants of Nature," published by the Smithsonian Institution, gives the cubical coefficient of expansion for these minerals, as follows:—

Quartz	·000036
Feldspar	·000017

"According to the same authority, quartz has another peculiarity of expansion, viz., that the expansion in the direction of the major axis is only half that in the direction of the axis perpendicular to the major axis. This unequal expansion may further contribute to its tendency to disintegrate the concrete under action of heat.

"Since the distribution of gravel is much more general than trap, the subject is of much importance, and tests should be made to determine if other gravels are equally defective."

View showing One of the Concrete Girders.

MEMORANDUM.

The Fire Resistance of Concrete.—The following is a short abstract from the Paper read by Sir Aston Webb, R.A., before the Insurance Institute of London, to which we referred last month in our Editorial Notes:—"I have visited a notable example of fire destruction and resistance, an immense building facing the docks, consisting of many floors and covering a large area, built externally with concrete walls, yet with wood-joint floors and roof carried on reinforced concrete stancheons and girders. This building caught alight after a munitions explosion, the roof and wooden floors are entirely consumed, together with the contents of great value to the nation at the present time, while the concrete walls, most of the stancheons and girders remain intact, and would have remained fully so if a more suitable concrete aggregate had been used. In one instance a portion of the outer wall for the height of the ground floor only was thrown down by falling machinery, the concrete wall above remains standing unsupported for a length of some 60 ft., a phenomenon that could hardly be obtained in another material, and one is tempted to ask how came such floors or roof on such a building.

"I am well aware of the objections there are to concrete construction, especially for domestic buildings, the difficulty of driving a nail or cutting a hole and, in fact, making any alteration in it, but with an increased demand for fire-resisting materials I am confident all these difficulties will be rapidly overcome."

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.—ED.

THE CONCRETE INSTITUTE.

THE REMODELLING OF AN OLD GRAVING DOCK AT SOUTHAMPTON.

By R. N. SINCLAIR, M.C.I.

The following is a short abstract from a paper read before the Concrete Institute at their meeting on February 22nd last:—

THE Graving Dock known as No. 3, which forms the subject of this paper, was built in 1853 from the design of the late Mr. Alfred Giles, Past President Inst.C.E., and was lengthened to its present dimensions in 1882. It has an inside length of 520 ft. and a width at entrance of 80 ft. The keel blocks are placed at a level of 24 ft. below H.W.O.S.T., the blocks themselves being 3 ft. 3 in. high. The Dock is closed by a pair of wrought-iron gates which, when opened, lie back in recesses, and when closed shut against a stone cill which is raised about 2 ft. 6 in. above the rest of the floor. The walls are 15 ft. thick at the base, and they are reduced by means of three sets of altars to a thickness of 5 ft. at the top. The floor has the shape of an inverted arch, and formerly contained five small altars or steps on each side. The walls are constructed of brickwork in lime mortar. The floor consists of the same material for a thickness of 4 ft., and below that of a similar thickness of lime concrete. The altars are capped with Portland roach stone, and the coping of the walls and the hollow quoins, against which the gates rest, are of the same material.

During the period intervening between 1853, when this dock was built, and the present time, a great change has taken place in the design of ships. The modern vessels are not only larger, but they are practically flat bottomed, and the rise of floor and the easy curves at the bilge of the older ships are now almost done away with. A corresponding change has had to be made in the shape of dry docks to accommodate these modern vessels.

No. 3 Graving Dock at Southampton was, however, designed to take the old-fashioned ship, and when the more flat bottomed vessels were introduced it was found almost impossible to get them in and out of the dock unless the keel blocks were raised. The usefulness of this dock was therefore seriously reduced, and in order to make it once more available for modern ships it was decided to flatten the floor by cutting away the haunches of the inverted arch.

As regards the loss of weight on the floor, it was, of course, an easy matter to compensate for this, and the principal compensation took the form of a counterfort wall built at the back of the existing wall. The cutting away extended from a point 12 ft. from the centre of the dock to the floor altar at the foot of the wall. In order to make a convenient pathway for workmen in the dock, this floor altar was widened to 2 ft. by means of a small concrete wall. The new counterfort wall at the back of the old wall was made of 6 to 1 Portland cement gravel concrete, 4 ft. to 5 ft. 6 in. wide and 8 ft. deep. It rested partly on timber piles driven at intervals of 10 ft., and partly on a special benching cut in the back of the wall. The top of it was tied on to the existing wall by 1¼-in. steel ties 5 ft apart; these ties passed through the wall and were hooked into the new altar walls. The new altar walls were made of 4 to 1 Portland cement gravel concrete and were 12 in. thick. To prevent them being knocked away by the rough usage which these walls invariably suffer, they were strengthened with No. 15 expanded steel, 6-in. mesh, ¼-in. by ⅛-in. strands. They were also secured to the old walls by means of two lines of Lewis ties, and also by the long ties which have already been mentioned. These walls serve the double purpose of compensating for the weight cut away and also of widening the top altar, which was formerly much too narrow for safe working.

The works were commenced in January, 1914, but owing to the necessity for keeping the graving dock in constant use they have been frequently interrupted. To commence with, the piles at the back of the wall were driven; and it was laid down that the penetration should not exceed 1/20th inch with a 30-cwt. ram falling 5 ft. The piles had to be driven 30 ft. to 45 ft. below ground surface before this test could be obtained. A timbered trench was then excavated for the counterfort wall, and the benching was cut out of the back of the old wall with hammers and points. At the same time the holes for the steel ties of the new face wall were drilled by hand, and the ties themselves were fixed and grouted. The concrete for the counterfort was next placed and the new rails for the cranes laid. This part of the work was completed in October, 1914, nine months after its commencement.

A long interval elapsed owing to the dock being in constant use, and then in February, 1916, a start was made with the cutting away of the floor, the dock being handed over to the engineers for that purpose. The cutting away was all performed by labourers with hammers and points. The brickwork came away fairly easily, but the stone floor altars were more difficult to cut. One line of stone had to be uprooted bodily, and the groove thus formed was filled up with 4 to 1 concrete. The debris from the cutting was all barrowed to either side of the dock, where it was lifted out by a travelling 3-ton crane into railway wagons, which were hauled away to a spoil heap. Meanwhile the new floor altar walls and upper altar walls were built behind shuttering. The concrete was mixed on the quay close by the dock by means of a ¾-cubic yard electrically-driven Ransome mixer.

The work was completed in September, 1916, the dock being closed to traffic for a period of seven months. It must be explained, however, that this period would have been shorter but for the necessity of carrying out other work. This additional work comprised repairs to the wrought-iron gates, the erection of a dam at the north end of the dock so as to admit of the entrance being dried out.

THE AMERICAN CONCRETE INSTITUTE.

DOES CONCRETE CONSTRUCTION REDUCE VIBRATION.

By MORTON C. TUTTLE.

The following is a paper presented at the Annual Convention of the American Concrete Institute in February, and, as the subject is one which has aroused considerable attention and discussion, the expressions of opinion contained in this paper may be of interest to our readers.

THE following expressions of opinion and reports of experience which have been received in connection with the Aberthaw Investigation of the Effects of Vibration in Structures are here presented somewhat in the form of a discussion, in the hope that they will encourage further expression. Manifestly there is no attempt on the part of the writer to draw final conclusions; such effort will be reserved until additional information has been collected and the experimental portion of the investigation is practically completed.

The first step in the investigation was to send letters to a selected list of manufacturers and engineers asking, among other questions, whether they had been able to trace any effects to the vibration of buildings, and if so in what types of construction? Out of nearly 1,150 replies, almost 400 contained matter of a really helpful or suggestive nature. It is from this group that the following quotations have been selected, as presenting various points of view regarding the relation of concrete construction to vibration in structures.

The obvious inference that such construction conduces to stability and to the elimination of vibration is voiced by many in such very general terms as "my experience has been that all brick buildings vibrate more or less, and the one remedy I can suggest would be to build our future factories of heavy reinforced concrete. This seems to be the prevailing opinion of our best engineers."

One writer simply says that he has "much faith in reinforced and suitable foundations"; while another who has had no experience with concrete-constructed buildings asserts, "there is no doubt in my mind, however, but that a rigid building will add considerably to the good running of the machinery"; and a third, whose buildings are of slow burning mill construction and reinforced concrete, states: "Of course it goes without saying that the amount of vibration with reinforced concrete buildings is considerably less."

Speaking of their experience in buildings of light mill construction, a confectionery concern concludes that "steel and concrete construction would be more desirable in such cases"; while a firm of silk manufacturers express their preference for "buildings of reinforced concrete, flat slab, in which type of building we believe vibration is reduced to a minimum."

That people build with faith in concrete is shown by this quotation: "During the past year we have erected a new reinforced concrete building with slab floors 10-in. thick, and we feel very sure that the matter of vibration will be eliminated entirely."

It will be recognised that such expressions carry comparatively little weight of experience—in fact, most of them are from letters of a very general nature, which convey no authoritative information.

In a slightly more restricted class may be grouped statements based upon individual experience somewhat more specific in their nature. Very concise is this from a large printing company: "In our new building vibration is hardly noticeable. The construction is steel and reinforced concrete." The experience with and advantages of reinforced concrete construction are thus expressed by another correspondent: "We have so far found the building without any vibration whatsoever, which we believe is of great benefit, owing to the fact that many sensitive automatic machines are used by us for making watch cases." From a large pulp and paper manufacturing concern comes this statement: "We find the combination of steel and concrete to be the only satisfactory construction for our purpose, as the mass and rigidity of such construction insures practical freedom from vibration."

A well-known builder of reinforced concrete structures says: "My observation of the effect of vibration on concrete is that, if the concrete is good, it withstands vibration better than any other material used in the building business. In general, there is much less vibration in concrete buildings than in any others."

A shoe manufacturer, speaking of the necessity that some of their machines should run absolutely true, and reporting experience in buildings of wood construction, where even with the machines braced from the floor to the ceiling, the vibration is so great that the operator has great difficulty in doing much or good work, sums up his experience in these words: "I find the same trouble in brick and wood buildings, but in concrete buildings bracing is not necessary, and all machines run truer." A typical case of contrast between structures is expressed in these words: "We are troubled in one of our buildings, which is of mill construction, with floors made of 2 by 4's placed edgeways and covered with maple flooring. The vibration of shafting on the lower floor is transmitted to the next floor above. This has proved objectionable to the workmen. Our other buildings are of concrete construction with reinforced floors, and we have no trouble in this regard."

Definite statements regarding the quality and quantity of output in concrete-constructed buildings are most suggestive of the real value of such construction in the elimination of vibration. A very specific statement to this effect is found in the following: "We have found that we can produce our goods cheaper since we placed the looms in the new concrete building, due to the absence of vibration." A motor-car manufacturer, speaking of timber construction, says: "Gear-cutting machines or grinders cannot be as successfully used here as in a building of reinforced concrete. Fully twice as accurate work can be done on a firm foundation."

"All of our machines, and especially looms," says a textile manufacturer, "work better on solid floors; therefore the remedy we believe to be in concrete construction." In a case where wooden floors have been replaced with concrete in a brick wall building the writer says: "I am safe in saying our percentage of breakage has been less and output per machine better, with less annoyance." As presenting some conflict of opinion, is the following from a leading mill engineer and architect. Speaking of the work of an investigator who has made the claim that machinery could be run faster in reinforced concrete than in regular mill construction buildings, on account of the lack of vibration, he says: "But I am inclined to think that the limitation is found in the machine itself and not in the building."

The investigation reveals very clearly the necessity of understanding all of the conditions if judgment is to be passed as to the causes or effects. Of course, the type of machine and the method of driving have much to do with causes of vibration. One concern says: "We drive all our machine tools with individual motors, and have developed a system of individual motor drive for existing machine tools which have been designed for the old-fashioned line shaft drive. With concrete floors and foundations and individual motor drive, all vibration is practically eliminated, and the form of construction in buildings no longer enters into the problem except in buildings of more than one story. Even in buildings of several floors with machine tools on each floor, the question of vibration is very much minimised by individual motors for each machine tool and the elimination of line shafts."

A manufacturer of rubber goods sends the report of a very careful investigation made to determine how the somewhat localised but very disturbing vibration caused by heavy mills in a reinforced concrete building could be eliminated. He sums up his opinion in these words: "After our experience, I firmly believe that the floors, in so far as possible, of concrete buildings should be independent of the outer wall. I furthermore believe it would be a good plan to set all heavy machinery on piers or foundations which are also independent of the floors of the building. This probably would only be possible in basements or on first floors, and would not be practical in the upper stories."

Many reports have been received regarding conditions in one-story shops, practically all of which, as would be expected, indicate the absence of vibration. Frequently reference is made to substantial foundations or to heavy concrete ground floors as responsible for this satisfactory condition. In general terms the expressions are about as follows: "All of our buildings are one-storey structures, mostly brick walls, mill constructed. All floors, with a few exceptions, are concrete—a few of the buildings are concrete throughout. We have noticed no excessive vibration, nor have we had any trouble or noticed any effect on the product of our men from this cause." The manufacturer of a line of high-grade machine tools, speaking of the fact that "in machine tool manufacture vibration usually causes rough and inaccurate work, which means extra hand work, such as scraping," say of their own plant: "Our entire building is of concrete, and all our heavy machinery is on the ground floor. As regards machine operation we have very little trouble which we can trace to our buildings. We have had difficulty, however, in taking fine measurements where very sensitive indicating mechanisms, both mechanical and optical, are used."

But all reports are by no means favourable to reinforced concrete construction. In many cases the reason is evident in the fact that the building is not suited for the processes carried on within it. Frequently the unexpected happens, due quite largely to the synchronising or getting in step of a group of similar machines. One mill architect, speaking of a printing plant, says: "They have their presses in a concrete building, and I understand the vibration is quite noticeable." He also states: "I have noticed that the same stamping machine in a mill-constructed building causes much more vibration than one installed in a reinforced concrete building." Another engineering concern says: "We have built some reinforced concrete buildings, flat slab design, for concerns using stamping and similar machinery for cutting shoe soles and parts. There is a good deal of vibration, but no harmful results have been observed."

Some of the most distressing conditions are reported in connection with printing plants. Here is one relating to a reinforced concrete building five stories high and 300 ft. long, which was to have had its numerous presses on the second floor, but the owners "were so impressed with the stiffness of the structure that the presses were finally put on the top floor, all parallel and running lengthwise of the building. The vibrations were said to be alarming at times, but were satisfactorily overcome by turning half at right angles, with the result that nothing further on the subject has been heard by the engineers."

In pleasing contrast to the preceding experience is this regarding a large printing company who put up a reinforced concrete building: "Previous to their occupancy of this building they had been located in an old brick and wood building. They find that they can now run their presses 20 per cent. faster than in the old building. They also state that the reduction in vibration has increased the comfort and the efficiency of their employees and the output of their machines."

The whole story regarding suitable construction is summed up in these words from a paper manufacturer: "We have both frame and concrete and steel construction, and have found that where we had trouble on account of vibration that was so strong as to interfere with the operation of the machinery, it was due to light construction in the frame as well as in the concrete and steel. Whenever reconstruction was necessary we built much heavier, and the required weight of material was put into foundations and otherwise. In most cases this solved the problem." Another paper manufacturer having steel and concrete buildings says: "They are practically rigid, but there is some vibration from the shaking motion of our diaphragm screens. We have never seen any bad results from this vibration, although it has been practically continuous for ten years."

Very emphatic is this from a manufacturer of farm implements: "We have had a great deal of difficulty in our concrete buildings due to the vibration from certain classes of machinery. We have in mind particularly the sheet metal working presses and shears which are placed on the fourth floor of one of our new concrete buildings. The vibration from these seems to be just the right amplitude to produce a disagreeable and even dangerous effect throughout the entire building. We have finally put large rubber pads underneath all of these places, and we think that this has largely overcome the difficulty, although in shearing heavy plate there is still a very appreciable vibration."

A valuable contribution to the discussion is made by a concern intimately connected with concrete construction, the chief engineer of which says: "I have been in a great many reinforced concrete buildings in which high-speed machinery has been used, and also in many textile mills, and while I was not examining these buildings with the idea of determining the type of construction to produce the minimum vibration, except in the case of the textile mills, I did note that where the so-called flat slab construction was used the vibration was heaviest, and that there also was considerable vibration in buildings composed of beams and girders with short span slabs. The vibration seemed to be reduced to a minimum on jobs where the floor slabs were deepest, and on this account we ourselves in designing several textile mills adopted a floor slab composed of terra-cotta tile and concrete joists, the object being to secure as deep a slab as possible without at the same time increasing the cost and weight to any material degree."

An expert in concrete construction who says that his observations have been only casual and that his conclusions on the same are, in consequence, only general, states:

"1st. It is very difficult to set up harmonious vibrations in a concrete structure.

"2nd. Localised vibrations are apparent in most concrete structures.

"Heavy machinery, like printing presses, sometimes vibrate the whole building to such an extent that the movement is noticeable without instruments. Heavy cutting machines appear to vibrate floors of buildings only locally."

This critical statement from an expert engineer is worthy of especial attention: "Since the development of reinforced concrete, with its inherent elasticity, the writer has used and recommended the use of that type of masonry. Prior thereto have used the 'hoop iron bond' and brass, iron, wood, and copper cramps.

"Have made a number of observations on tall structures; and have not found one that did not 'come and go' under a 'whole sail breeze.' Have also noted the swing due to temperature and earth tremors. The result of all of it is that the writer can only say that any structure should not be rigid. At present the most flexible masonry we have is reinforced concrete.

"As a matter of history, the U.S. Government building in San Francisco, which went through the earthquake, is most thoroughly laced with strap iron and cramped; a fact to which the writer can certify, but which has probably been forgotten."

The difficulties attendant upon an investigation of vibration and the reasons why the whole matter is still in a controversial stage are well expressed in the following from a consulting engineer: "The cause and effect of vibration in buildings are so uncertain unless especially studied that I should think that the average engineer would be able to give a little attention to it and arrive at a conclusion that would be worth mentioning. So far as my own experience goes I believe that the monolithic structure is the right answer. I have found very little vibration in buildings of that type, whereas there was considerable vibration in buildings of other types containing the same kind of machinery and carrying on the same processes."

Many more suggestive quotations from our correspondence might be presented, but the writer trusts that these will be sufficient to draw out discussion.

MIDLAND INSTITUTE OF MINING ENGINEERS.

THE CEMENTATION PROCESS AND THE USE OF CONCRETE IN MINING.

By THOMAS BLANDFORD.

The following is an abstract from a paper read before the Midland Institute of Mining Engineers, at Doncaster, by Mr. Thomas Blandford, in which he dealt with the cementation process (François system) as applied to mining:—

APPLICATIONS OF THE PROCESS.

Amongst the cases in which the cementation process had been successfully applied might be included specially: (1) Shaft-sinking or level driving; (2) underground dams; (3) underground fires; (4) defective boreholes; and (5) defective shaft-lining.

Shaft-sinking.—Cementation as applied to shaft-sinking consists of a thorough treatment of the measures through which it is desired to sink (thus rendering them practically watertight), by the injection of cement into all the existing fissures or cracks in the ground previous to the commencement of actual sinking operations. The mode of operation may be sub-divided into two distinct methods of application: (1) Boreholes through which the cement is introduced into the ground put down inside the perimeter of the shaft required to be sunk; and (2) boreholes through which the cement is introduced into the ground, put down around the outside of the perimeter of the shaft, in a similar way to the boreholes used in the freezing process.

The first of these two methods has the advantage of indicating clearly the position of all water-bearing fissures, and also gives an approximate idea of the size and extent of such fissures, as both the quantity of water and its pressure are registered as soon as any fissures are encountered. The cementation in this case is carried out in successive stages—that is to say, a predetermined length of ground is first of all treated, sunk through, and then lined; after this work has been completed, an entirely fresh set of boreholes is put down from the shaft bottom and inside the perimeter of the shaft. On reaching a fissure containing water during boring, this water rises up the borehole pipe; but, as a stop-valve is fitted on the pipe, the water is kept under absolute control until it is dealt with by cementation.

The second method, in which the holes are bored outside the perimeter of the shaft, is said to have the advantage that cementation and sinking can be carried out simultaneously. This method, under certain conditions, may be attended with satisfactory results; but in the author's opinion, where such boreholes are put down from the surface to intersect a variety of fissures, both large and small, and the injection of the cement is carried out continually from the surface-level of the shaft and above the normal water-level of the ground, there is less likelihood of obtaining successful results than when the cement is introduced from the shaft. There is always a tendency for the cement mixture to follow the line of least resistance during injection, in such a way that if the borehole intersects a large fissure attended with several smaller ones, the most extensive fissure would be filled with cement, whereas the smaller fissures may only be filled in the immediate vicinity of the borehole; and upon proceeding subsequently with the sinking, water would be found still to exist in the region of the small fissures in the ground as a result of imperfect injection.

Suitable Measures for Cementation.—The cementation process can be employed satisfactorily in practically all kinds of rock, both porous and non-porous; but is of no value in the case of a surface quicksand. The first trial of cementation with the internal method of boring was carried out at the Mine de Marles in 1908 upon a disused shaft that had collapsed in 1854, had run in, and had filled with water. The crater formed by this collapse at the shaft-top was 92 ft. in diameter. A strong concrete raft was constructed, through which boreholes were put down, and cementation then commenced, the object being to solidify the broken material and to fill the fissures in the ground at the points where feeders of water existed. The strata in this case consisted of chalk, and the results obtained were highly satisfactory. The cementation was carried out under the direction of and on the plans made by Monsieur Deffieux, chief engineer and agent to the company. Amongst other work on the Continent successfully completed since 1908 may be mentioned a shaft sunk through limestone by cementation at Forte-Tailée; sinking through blue marlstone at Zeche Ewald, in Westphalia; and sinking through limestone and clay at Ottange, Lorraine.

Examples of Cementation.—The author then went on to give particulars of the successful application of the process in mining districts in this country.

Shaft-lining.—Since the introduction of cementation into this country, continued the author, many improvements have been made upon the older types of shaft-lining, and where the process is employed for the treatment of virgin ground before sinking, concrete as a subsequent lining has been largely used. Two methods in particular have been employed, as under:—

(1) That of lining a shaft with specially-moulded and interlocking concrete blocks prepared on the surface. After sufficient time has been allowed for the blocks to mature, they are built into the shaft, and are backed up in some cases with concrete and in others with ordinary rubble filling. In dry ground, where it is necessary to close off any water by means of such lining, this method is quite satisfactory. If, however, as is usually the case, it is necessary to seal off the small percentage of water remaining after treatment of the ground, and which is found to exist during sinking, then trouble may be experienced in the endeavour to close off this water and to make the shaft dry. The chief reason is that, even though a considerable thickness of concrete is put in behind the lining blocks, and although such blocks may be strongly reinforced, there is a tendency for the water to find its way through the concrete filling when existing under pressure, despite the relief pipes which may be fixed in the concrete. The result is that pressure then exists upon the exterior face of the blocks, and this will almost certainly cause displacement or rupture. Where ordinary rubble filling is placed behind lining blocks, cement can afterwards be injected into this filling with the object of forming concrete; but this may prove to be a tedious process and expensive in cement, and if the water which it is desired to shut off exists under pressure, it may be found difficult to obtain a watertight finish.

(2) The second method of utilising concrete, which has been attended with considerable success, is that of the construction of reinforced lining with mass concrete in the shaft, such concrete being carefully rammed solidly into position. Removable steel facing plates are built up as walling proceeds, and these retain the concrete until it sets; the plates are taken away afterwards, and leave a perfectly circular, smooth concrete wall. In this case pipes are also fixed for the

conveyance of any remaining water from the rock to the shaft during the process of walling, and after sufficient time has elapsed for the concrete to set, this water is shut off by injection. The design of reinforcement and thickness of this type of wall can be arranged to suit the pressure which it is required to withstand, and consequently with increasing depth and pressure its use has been proved to compare favourably in cost with that of cast-iron tubbing. A valuable feature is that if at some time in the life of a shaft any earth movements should take place which should cause cracks in the lining, very little water would probably be met with on account of the previous cementation of the ground surrounding the shaft, whereas in the case of cast-iron tubbing, if any failure should take place, it would be necessary to deal with the whole quantity of water which was met with during the sinking through the length where such failure occurs. In addition to this, the fixing of a solid mass of concrete into a shaft as a lining forms an absolutely close bond with the rock itself, and all irregularities formed in the shaft sides during sinking are tightly filled, and by subsequent injection made practically watertight, so that the concrete forms a solid mass with the rock itself. In the case of cast-iron tubbing, however, even with the best back-filling of concrete and grouting put in under wet conditions, there will still exist cavities containing water under pressure and having a corrosive action varying in degree, for which allowance must be made in the design of the tubbing, according to the life required of it.

Underground Dams.—High-pressure cementation has been proved to possess great advantage in closing off underground feeders of water in connection with underground dams. In the first place, dams which have been constructed to meet unexpected inrushes of water have been put in with all possible speed, and sometimes there is not sufficient time to allow of the constructional work becoming properly matured and set before being subjected to water pressure. The consequence is a leakage may occur through many places, and, although such places may be very small in area, their very smallness does not allow of any further operation being carried out to close them under the older methods. In such cases high-pressure injection of cement would solve the difficulty, as it is possible to fill up such minute crevices in either brickwork or concrete.

Underground Fires.—In a manner similar to that in which it has been found possible to close up the finest of water-bearing fissures by means of the injection of a small percentage mixture of cement and water under high pressure, so it has been proved that air-leakage can be stopped through the cementation of brick walls or the lining of roadways, and the area affected can be satisfactorily sealed up.

Defective Boreholes.—Sometimes boreholes in their progress to a required feeder of pure water have to pass through one or more beds containing inferior or corrosive water. After a time it may be found that the lining tubes in these boreholes become entirely corroded at the points in contact with the bad water, with the result that the borehole is useless. In such cases the upper feeders of bad water can be successfully closed off altogether by means of cementation, without the aid of any tubing, and the pure-water feeder again recovered. A similar case to the above has been already successfully dealt with in the Yorkshire Coalfield in a comparatively short time.

Defective Shaft-lining.—Many old shafts in this country have been sunk and lined with ordinary brickwork through water-bearing measures, the water being originally collected as far as possible in water garlands. In course of time, however, the original waterways became choked up, the result being that wetness of the shaft gives rise to serious inconvenience. In other cases in course of time, through various reasons, water which has originally been closed off by means of tubbing is found to have broken through the ground below the tubbing-crib, and shows itself in the brickwork below such tubbing. In the majority of these instances it is quite possible and practicable to close such water completely off and bring the shaft again to its original state of dryness.

In concluding, the author remarked that it was somewhat difficult to give any generalised idea of comparative cost of the process, as the main factors upon which the cost depended were those of the quantity expected, the total depth at which water would be encountered, and the consequent rate of progress. When considerable quantities of water were met with at great depths, and the use of sinking pumps and tubbing was necessary, the advantage in cost to be obtained by adopting cementation was more apparent.

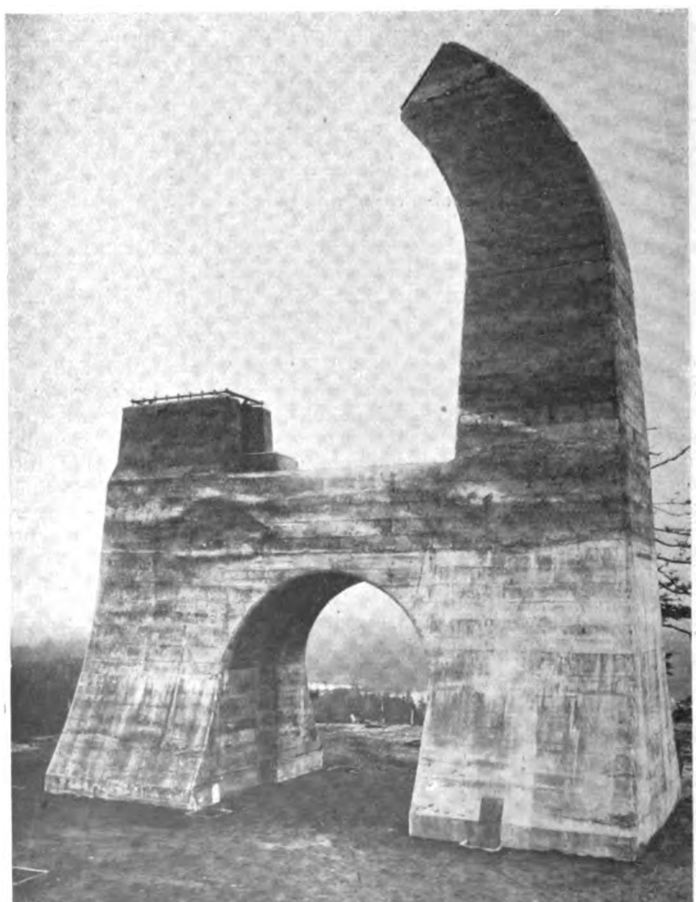
NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

REINFORCED CONCRETE TOWER FOR THE LARGEST TELESCOPE IN THE WORLD.

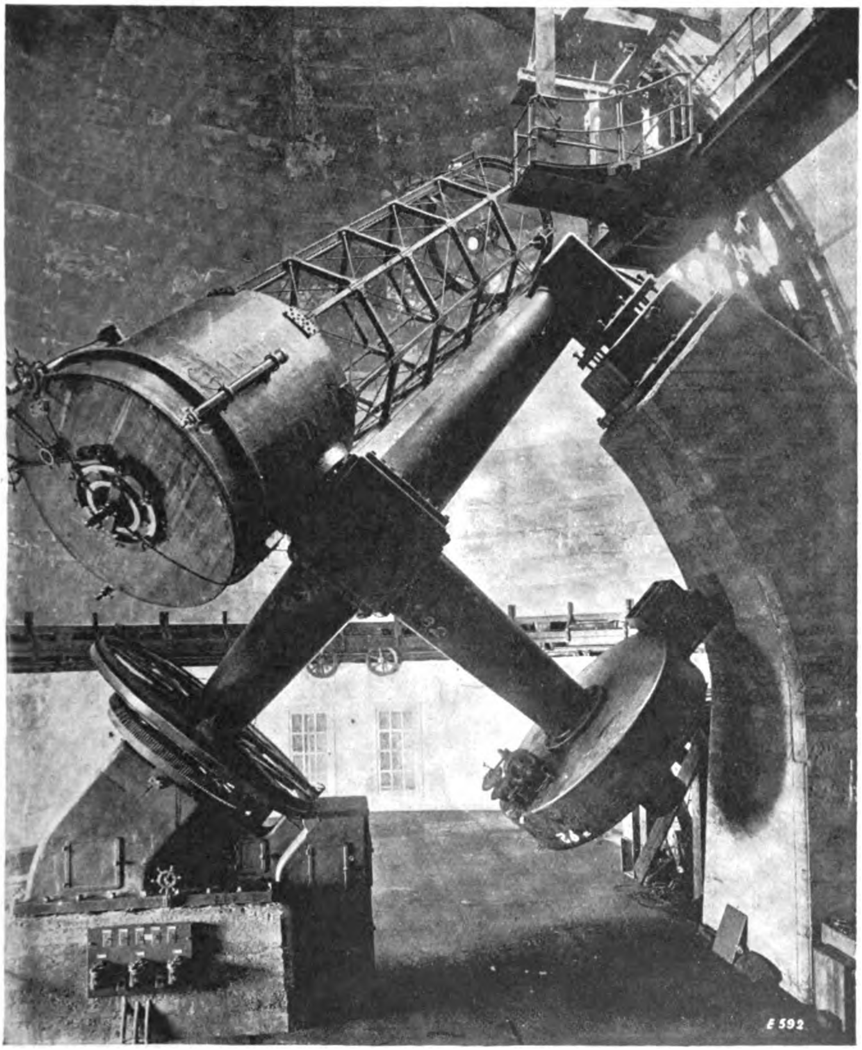
THE two accompanying illustrations show the reinforced concrete work in connection with the installation of a large telescope on Saanich Mountain, near Victoria, British Columbia.



VIEW SHOWING CONCRETE CONSTRUCTION TOWER FOR TELESCOPE AT MOUNT SAANICH, B.C.

REINFORCED CONCRETE TELESCOPE TOWER.

The telescope is mounted on a reinforced concrete tower. The work was carried out by Messrs. McAlpine, Robertson and Company, of British Columbia.

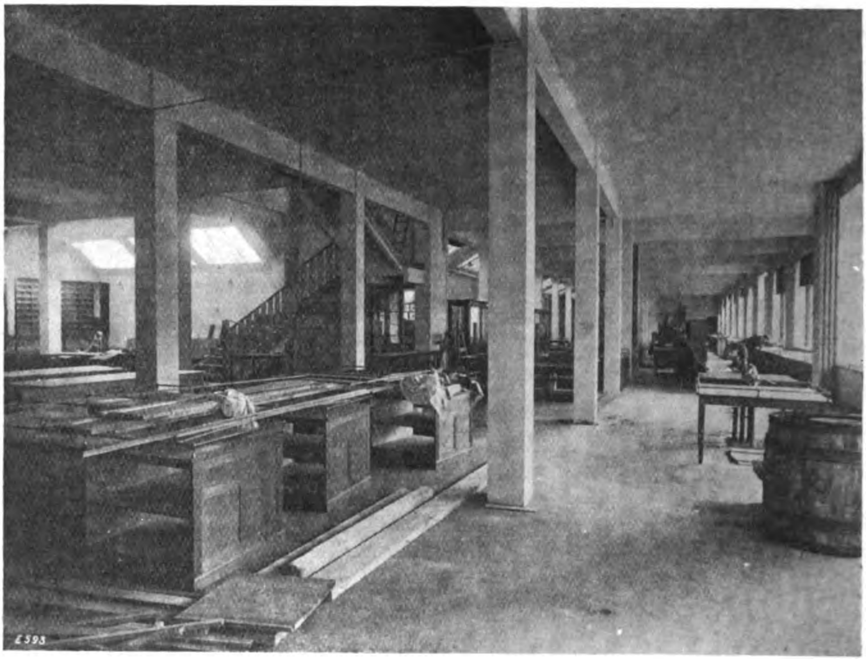


TELESCOPE INSTALLED IN REINFORCED CONCRETE TOWER, MOUNT SAANICH, B.C.

BUSINESS PREMISES AT SCARBOROUGH.

In our issue of October we made a brief reference to the new warehouse which had been opened at Scarborough by Messrs. Boyes and Company. We are now able to give two illustrations of this building, an exterior and an interior view.

The building is steel frame rising from the basement, part two storeys and part three storeys over, with clock tower above. The exterior walls are of artificial stone



VIEW OF BUSINESS PREMISES AT SCARBOROUGH.

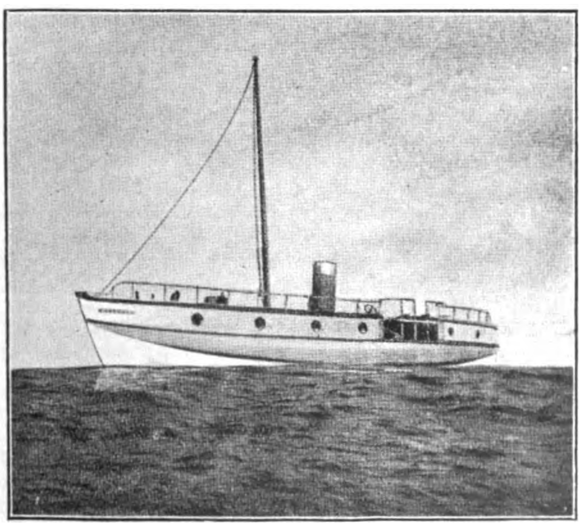
and the whole of the structural steel work is encased in expanded steel-concrete. The flooring, flat roofing and staircases throughout are also of expanded steel-concrete.

The architect for the building was Mr. J. Caleb-Petch, of Scarborough, and the work was carried out under his supervision by Mr. F. W. Plaxton, of Scarborough.

The expanded steel sheet and steel bar reinforcement was supplied by the Expanded Metal Company, Limited, of London and West Hartlepool.

MEMORANDUM.

A Reinforced Concrete Motor Cruiser.—By the courtesy of the *Motor Boat* we are able to publish the following particulars and illustration:—One of the latest examples of reinforced concrete shipbuilding is the motor cruiser *Wanderer*, illustrated here, which measures 41 ft. overall, with a beam of 8 ft. This craft was built by David L. Munro and Ivar Widing, of the Savin Hill Yacht Club, Dorchester, Mass., who propose to use their boat as a base for obtaining moving pictures in different parts of the world. The framing of the boat is of angle steel, and a 10-in. steel H-beam forms the keel. Galvanised expanded steel was attached to the framing to hold the concrete, which tapers from 1½ in. thick at the keel to ⅞ in. at the gunwale. At each side at the water line, as may be seen in our illustration, is a sponson, which increases the beam to 11 ft., and gives the vessel great buoyancy in a seaway, making her, in fact, practically unsinkable. Power for propulsion is derived from a 25 b.h.p. to 30 b.h.p. four-cylinder Buffalo engine, which gives a speed of 7½ knots. Either petrol or paraffin may be used for running, and the tanks hold 1,000 gallons, or enough for a cruise of, say, 40 days. Apparatus for developing moving picture films is fitted up in the after cabin, while in the main cabin forward special bunks with deep sides for bad weather are provided.



41-FT REINFORCED CONCRETE CRUISER.

MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

The Employment of Concrete as a Substitute for Timber.—The following question was put in the House of Commons on March 22nd:—

Q.—Mr. Wiles asked the Financial Secretary to the War Office whether, having regard to the high price of timber and the difficulty of obtaining freights for the importation of supplies from over the seas, he will ascertain if his departments are making the fullest use of concrete, which is a material entirely of home production and which can so often be used instead of timber for constructional purposes?

A.—Mr. Forster: The question of using concrete and reinforced concrete for constructional and other purposes is being carefully considered by the War Office in conjunction with other departments.

An Important Economy in Coal.—Coal slack or coal dust is to be found in nearly every household. It is generally used to bank a fire, burns dull, much of it drops through the grate, and is so unsatisfactory that one often pays to have it removed. No more waste of coal slack. Buy a small quantity of Portland cement, then add one part by measure (not by weight) to twenty parts of coal slack, mix *very thoroughly* in the dry state, then add *gently* and by degrees a *small* quantity of water, again well mixing all the time.

Care must be taken not to make the combination *too wet*—it should just hold together when squeezed in the hand.

It is now ready to be placed in a mould. An excellent one is an ordinary small flower-pot, four to five inches in diameter. Press the mixture into this firmly, and it can be at once turned out by inverting the pot. Keep in a dry, cool place for five or six days, and it is ready to burn, which it will do like an ordinary lump of coal.

Alternatively the mixture can be moulded in the hands like a snowball, and in a week becomes quite firm.

N.B.—As a guide to correct proportions, a bucket measure (say 3 gals.) of coal dust will require 1 1·5 pints of cement (i.e., the 5-inch. flower-pot about three parts filled) and about 2½ pints of water.

Uniform mixture is the secret of success, and a batch as above will be found a convenient quantity to work up at a time.

Concrete-lined Oil Storage Reservoirs.—A large California oil company is using thirteen concrete-lined oil-storage reservoirs, ranging in capacity from 500,000 barrels to 1,000,000 barrels each. Some of these have been in use eight years with excellent results. The company's investigations support the idea that filling small storage tanks with water prior to running in the oil is of great advantage in preventing any appreciable absorption.

The Damage to Brixham Breakwater.—The Harbour Commissioners of the Brixham Urban District Council have received the report of the engineers, Sir John Wolfe Barry, Lyster, and Partners, relative to the damage to Brixham Breakwater during the gale on January 26th and 27th last. The report showed that the principal damage was at the extremity of the breakwater, where the rounded end had been washed away up to the concrete foundation of the lighthouse, and practically the whole of the parapet wall has been more or less damaged. The concrete foundation is intact. The lighthouse has suffered no material damage. The engineers consider it advisable to reset the parapet in cement mortar. The rounded end beyond the lighthouse and some of the pitching on the seaward face should also be bedded in cement mortar or concrete.

Silo Installations in the Argentine.—Cattle breeders and farmers generally in the Argentine Republic have been impressed during recent months with the necessity for being better provided with storage facilities for feeding-stuffs. This is due to the drought and damage by locusts. Attention has consequently again been turned to the building of silos. As these are to some extent being taken in hand by local contractors, the demand is not so much for imported steel silos as for the metal parts used in the reinforced concrete constructions. Machinery for preparing ensilage and filling the silos will, however, have to be imported, and there is a prospect of considerable business during the next two or three years for a firm who will demonstrate the advantages of suitable installations.—*Times.*

The Injection of Cement in the Simplon Tunnel.—We give the following interesting particulars abstracted from *Il Cemento*:—On the southern side of the Simplon tunnel, at a distance of 6,500 yards from the southern entrance and extending to the middle of the tunnel, there were several places in which the walls were in a very bad state. For instance, in the Lebendung Gneiss there were several zones, each 10 yds. wide, in which not less than 170 broken stones could be found, and periodical inspections have proved that the earth movements causing this damage still exist, and there is still a continuous breaking of the stones. It has, therefore, been decided to strengthen these weakened places by injecting cement into them.

The plant used for this purpose is mounted on six railway wagons. The first wagon is directly coupled to the locomotive and carries a compressor, of the Burkhard type, and a reservoir of cold water. The compressor is driven by steam from the locomotive. The second wagon carries an air reservoir compressed to seven atmospheres and also three tanks containing the cement mixture. The latter are in direct communication with the air reservoir, so that the cement mixture is under a pressure of seven atmospheres and is injected at this pressure through flexible pipes into the holes made for this purpose in the walls of the tunnel. The third wagon carries the gravel and cement, the fourth is a water tank, the fifth carries timber and similar materials, and the sixth is a carriage for the workmen.

The holes by the walls, through which the cement is injected, are made by pneumatic hammers operated by air from the compressor.

The cement mixture must not be either too stiff or too liquid, and some experience is required to keep it at the required density.

Previous to injecting the cement the joints in the walls were examined and any defects made good with cement. Any leaks which appeared during the injection were stopped with clay.

The injected material often extended through a radius of ten to fifteen yards from the point where it was introduced. The quantity absorbed by the different holes varied enormously; in some cases hardly any cement was absorbed, but one hole required 590 cwt. of cement and sand to fill the spaces behind it.

In every hole two injections were made at an interval of twenty-four hours, during which time the water in the cement mixture drained out slowly through the wall, leaving spaces which required a second injection before they were properly filled.

Test holes made to ascertain the results of the injection showed that all the cavities were filled up with the cement mixture, with the exception of a very few small spaces.

A Definition of Concrete.—One of the American journals has recently published the following description of concrete as defined by Mr. W. L. Kidson, the Editor of the "Seattle Bulletin":—

The Modern Atlas of the Universe am I.

Across the world I weave a web of everlasting highways which bring the crowded city's life through smiling fields, o'er rugged hills and laughing brooks, to view

CONCRETE & CONSTRUCTIONAL ENGINEERING

the miracles of Nature. I bear the burdens of a million carriers of the world's goods from countryside to city marts and make that burden light through the cheapness of my building.

For twenty centuries the paths I laid have echoed to the tread of conquering legions and marked the rise and fall of nations, and yet the breast which thrilled to the tramp of victorious Cæsar's hosts still guides the feet of science to the mighty works of ancient Rome, living for us in all their architectural effects of beauty and grandeur, because I gave them everlasting life.

The modern, as did the ancient, conqueror of Nature enlists me in his service. Above my tunnels tower wonderful snow-capped mountains. Beneath the mighty rivers I stretch my subway fingers, and above its raging waters I lay my arms in bridges, and link the crowded city traffic to country fields, and carry with safety the countless thousands who put their trust in the power of me.

Amidst the roar of grinding wheels and powerful engines I stand a bulwark to the elements, that the commerce of the world may go. Upon my shoulders rear the protecting guns of our coast defence, that a nation may live; and with sheltering arms I bear the blows of wind and rain and fire without flinching, that those within my home may dwell in peace.

I am everywhere.

I bear the burdens placed on me and murmur not, though you place my feet beneath the surface of the earth, beneath its rivers or in the sea, or rear my head towards the heavens above.

From leagues away I bring the mountain streams to your doors—sweet nectar to sip, great wheels to turn, to light your way, to clothe, to feed the teeming millions, to drive the speeding trains across the earth or flash the spoken word around the world.

The wrath of Nature affects me not; the ravages of time leave me whole. Upon my mighty shoulders I bear the weight of the wonder works of architect and engineer. I am everlasting—a product of the hand that wrought the Universe. I am safety, economy, and permanence for the constructive works of the world.

I AM CONCRETE.

Construction of Concrete Vessels in France.—Arrangements are being made for the construction of concrete vessels in France, and a company has been formed at Paris, to be known as Le Matériel Flottant, with the object of building sea-going lighters and also docks and other floating or fixed constructions of this material.

Huge Coal-Pit.—A huge pit has been constructed for the Duquesne Light Company, of Pittsburg, in which 100,000 tons of coal can be stored. Danger from spontaneous combustion will be prevented by submerging the coal in water up to the top of the pit. A concrete lining was laid in blocks about 40 by 50 ft. in size, separated by construction for expansion joints, waterproofed by pitch and tar paper above a 12-in. base of concrete 4 ft. wide.

Progress in Mauritius.—The report presented to the Colonial Office on the progress of Mauritius during 1915-16 states that amongst the principal works undertaken by the Public Works Department was the replacing of wooden road bridges by reinforced concrete structures. Ten bridges have been reconstructed.

Sewer Construction in Quicksand.—Mr. R. H. Parsons, the city engineer of Peterborough, Canada, has successfully completed the laying of 7,100 lineal ft. of sewer in sand with water 8 ft. below the surface. Immediately the wet sand was excavated it became quick and required most careful handling. The sewer pipes were cast in moulds and were reinforced with triangular mesh 4 in. by 4 in.—½ lb. of metal to the sq. ft., placed in position to take up tensile stresses. The pipes were 3 ft. long.

Cardiff.—Subject to the approval of the Local Government Board the Corporation has accepted the tender of Messrs. Tucker Bros., of £1,484 17s. 9d., for the extension in reinforced concrete of Hayes sub-station.

BOOKS AND PUBLICATIONS RECEIVED.

Garden City Houses and Domestic Interior Details.
Published by Technical Journals, Ltd. London: 27-29, Tothill Street, Westminster. 104 pp. + viii.

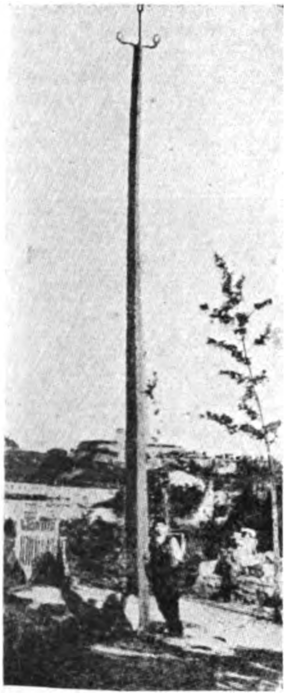
Contents:—Introduction with Typical Specification; Exteriors and Plans; Interior Details.

This volume illustrates some of the excellent examples of domestic architecture which have been carried out during recent years, the majority of these being taken from the garden suburbs of Hampstead and Gidea Park. Many sizes and types are given, and the book should be very useful as a reference to the architect who is interested in domestic work. In nearly all cases a photographic view of the completed house is given, together with plans, and many useful interior details are shown in the section devoted to this portion of the work.

We should like to correct a mis-statement which occurs in the introduction, where it is stated that all the houses are built of brick. This is not the case, as concrete blocks were employed in at least one of the examples given—viz., that on page 24, which illustrates a house erected in Reed Pond Walk, Gidea Park.

With this year's issue of **Laxton's Builders' Price Book**, this valuable work of reference has reached its hundredth annual edition.

The arrangement of the book has not been in any way altered this year, but for the first time a new feature has been introduced in the present edition in the shape of the list of "Specialities" extending over thirty closely printed pages. This new feature should be of much service to those requiring to trace at once the firms by whom the "Specialities" used in the building trades are manufactured. The list, in fact, gives facilities for at once tracing the names and addresses of the manufacturers of over one thousand specialities, though, of course, it does not profess to be absolutely complete. The book should be of great use to all.



A CONCRETE TELEGRAPH POLE IN ITALY.

CONCRETE THE MONEY SAVER

CONCRETE AS A SUBSTITUTE FOR TIMBER.

The question of finding good substitutes for timber is an urgent one at the present time, inasmuch as the home grown timber industry is greatly hampered in many ways, and there must necessarily be a great restriction placed on the import of this material. We have already pointed out in these pages that this difficulty may, to a very great extent, be overcome by the employment of concrete. In this connection we would refer to some remarks made recently by the Controller of Timber Supplies (Sir Bampfylde Fuller), at a conference held last month by the English Forestry Association. At this conference the Controller stated in the course of a speech that "there was undoubtedly immense wastefulness in the use of timber, and if last year's rate of consumption continued we had only four or five months' supply. Reinforced concrete must be more largely used in building, anything like continuous wood roofing must be stopped. . . ."

In the following pages we have illustrated a few of the numerous instances where the employment of concrete in lieu of timber is not only possible but would prove of advantage to those who employed it, and thus the timber supply of the country might be conserved, and we invite the earnest attention of all concerned in this very important problem to the points raised here.—ED.

INTRODUCTION.

THE war which is now raging has caused us to alter our ideas, methods of doing work, and, last, but not least, the use of different materials. Few people (excepting constructional engineers) seem to realise the uses to which concrete can be put. The embargo now placed upon imported wood by the Government makes one look around to see what is to be done to replace timber. There are certain works which must be carried out, and if wood cannot be obtained a substitute must be found. The substitute we suggest, which is likely to be adopted, is *concrete*, and it is proposed here to give illustrations and some details of different work which has been carried out in concrete where ordinary timber would have been used.

In many cases concrete articles have proved in pre-war days to be as cheap as wooden ones, and the durability of concrete is beyond comparison with that of wood. The life of concrete articles, with fair wear and tear, is practically unlimited; for years after making the goods are hardening and strengthening; but with wood this, as is well known, is not the case, as deterioration commences almost at once.

ARTICLES WHICH CAN BE MADE OF CONCRETE.

As an illustration of the different uses to which concrete can be applied we give a list of some of the articles which can and have been made to advantage in concrete. In many cases they have proved cheaper than wood, even in pre-war days:

Fence posts and posts of every description.

Telegraph and telephone poles.

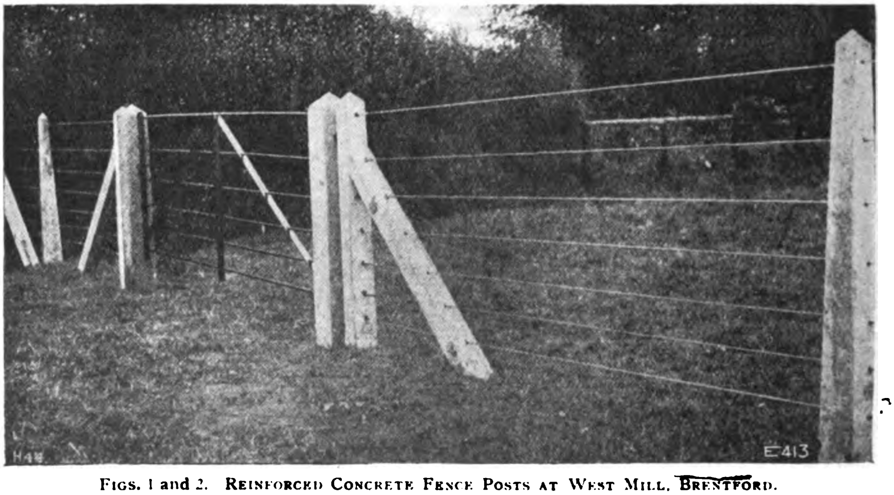
Electric light standards.

Gas lamp posts, etc.

On railways there is practically no limit to the use of concrete; but we shall deal with this at some length later on.

In mine works it can be applied for mine shafts, pit props and mine airways, etc.

On the farm and estate it can be utilised in many different ways, and it will be found that it can be employed instead of wood, especially at the present time, and in most cases at less cost. Concrete silos have been erected at a cost which compares favourably with those erected with wood, but local conditions largely govern the cost of concrete ones.



FIGS. 1 and 2. REINFORCED CONCRETE FENCE POSTS AT WEST MILL, BRENTFORD.

It has also been used for greenhouse construction and has proved very satisfactory. In cottage construction, in addition to its use for the actual structure, concrete can be used for such fittings as mantel-shelves, chimney-pieces, food lockers in larders, window frames, sinks and many other articles which are necessary when fitting up cottages.

METHODS AND SYSTEMS IN WORK OF CONSTRUCTION.

There are many different systems and methods which can be adopted when making or constructing any of the before mentioned articles, etc.; but they can all be made very simply and on the spot if the ordinary rules are followed underlying the general principle of concrete construction work. We have dealt at length in recent issues of this journal with most of the articles mentioned, and we propose now to devote some space to dealing in summarised form with the process of making the various articles mentioned and also to give illustrations of actual work carried out.

Some types of work are made *in situ*, while others are made upon the moulded system which allows the mould to be used continually without the necessity of waiting for the concrete to set. This method is known as the "semi-dry" system.

CONCRETE FENCING.

Concrete fencing posts can be made upon the semi-dry principle or upon the wet system. All fencing posts require to be reinforced, and this can be done with steel rods varying in size, according to the size of the post and the use to which it is going to be put. Naturally a gate post requires stronger reinforcement than an ordinary fencing post. In *Figs.* 1 and 2 views are given of concrete fencing at Brentford. An iron gate is shown fixed to a concrete gate post, and it also has a concrete shutting post. In our issues of April and May, 1916, we gave full details of the making of moulds for fencing posts, etc., and also instructions of how to make the posts themselves. In *Fig.* 3 mortised concrete fencing posts are shown,

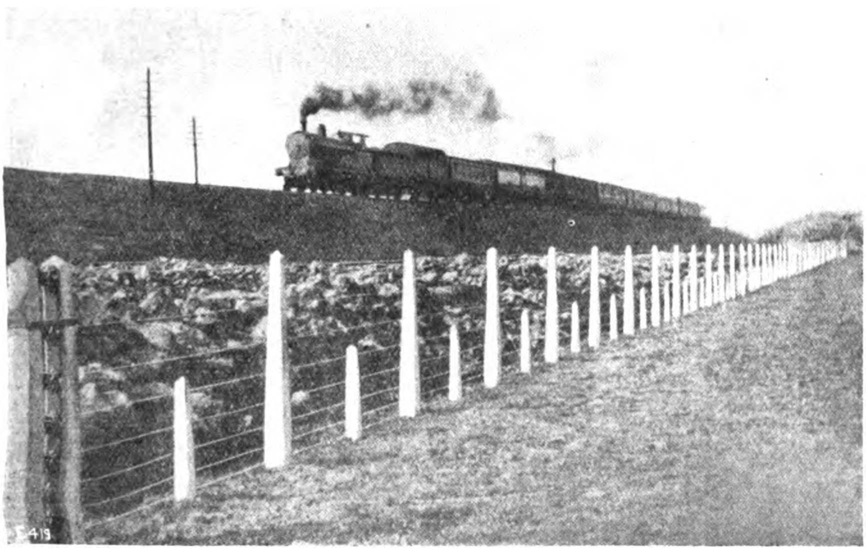
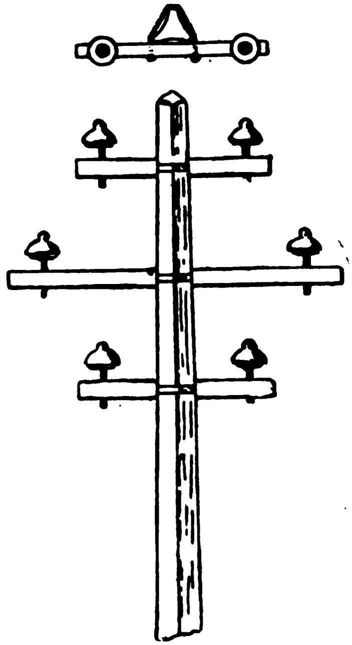


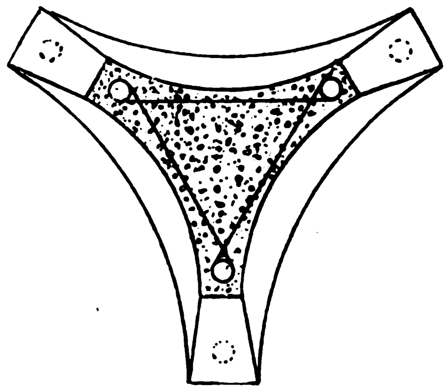
FIG. 3. REINFORCED CONCRETE FENCE POSTS ON THE LONDON & NORTH WESTERN RAILWAY.

which illustrates that concrete posts can be made just as easily to receive rails (the mortise being made in the posts) as with holes to receive wire.

POLES AND STANDARDS.

Telegraph and Telephone Poles.—There are several different types of concrete telegraph and telephone poles now in use, both in this country, in U.S.A., and on the Continent. It is quite common nowadays to read the articles in the newspapers from different war correspondents with such expressions as "all that remained to be seen in the fire swept zone were the reinforced concrete telegraph poles." This goes to show to what extent concrete poles were used in pre-war days upon the Continent. They are especially useful when it is necessary to place poles upon marshy ground. As to the cost of reinforced concrete telegraph poles, they are a little more expensive in the initial outlay than wooden ones, but compare the life of a wooden pole with a concrete one. The life of a wooden pole is at the most sixteen years, but a concrete one is practically everlasting. There is one drawback to the solid type of posts and that is their weight; but this has of late years been overcome by making them hollow. *Fig.* 10 shows a reinforced hollow concrete telegraph post. It is of a triangular section and has holes running horizontally as well as the main vertical holes. This makes a very light post, and it is made upon the "Marriott system" of reinforced concrete. The weight of this post, it is claimed, is only double that of wood, but the average solid post is at least three to three and a half times as heavy. Thus a good saving is effected.





FIGS. 4 and 5.

Showing details of reinforced telegraph poles erected in Brescia, Italy. The poles are from 26 ft. to 33 ft. high, and have to resist a horizontal tension of upwards of 1,200 lbs. at the summit. A general view of this pole is seen on page 231.

Electric Light Standards.—Electric light standards are similar in type to those referred to in the preceding paragraph. The following illustrations and particulars refer to some electric light standards erected in Michigan:—

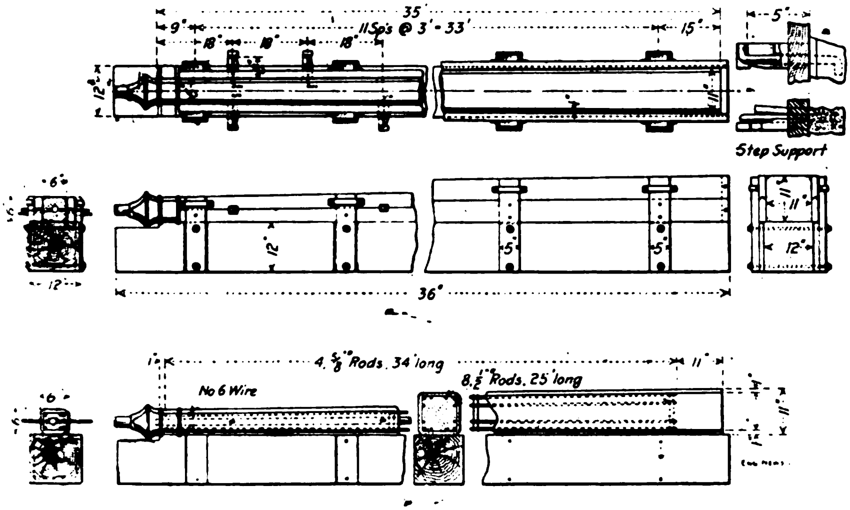
The poles are 11 in. square at the base and 6 in. at the top. The reinforcement consists of one $\frac{5}{8}$-in. square twisted bar 34 .c. long in each corner extending from about a foot above the base to the top, and two similar bars, $\frac{1}{2}$ in. square, 25 ft. long, in each side, extending to within 9 ft. of the top, so that the cross-sectional area of the reinforcement for the bottom part of the pole is 3·56 sq. in., but for the top 9 ft. of the pole is only 1·56 sq. in. The bars were tied together at intervals of 4 ft. with two turns of soft steel wire, bent to a square, within which the rods were placed and secured at proper spacing by winding with stone wire as shown in the accompanying illustrations.

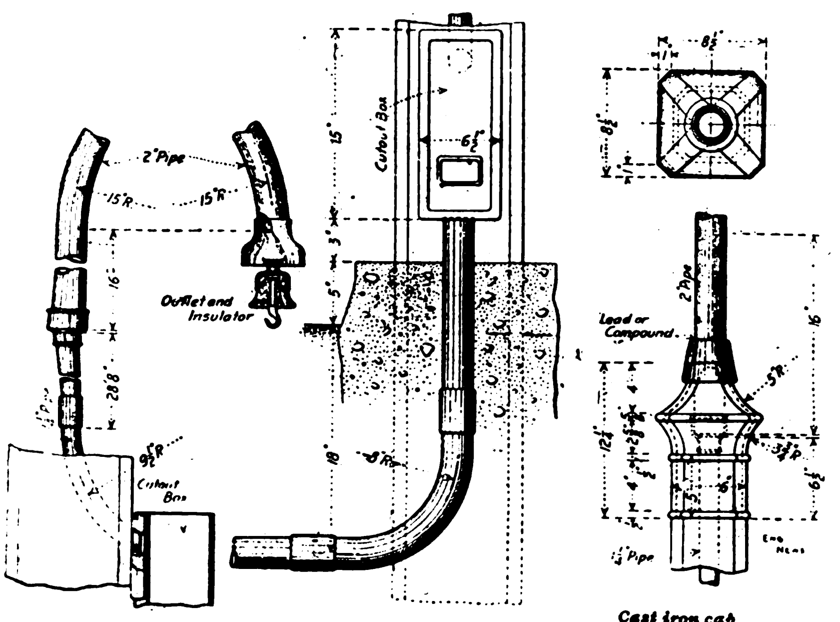
The wires are brought from the main conduits through 2-in. galvanised duct to the concrete base in which the pole is set, and up along the outside of the pole to the cut-out box located about a foot above the base. The poles were moulded in a horizontal position, and the forms for the concrete are shown on page 235.

The cost of this lamp post fixed in position worked out at 12s. This was, of course, the pre-war figure, but even allowing for the extra cost of materials at the present time it would probably be cheaper than an iron post.

In *Fig.* 17 an electric light standard of architectural pretensions, such as can be found in Hungary, is shown. It is constructed entirely of reinforced concrete.

Gas Lamp Posts, etc.—Even lamp posts for ordinary street use have been made with reinforced concrete. A very good example has been designed and constructed by Captain D. Ogilvy, of Ahmednegar, Deccan, illustrated in ***Fig.*** 18 and fully described in our issue of January, 1914. It has many good points, such as simplicity in design, facility of manufacture, together with its low cost, and this should commend it to the engineers to small local authorities, both at home and in the Colonies, and to the Cantonment Authorities of India.





FIGS. 6 and 7. SHOWING FORMS AND DETAILS OF CONSTRUCTION OF ELECTRIC LIGHT STANDARDS IN MICHIGAN.

A number of concrete lamp posts have been erected at Ann Arbor, Michigan. These posts are 25 ft., being 18 in. in diameter at bottom and 5 in. at the top. They are reinforced with four ⅝-in. steel rods. The posts each approximately weigh

1,200 lb. The concrete was formed of 2 of sand, 4 of ½-in. crushed limestone, to 1 of cement. The concrete was mixed wet and poured into the mould and finished with the trowel. The posts are then allowed two days to set before removing the sides of the mould. They were then allowed four days longer before removing them from the bottom board or plate. After this they were allowed another ten days to season before being erected. In making 100 of these poles 30 tons of crushed stone, 98 bushels of sand, and 47 bushels of cement were used. The total weight of the reinforcement used for these posts was 4,300 lb.

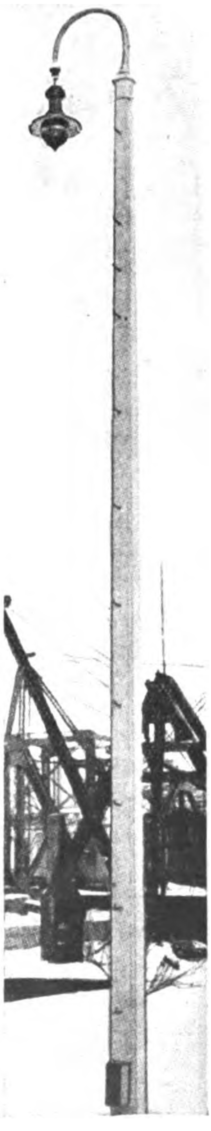


FIG. 8. VIEW OF FINISHED LIGHT STANDARD AT MICHIGAN.

CONCRETE ON RAILWAYS.

The uses to which concrete has been applied on railways has for some time past had a tendency to displace wood, even before any shortage of timber was thought about. The durability of concrete commends itself to the leading railway

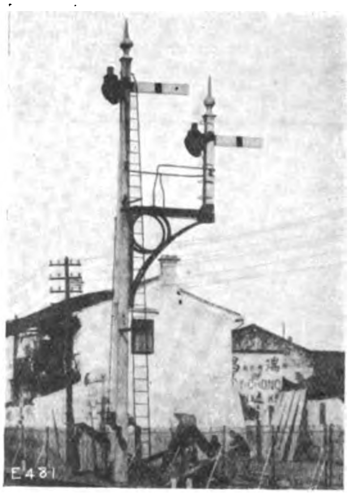


FIG. 9. A CONCRETE BRACKET SIGNAL ON A CHINESE RAILWAY.

companies of this country. It has and is being used in the form of sleepers, gradient posts, fence posts, straining posts, gate posts, mill posts, signal roller benches, manholes and cesspools, for drains upon main lines, name boards, platforms, and for many other uses.

Regarding construction of platforms much could be said, but it is an understood fact that since concrete has been used for making railway plantforms a great saving in the cost has been effected.

In *Fig.* 11 a type of signal post is shown, such as are in use upon the Midland Railway. These are reinforced hollow posts with holes running horizontally as well as the vertical hole, and are made upon the " Marriott " system. Some interesting illustrations of the application of concrete on Chinese railways are shown in *Figs.* 9, 14. 15, 16.

While on the subject of concrete for railways it will be interesting to mention that the Great Western Railway produce some 40,000 concrete fencing posts annually. Railway sleepers made of concrete have not in this country been so readily adopted

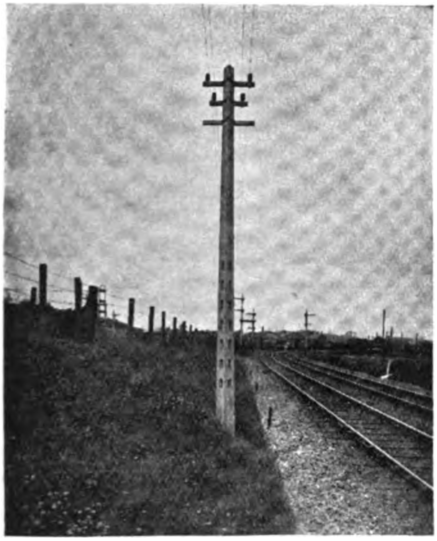


FIG. 10. A TRIANGULAR HOLLOW TELEGRAPH POLE.

FIG. 11. A SLOTTED DISTANT SIGNAL POST AS USED ON THE MIDLAND RAILWAY.

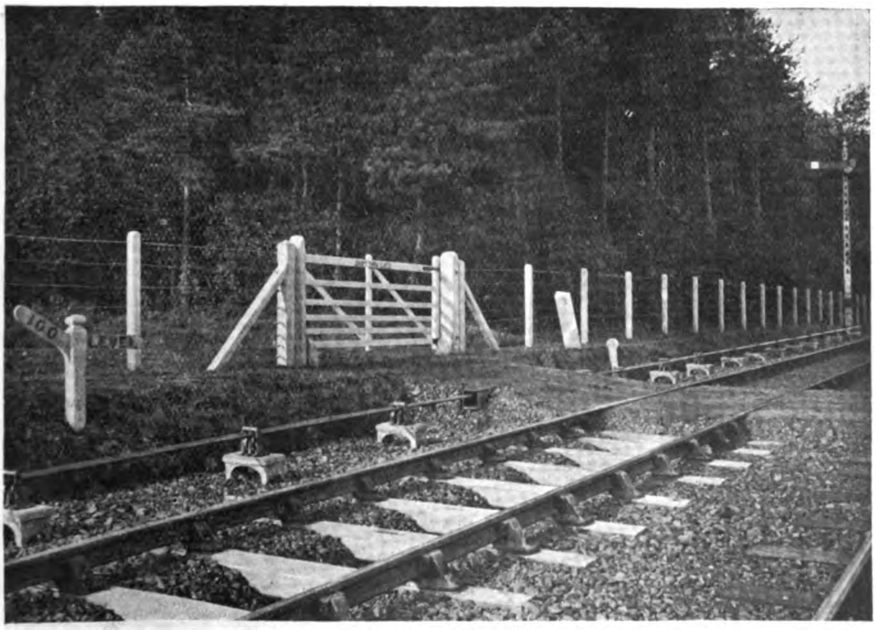
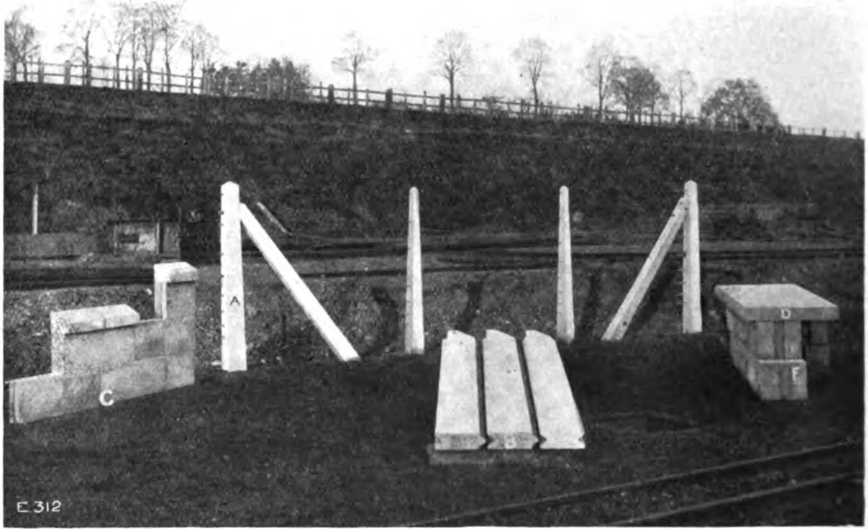


FIG. 12.

This illustration shows concrete sleepers, signal post, gate post, signal rod roller benches, and also fencing, gradient post, mile post and gang post.

All the examples shown on this page are illustrative of the "Marriott" system of patented reinforced concrete designs.



A. Reinforced Concrete Fence Posts; B. Reinforced Concrete Piles; C. Concrete Partition Slabs: D. Concrete Platform Coping; E. Concrete Plinth Blocks; F. Concrete Walling Block.

FIG. 13. CONCRETE ARTICLES ON THE L. & S. W. RLY.

FIG. 14. CONCRETE PLATFORM WALL BLOCKS IN POSITION.

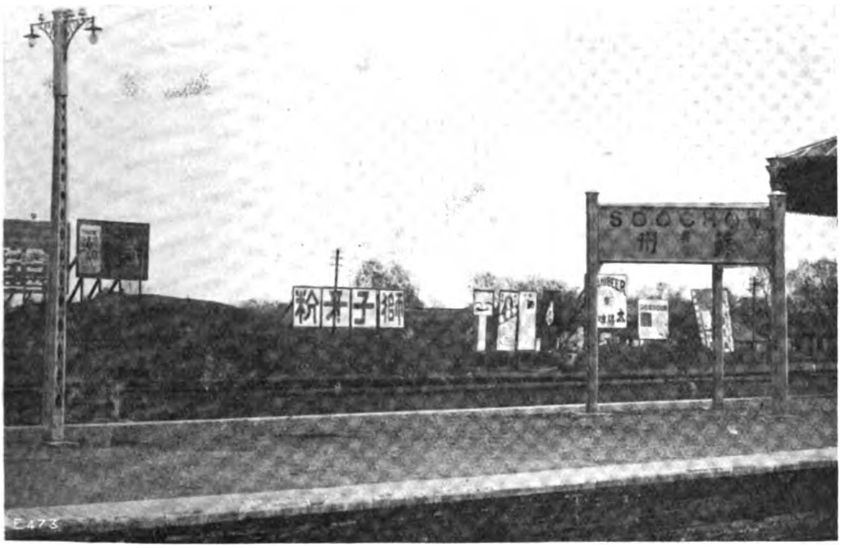


FIG. 15. VIEW SHOWING A STATION NAMEBOARD IN CONCRETE ON A CHINESE RAILWAY.

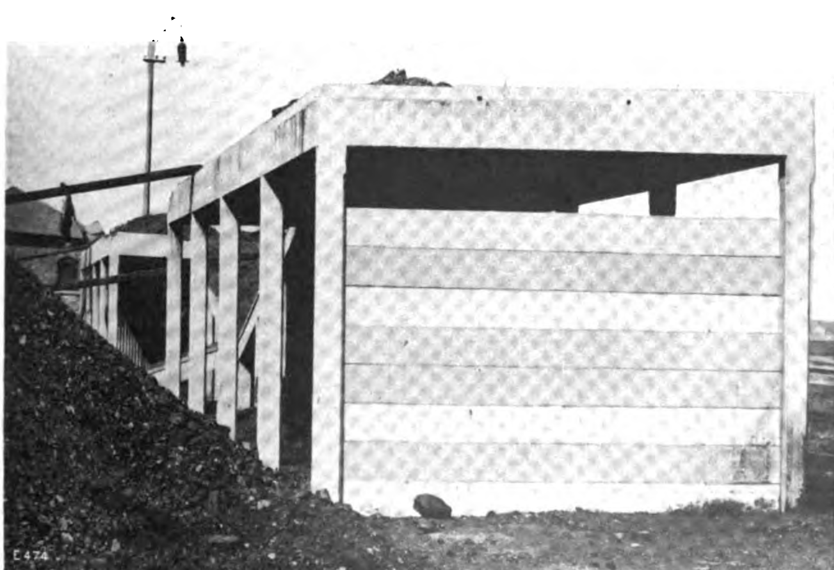


FIG. 16. REINFORCED CONCRETE COAL STAGE ON A CHINESE RAILWAY.

as elsewhere, but with the shortage of timber there is no doubt that they will come more into use in the future.*

Station name plates of concrete are also coming into use. The letters can be of coloured cement. Quite artistic plates can be produced at prices that will compare

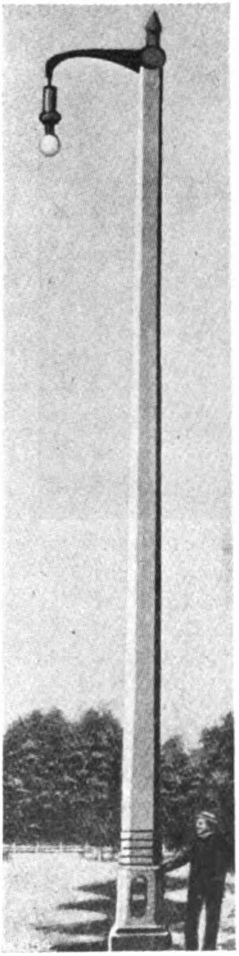
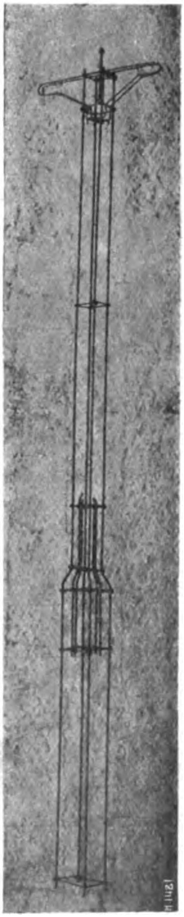


FIG. 17.
A REINFORCED CONCRETE ELECTRIC LIGHT STANDARD IN HUNGARY.



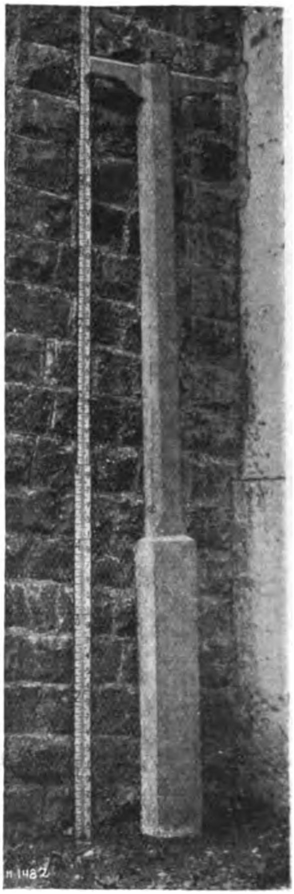


FIG. 18. REINFORCED CONCRETE LAMP POSTS AT DECCAN.

favourably with enamel or wooden name boards. The advantage of the concrete names plates is that when once they are fixed they are done with, there being no incidental expenses for upkeep, as the letters, once coloured, do not require repainting, as is the case with wooden or iron plates.

* We propose shortly devoting a special article to railway sleepers, and therefore no further reference is made to them in this article.

(To be continued.)

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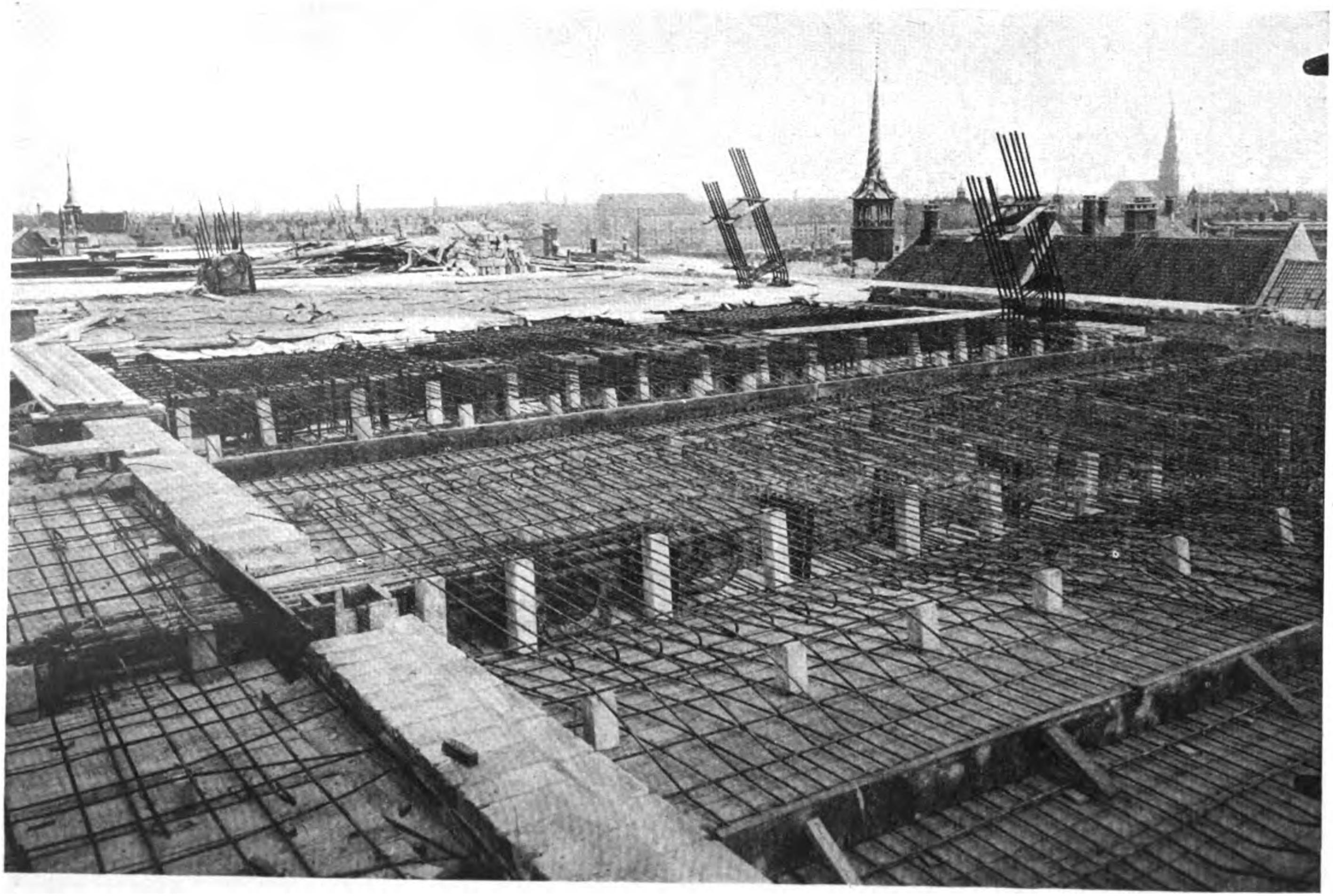

Reinforcement to Beams and Slabs before Concreting at the New Royal Palace, Copenhagen.
(For description see page 243)

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EDITORIAL NOTES.

CONCRETE AS A SUBSTITUTE FOR TIMBER.

THE difficulties of obtaining timber have been accentuated of late; transportation in every form, by sea, by inland water, and by rail is being used to its utmost capacity for war purposes, and the carriage of every kind of timber has become a matter of inconvenience.

As advocates of the use of concrete, wherever practicable, suitable, and economical to the public and private purse, we would again draw attention to the great advantages of the more extensive use of concrete as a timber substitute.

We are fully aware that many old traditions would have to be scrapped: the trades union practices may have to be affected, but in times like the present much that we should like to preserve has to go by the board, and, if concrete can save timber, concrete should be applied.

We have emphasised that concrete and reinforced concrete can be readily obtained in practically any locality with the least possible demand on the transportation services, inasmuch as some three-fourths of the bulk of concrete comprises local aggregate, be it stone, gravel, slag, ballast or the like, whilst only one-fourth of the bulk and, in many cases, less than one-fourth has to be carried comparatively short distances, this quarter or less comprising the binding material, *i.e.*, Portland cement. Portland cement, it should be remembered, is essentially a home product, comprising our own clays and chalk, and not one ounce of the constituents has to be brought by sea.

When others and ourselves advocate the use of concrete the "man in the street" imagines that concrete can only be applied to buildings and public works. The "man in the street," and he includes many who should know better, will not realise that concrete is equally applicable to the fence post, the telegraph pole, the shore, the strut, and many other of those minor applications of timber which absorb so much sound wood in the ordinary times of peace. The concrete railway sleeper for sidings is another long-neglected adjunct.

It is to be hoped that the minor uses of concrete will soon be realised. It would be well for our national economy and for practical purposes if these minor uses were officially popularised, preferably through the instrumentality of the Board of Trade, the Board of Agriculture, the War Office, and the Ministry of Munitions.

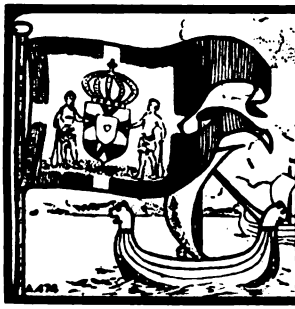
As far as the Government Departments themselves are concerned, it has been stated in the House of Commons that a Cabinet instruction has been issued (see our Memoranda, p. 285). We fear that even a Cabinet instruction will not go very far, and in any case only apply to the Government Departments, unless some statesman takes a firm stand and practically *insists* on timber being economised for minor uses, that is to say, the minor needs of not only Government Departments, but the great spending corporations and the public.

It seems extraordinary how difficult it is for a simple proposition, such as that of the concrete substitute for timber, to be appreciated and to be pressed home to those who control the economies of the country during the war. Our conservatism, our delight in tradition, goes too far in such cases. Should the same circumstances arise in the United States we are convinced that concrete would practically become omnipresent within six months and timber would become a rarity for the minor uses.

As it is, however, no matter what the claims of convenience, of economy, in transportation and of maintenance may be, the advocacy of the use of concrete during the war period as a practical solution of many difficulties falls, as a rule, on deaf ears, with the result that hundreds of thousands of pounds are wasted and tonnage galore uselessly applied on land and sea and on inland waterways alike.

Would that it were different.

Where is the statesman who will insist on the simple remedy?



CONCRETE CONSTRUCTION IN THE NEW ROYAL PALACE, COPENHAGEN.

By GEORG BROCKNER.

Some interesting reinforced concrete construction has been carried out in connection with the above building, of which we publish a few details below.—ED.

Some very extensive and complicated reinforced concrete work is being carried out in connection with the New Royal Palace at Copenhagen, Christiansborg, the principal feature of interest being the spire, which has been built entirely in reinforced concrete. Very elaborate and careful calculations had to be made, and the work is being carried out under the sole charge of Professor E. Suenson, of the Copenhagen Polytechnic College, Copenhagen, an eminent authority in Denmark on this form of construction.

As just stated, reinforced concrete has been used everywhere, iron girders and wooden beams being entirely avoided, partly to ensure safety against fire (and the history of the Royal Palace of Copenhagen has a record of disastrous fires, the last Palace being entirely burnt down some thirty years ago), and partly in order to reduce the cost.

The building proper is of masonry, a considerable portion of the old walls being re-used, so far as the outer walls and the longitudinal partitions are concerned, but the isolated pillars within the building are reinforced concrete.

Where no specially decorative scheme for ceilings was required, flat arches of 4 to 5 m. span have been very generally adopted. The thickness at the top is 8 cm. and 24 cm. at the abutments. Generally speaking, no special insulation against sound has been employed, but where special insulation has been deemed desirable, or where the floors had to be plain slabs, without beams, very light "moler" blocks, which considerably deaden sound, have been employed. The concrete floors are covered with linoleum, terrasite or marquetry. In some cases the ceilings have been finally cast on the spot by casting in plaster of Paris moulds, the cast and finished surface being whitewashed, and not polished. At other places granite mortar has been used for surfaces, which afterwards have been hewn with pneumatic hammers.

Everything possible has been done to ensure good workmanship and materials. With regard to the materials, exhaustive tests were made and strict regulations enforced as regards their quality and application to the work. The concrete has been machine mixed throughout, the proportion in all cases being 1 : 2 : 3 :, and strand gravel and small pebbles from the sea have been used. In order to guarantee the proper position of the reinforcement, small tiles burnt to a clinker, 1 by 5 by 5 cm., have been extensively used. Uniformity of thickness of the concrete slabs has been ensured by placing small concrete blocks of the proper height on the shuttering, which blocks also supported the bent rods which constituted the reinforcement, the rods and the blocks being concreted in at the same time.

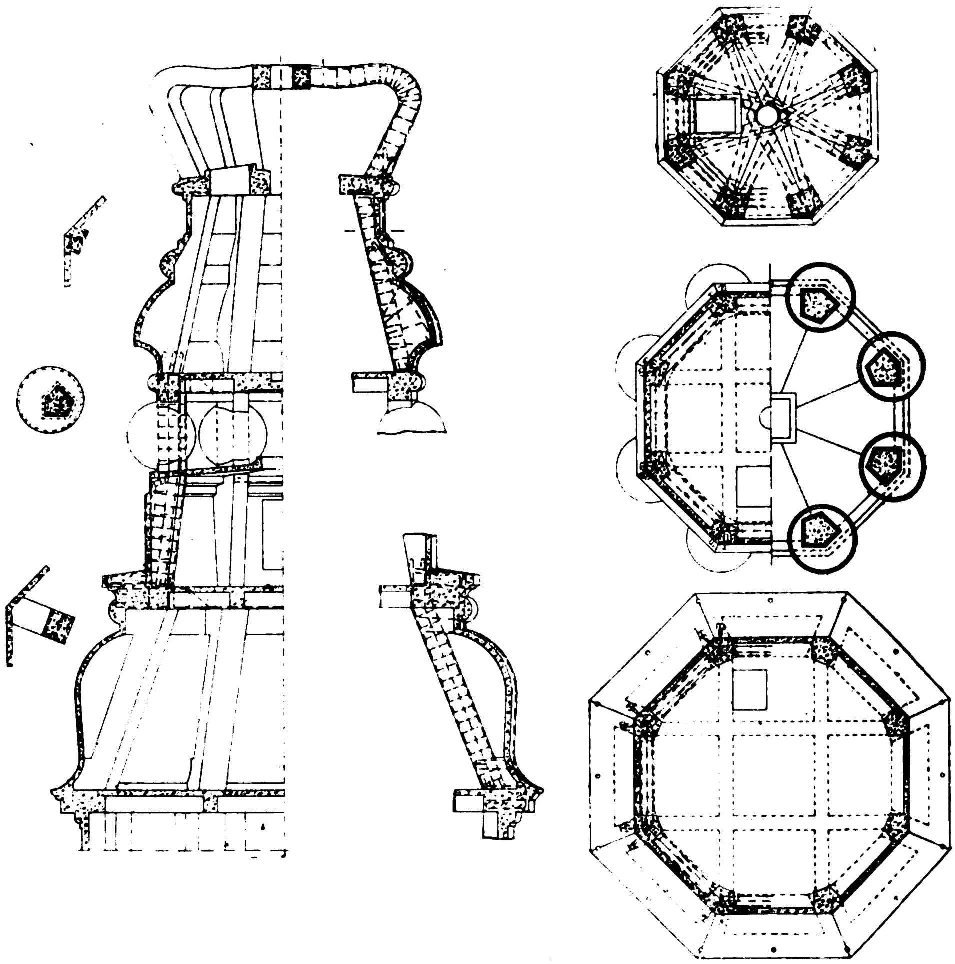


Fig. 1. Details of spire construction.

REINFORCED CONCRETE WORK IN THE NEW ROYAL PALACE, COPENHAGEN.

The floors above the large halls, where no columns were desired in the latter, were supported by hanging pillars, which were carried up and suspended from the roof, these pillars, in some cases, being incorporated in the partitions which occurred on the upper floors.

In the roof construction large braced frames were constructed, to which these suspended pillars were attached. The permissible strains were put at 40 kg. per sq. cm. for concrete and at 1,000 kg. per sq. cm. for steel.

The Palace is partitioned off into five fire-resisting divisions in the top storeys. These fire-resisting partitions are of reinforced concrete 10 cm. thick strengthened with ribs.

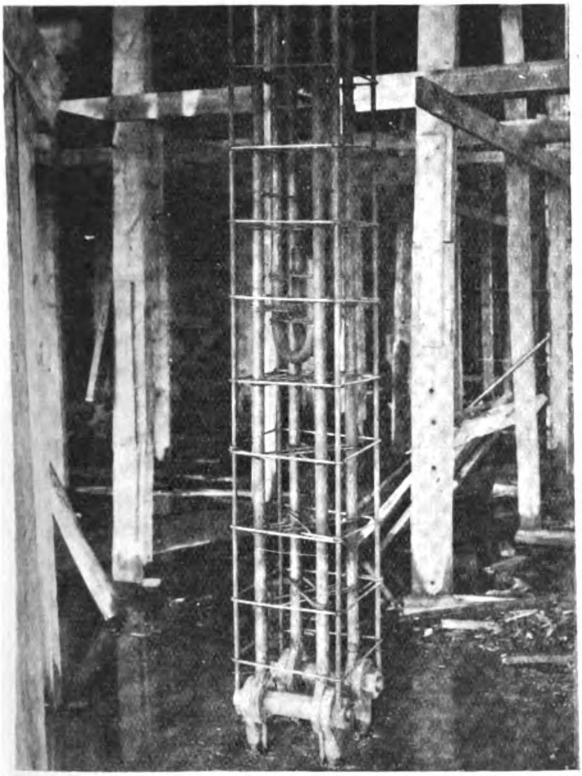


Fig. 2. Reinforcement in suspended pillar.
REINFORCED CONCRETE WORK IN THE NEW ROYAL PALACE, COPENHAGEN.

The normal roof construction consists of large reinforced rafters extending through two storeys and calculated as two-hinged arches, supported in the middle. These rafters support the roof construction over the mansard storey by means of a central purlin, and at the top they carry the upper roof construction.

Above this mansard roof are light rafters which again support purlins of reinforced concrete. On the purlins are laid light wooden rafters to which the tiles are attached. A bold moulding is formed by the purlin which is placed at the intersection of the two slopes. In the reinforced concrete ridges are cast holders of rod or flat iron for the fastening of the wooden rafters.

In some of the upper floors glass is provided so as to secure more light, this being prismatic to diffuse the light in such a manner that the concrete in which the glass is set is not visible from below.

For all the pillars and in the members of the roof construction links are twisted round the rods in such a way that the reinforcement is perfectly rigid and cannot be displaced when concreting. All the staircases are of reinforced concrete, formed as sloping planes to provide a soffite upon which the steps are afterwards placed, these latter being either wood, stone, or concrete.

During the excavations for the foundations of the tower ruins were found of the previous castles built on the same site, and which had almost all been destroyed by fire. Well preserved remains were found of the old stronghold, "Hafu," built by Bishop Absalom, the founder of Copenhagen (who died in 1201), and as it was considered a pity to cover up these ancient ruins again, a concrete ceiling or cover was placed above them, so that they are now accessible, and this ceiling or roofing now forms part of the floor of the interior courtyard.

The spire can, no doubt, lay claim to being one of the most remarkable pieces of reinforced concrete construction so far completed. In spite of the elaborate design and the great height it is entirely built up of reinforced concrete, which is again to be covered with concrete, for the fastening of which the requisite arrangements have been provided as the building went on. In the illustration of the completed spire it will be seen that a crown is formed near the top, and some idea of the size can be gathered from the photograph in *Fig.* 8, which shows the shuttering required. The actual reinforced concrete construction was carried up some distance above this feature, and the method generally employed was that of forming thin reinforced slabs shaped to the required contour and stiffened by eight vertical piers or struts, spaced equally around the perimeter, as given on the plan at the various levels. Horizontal slabs stiffened with diagonal beams were constructed to form floors at different planes in the height, these occurring generally where a distinct change in the contour was necessary. The various parts were well connected by carrying the reinforcement from one member well into the adjacent construction, as will be seen in the drawings which are illustrated. The elaborate detail and varying section

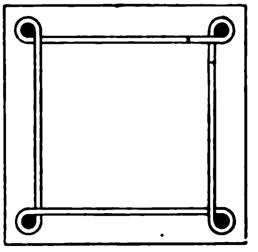


Fig. 3 Type of links used in columns.
REINFORCED CONCRETE WORK IN THE NEW ROYAL PALACE, COPENHAGEN.

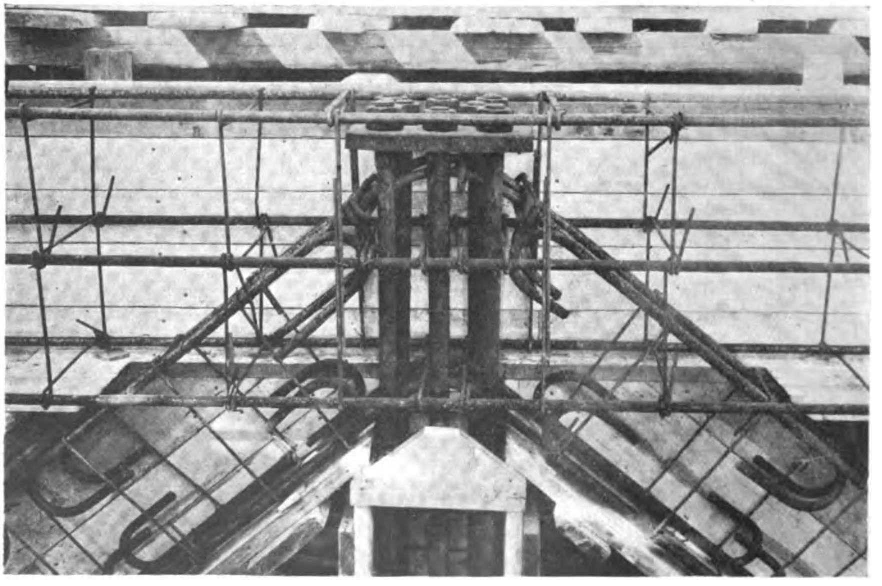


Fig. 4. Bearing pillar over the Knight's Hall.
REINFORCED CONCRETE WORK IN THE NEW ROYAL PALACE, COPENHAGEN.

necessitated a great deal of complicated work, and the whole spire is an excellent example of what may be termed the decorative possibilities of a constructional material which is adaptable to any form. There were ten different sizes of rods used in the spire reinforcement, and the total weight of steel employed in this feature alone was about 140,000 kg., while the concrete required was 1,263 cm., and the shuttering necessitated the use of about 6,356 sq. m. of boarding. The specification comprises fourteen sections, the volume of

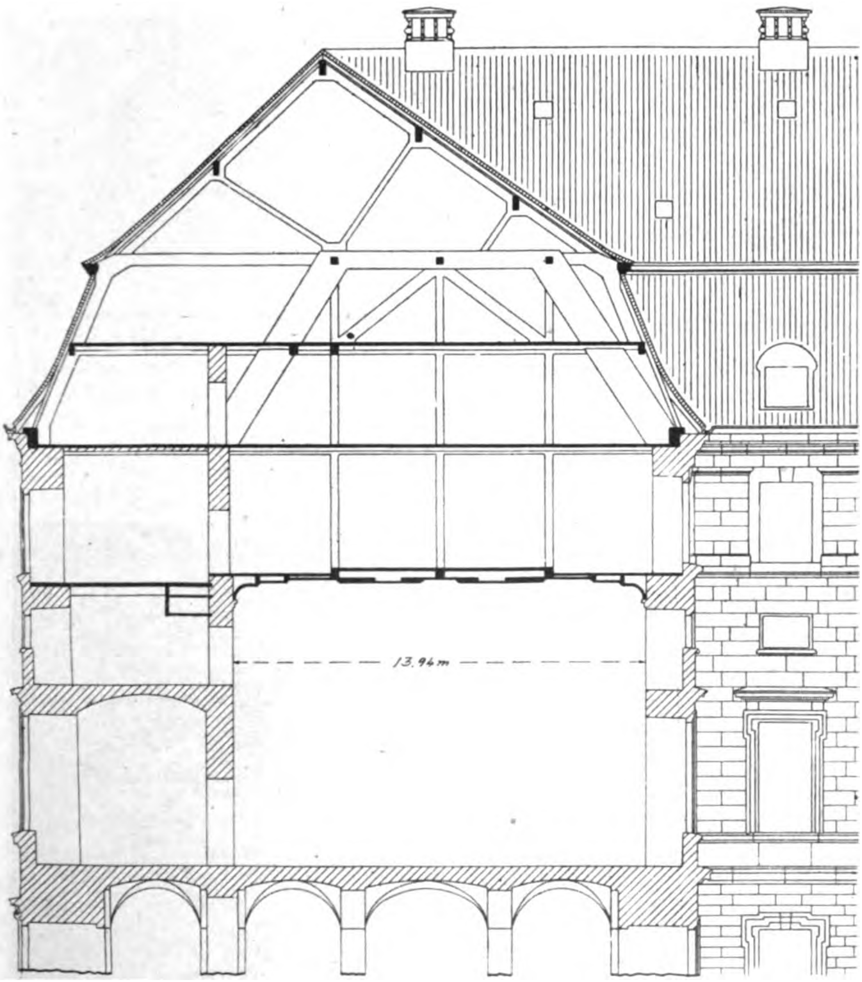


Fig. 5. Section showing suspended pillars over large hall.

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the concrete, the area of the shuttering, the dimensions and weight of the reinforcement are calculated, and the position of each rod is signified in every detail, so as to make sure of perfect work, nothing in the way of the slightest detail being left to the discretion of the contractor.

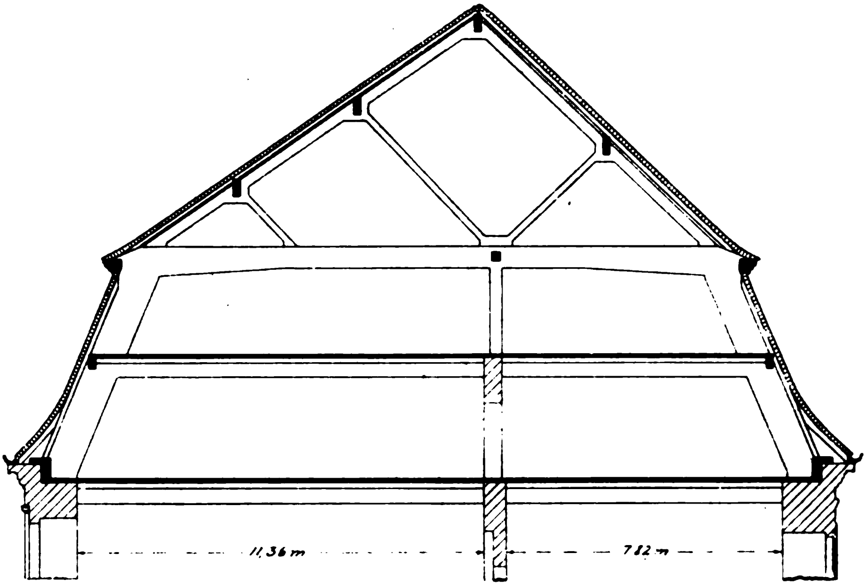

Fig. 6. Section through Mansard Roof.

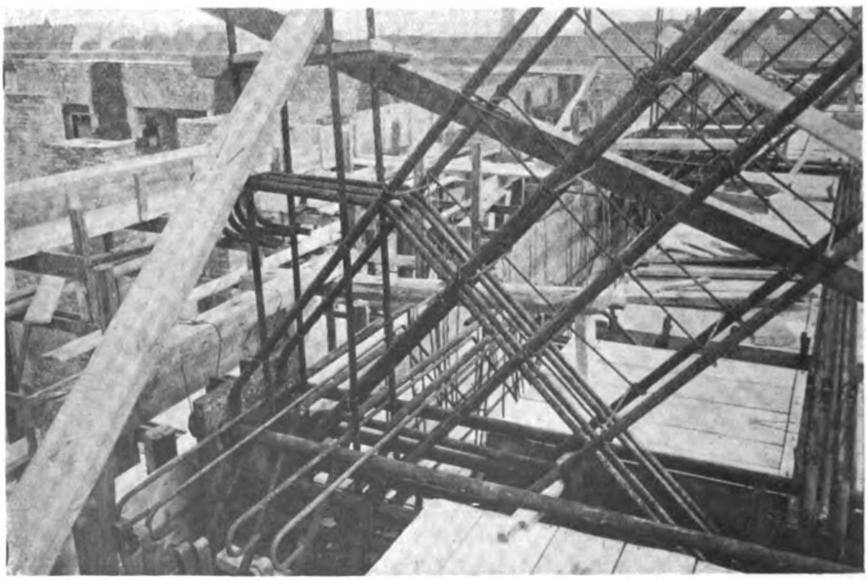

Fig. 7. Intersection of main rafter and floor beam.

REINFORCED CONCRETE WORK IN THE NEW ROYAL PALACE, COPENHAGEN.

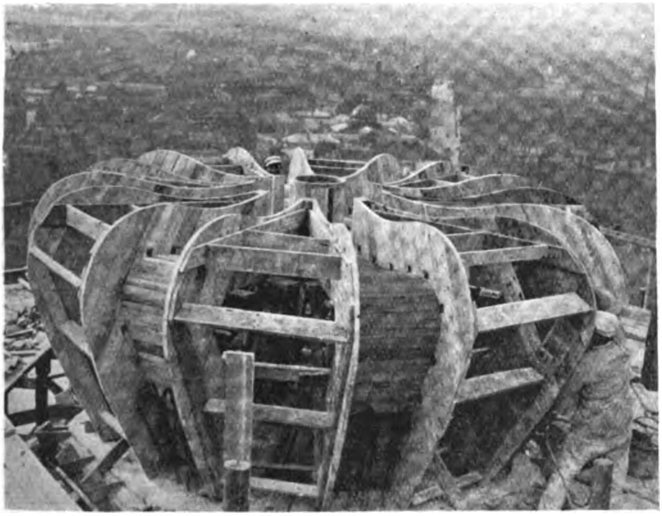

Fig. 8. Shuttering to crown on top of spire.

The reinforcement consisted of faultless, pliable steel, with an ultimate tensile strength of 3,700 kg. per sq. cm., the elongation to be at least 20 per cent. for a rod of 7 mm. thickness or more, and not less than 18 per cent. for smaller rods, the final elongation to be measured on a length equal to 11, 3 × F, F being the section of the rod. Both in the state of delivery and after heating, with subsequent dipping in water having a temperature of 28° C., it was specified to stand cold bending, 180°, round a rod the diameter of which was equal to the thickness of the tested piece, without showing any cracks on the convex side. All the rods had to be bent exactly as shown on the drawings and be kept at a distance of 1 cm. from the surface of the concrete, and this was accomplished with small tiles, as already mentioned.

The time allowed for the hardening of the cement was be-

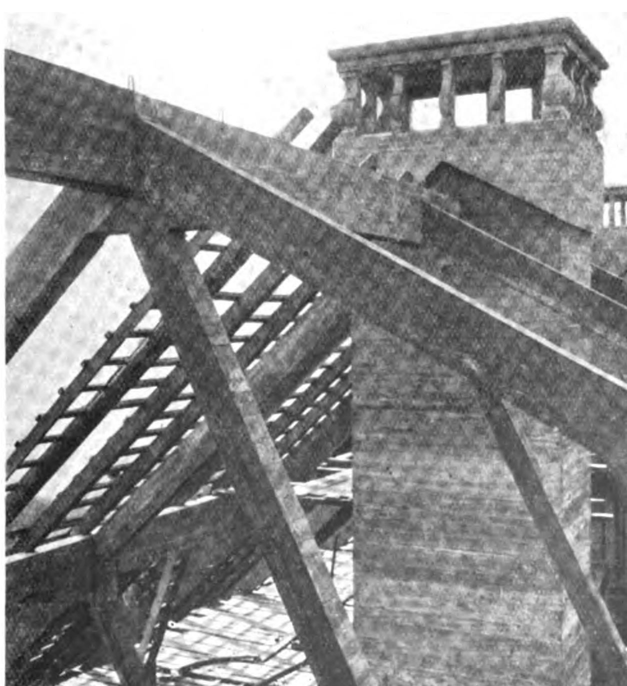

Fig. 9. Reinforced Concrete roof construction.

REINFORCED CONCRETE WORK IN THE NEW ROYAL PALACE, COPENHAGEN.

tween 6 and 9 hours. The compressive strength was specified to be not less than 250 kg. per sq. cm. after 28 days, and the cement was not to be used until the 28 days' certificate of the State Testing Institute had been obtained unless

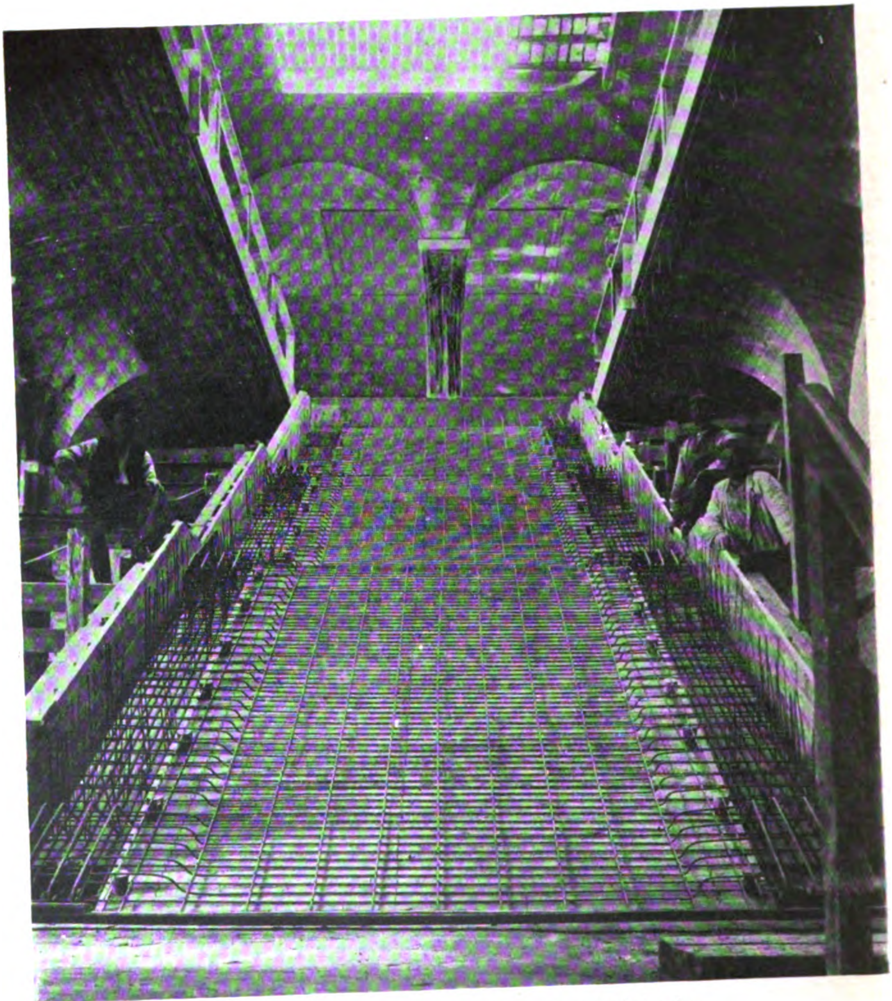

Fig. 10. Construction of grand staircase to second chamber.

REINFORCED CONCRETE WORK IN THE NEW ROYAL PALACE, COPENHAGEN.

the contractor offered other adequate guarantee. The aggregate was specified to be clean and strong and pass through a sieve with 3 cm. dia. holes. The concrete was given as 1 cu. m. sea-pebbles, as just described, 0·67 cu. m.

sand, and 467 kg. cement; the rods in the bottom of the slabs, beams, and mouldings, however, first being covered with a layer of mortar consisting of

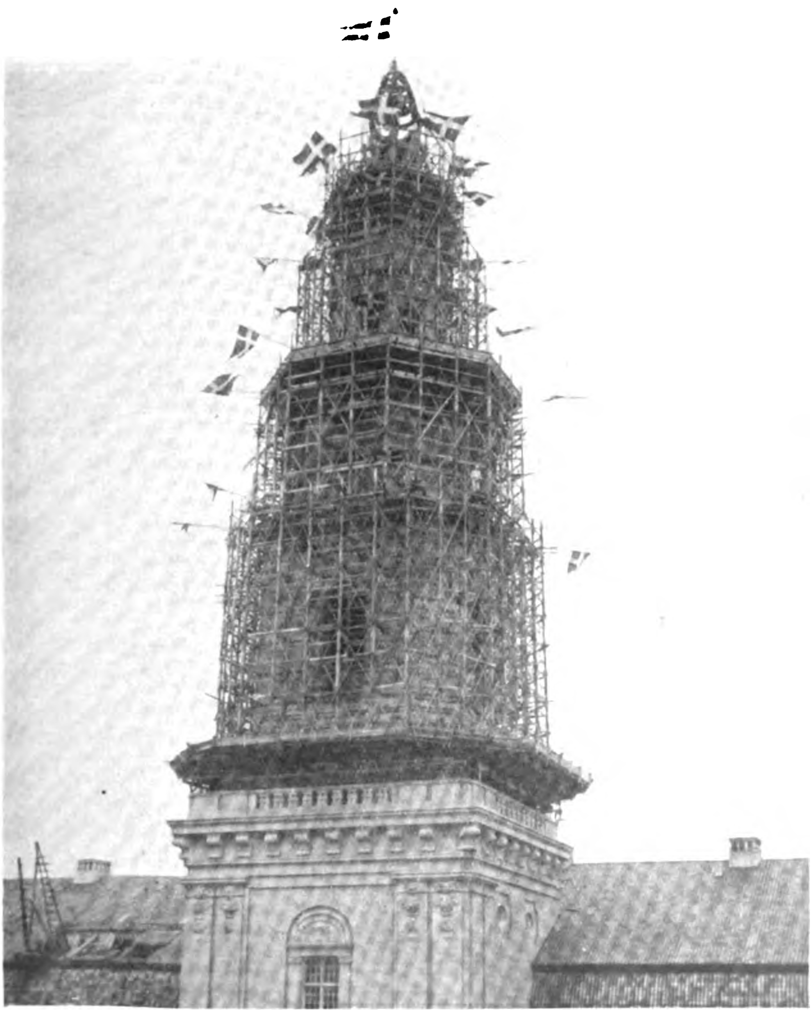

Fig. 11. View of the spire with concrete work completed.

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1 cu. m. sand and 700 kg. cement, which mixture also had to be used in places where the rods were numerous and complicated. During the concreting of

pillars and outer surfaces the moulds were left open on one side, and closed by means of narrow boards as the concrete was placed. As soon as the concrete had hardened it was covered with sand, cement bags, or matting, kept moist for the next 14 days. The floors, with one or two exceptions, were covered with a layer, 1 cm. thick, of cement mortar, 1 : 2, to give a wearing surface.

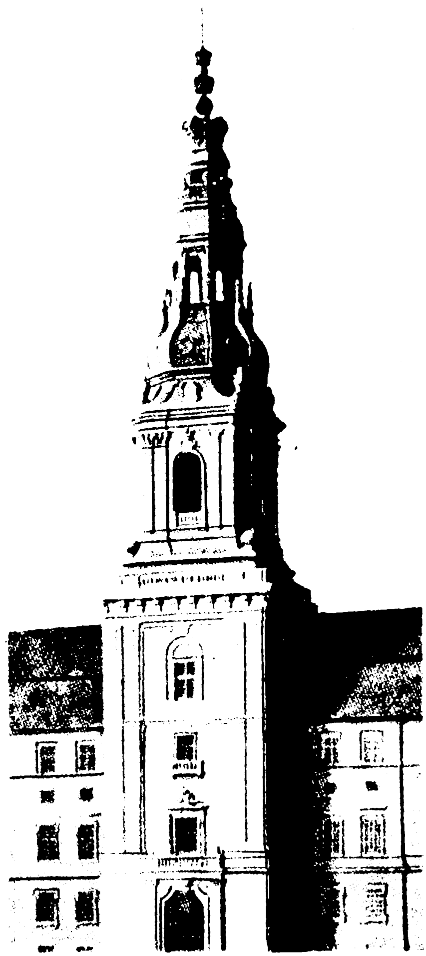

Fig. 12. The spire when finished.

REINFORCED CONCRETE WORK IN THE NEW ROYAL PALACE, COPENHAGEN.

PROBLEMS IN THE THEORY OF CONSTRUCTION.

THE EFFECT OF VARYING MOMENT OF INERTIA UPON CONTINUOUS BEAMS

By EWART S. ANDREWS, B.Sc.Eng., M.C.I.

ALL the recognised formulæ in common use for the design of continuous beams involve the assumption that the moment of inertia is constant throughout the beam, whereas in the detail design of continuous beams in practice it is the custom to vary the reinforcement, and therefore the effective moment of inertia from one point to another according to the change in the bending moment. The question then arises as to what extent this variation in section affects the accuracy of the formulæ based upon the Theorem of Three Moments, assuming a constant value of the moment of inertia. The results of only a few experiments upon the subject have been published; the only ones known to the author are contained in a report of some experiments made in Germany, and they indicate that no appreciable error is involved in making the usual assumption.

At the outset we may state that it is very difficult to deal with the effect of a varying moment of inertia in most cases, although the effect can be expressed by general mathematical formulæ; the difficulty lies in the application of these formulæ to derive the results for the various cases.

In the present article we will deal with some of the cases that can be solved and will consider their effects upon the results.

Case I. Constant stress for the two equal spans uniformly loaded.—Fig. 1 shows the B.M. diagram for the case on the ordinary assumption that the section remains constant. If the section of a beam varies so that the maximum stress in the material is constant, the depth of the beam and position of the neutral axis also remaining constant, then by the general formula (1)

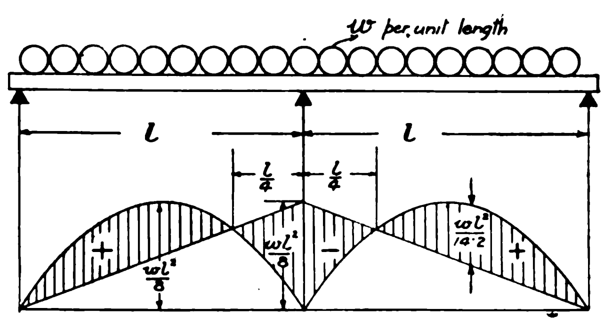

FIG. 1.

$$\frac{f}{y} = \frac{B}{I} = \frac{E}{R}$$

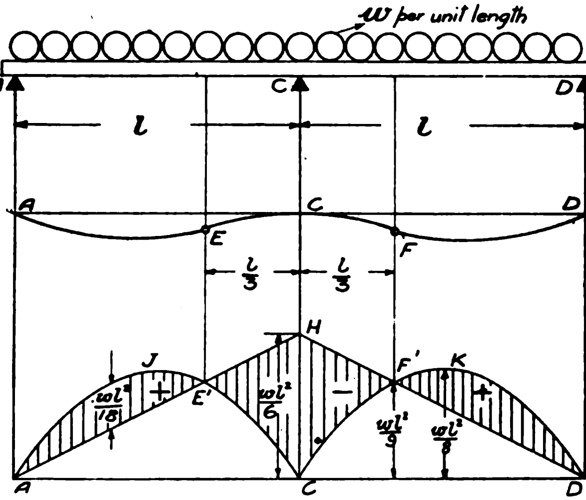

FIG. 2.

in which

f = Stress in the material,
y = Distance from the neutral axis,
B = Bending moment,
I = Moment of inertia,
E = Elastic modulus of the material (assumed constant),
R = Radius of curvature of the beam,

we have

$$\frac{E}{R}=\frac{f}{y}=\text{constant.}$$

$\therefore$ R is also constant, or the deflected form of the beam will be in circular arcs.

When therefore the deflections are small, as they will be in practice, the points of contraflexure E, F, *Fig.* 2, will occur practically at distances $\frac{l}{3}$ from the centre C. This will be seen if we take a pair of compasses set with a large radius and from a centre vertically below C, and then with the same radius we draw an arc from a centre above the beam to pass through A and to touch the first-arc; the greater we make the radius, the more nearly will the point of contact of the two arcs, *i.e.*, the point of contraflexure, approach a distance $\frac{l}{3}$ from C. In the limiting case, therefore, the points of contraflexure will be as shown in *Fig.* 2, and the reverse bending moment diagram AE^1HF^1D will pass through the points E^1, F^1, at which the free bending moment is $\frac{wl^2}{9}$. This makes the reverse bending moment at the support $=\frac{wl^2}{9}\times\frac{3}{2}=\frac{wl^2}{6}$; and the resulting bending moment diagram would come as shown shaded in the diagram.

Now, an inspection of this diagram shows that the intermediate bending moment has a maximum value of $\frac{wl^2}{18}$ and that is much less than would be provided for in practice. In practice, therefore, the moment of inertia provided for the intermediate section will be more than is sufficient to keep the stress constant throughout the beam, and that will have the effect of moving the points of contraflexure towards the centre support C, so that the reverse bending moment at the support will approach the value $\frac{wl^2}{8}$. This will be seen more clearly from the next case.

Case II. Two equal spans uniformly loaded, the sections being the same at the points of maximum positive and negative bending moment, and the section changing so that the stress remains constant from the end supports to the points of the contraflexure and also constant between the points of contraflexure.

In this case let the points of contraflexure be at distance αl from the centre support C, *Fig.* 3, and let B_S and B_I be the maximum support and intermediate bending moments respectively. We then have

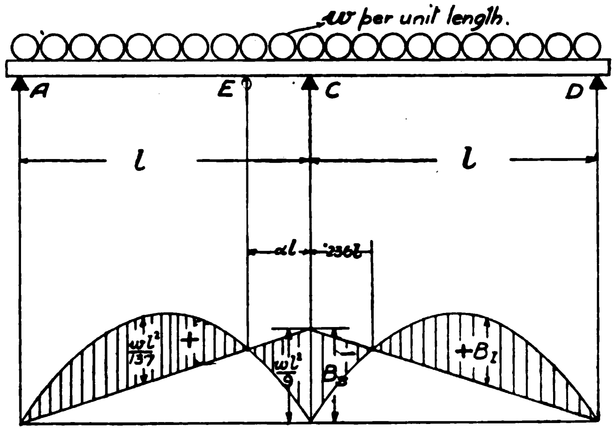

FIG. 3.

$$B_I = \frac{w\{(1-\alpha)l\}^2}{8}$$

$$= \frac{wl^2.(1-\alpha)^2}{8} \quad (2)$$

$$B_S = \frac{w(-\alpha l)^2}{2} + \frac{w(1-\alpha)l}{2}.\alpha l$$

$$= \frac{wl^2\alpha^2}{2}. \quad (3)$$

The value of B_S is obtained by treating the portion EC as a cantilever with a uniformly distributed load of intensity $\underline{w}$ throughout its length and an isolated load at the point E equal to half the weight on AE.

Returning to our general formula (1) we have

$$B\,R = E\,I$$

$$\left.\begin{array}{l} \therefore B_S R_S = E_S I_S \quad . \quad . \quad . \quad . \\ \text{and } B_I R_I = E_I I_I \quad . \quad . \quad . \quad . \quad . \end{array}\right\} \quad (3a)$$

E may be assumed constant and we have assumed that $I_S = I_I$ so that we have

$$B_S R_S = B_I R_I \quad . \quad . \quad . \quad . \quad . \quad (4)$$

We next obtain a relation between R_S and R_I by assuming, as we are justified, that they are large and that the centre of the circular arc into which the portion EF bends is vertically below C and that of the arc into which AE bends is vertically above its mid-point.

$$\text{This gives} \quad \frac{R_I}{R_S} = \frac{\frac{(1-\alpha)}{2}}{\alpha}$$

$$\therefore R_S = \frac{2\alpha R_I}{(1-\alpha)} \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Now putting the results of equations (2), (3) and (5) into equation (4), we get

$$\frac{wl^2}{8}(1-\alpha)^2 R_1 = \frac{wl^2}{2}\alpha.\frac{2\alpha R_1}{(1-\alpha)}$$

$$i.e.\ (1-\alpha)^3 = 8\alpha^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

This equation cannot be solved by direct means, but by substitution of trial values of α and plotting, we find $\alpha = {\cdot}236$.

This gives a support B. M. equal to $\cdot 118\,wl^2$, as shown in *Fig.* 3, which is approximately $\frac{wl^2}{9}$. The maximum intermediate B. M. comes equal to $\cdot 073 wl^2 = \frac{wl^2}{13{\cdot}7}$. This result is particularly interesting because the resulting central bending moment comes a little less than for the case in which the section remains constant.

In the design of continuous beams in practice it is usual to assume equal bending moments at the support and intermediate sections and to bend up the bars according to the variation of the bending moment in a manner which approximates to the case under consideration in cases where the depth remains constant. The variation of moment of inertia in practice will be somewhere between the condition of uniform stress which we have taken as a limiting case and of constant section, and the above reasoning shows that the error of working by the ordinary theorem of three moments will be very small.

If, as is common in practice, haunching is provided at the supports, the values of I_S and I_l will not be the same, even if the sections are designed for the same bending moments. In the previous equations allowance may be made for any given variations in I_S and I_l.

Case 3. Uniformly loaded beam of infinite number of spans or beams with fixed ends, the moment of inertia being constant between the points of contraflexure, and constant but of different value from the points of contraflexure to the ends.

This case was, we believe, first investigated by Mr. P. E. Stevens, A.M.Am.Soc.C.E., in the discussion of a Paper by Mr. W. H. Burr, M.Am.Soc.C.E., on "Reinforced Concrete Work of the McGraw Building" (Vol. LX, 1908, Trans. Am.Soc.C.E.). We will treat it in a different manner which arrives at the same result.

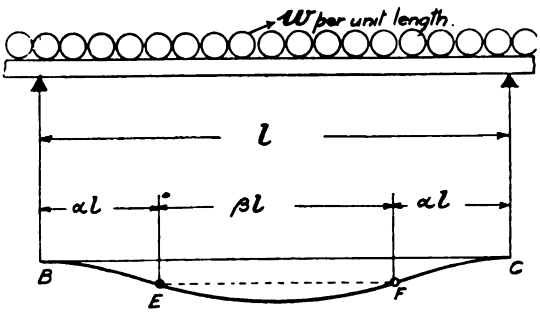

FIG. 4.

Let BC, *Fig.* 4, be the beam of which the points of contraflexure E F are at distances αl from the ends, the length EF being βl, and let I_l and I_S being the moments of inertia for the lengths EF and BE or CE respectively. Then the condition that has to be satisfied is that the slope of the beam at the point E must be the same whether considered from the centre portion EF or for the cantilever portion BE.

We will work by Mohr's method which treats the bending-moment diagram upon the beam as an imaginary loading, the slope at the end of a simply supported beam being proportional to the imaginary reaction, *i.e.*, to half the area of the B.M. diagram, and in the case of the cantilever the end slope being proportional to the area of the B.M. diagram.

∴ Considering span EF we have

$$E\,I_l \times \text{slope at } E = \tfrac{1}{2} \text{ area of parabola of height } \frac{w \times (\beta l)^2}{8}$$

$$= \frac{1}{2} \times \frac{2}{3}\beta l \times \frac{w \times (\beta l)^2}{8}$$

$$= \frac{wl}{24}\,\beta^3 \quad . \quad . \quad . \quad . \quad . \quad . \qquad (7)$$

Considering the cantilever portion, we note that the B.M. diagram will be a parabola of height $\frac{w(\alpha l)^2}{2}$ at B due to the uniform load on EB, and a triangle of height $\frac{w\beta l}{2}.\,\alpha l$ at B due to a point load at E equal to half the load on EF.

We thus have

$$EI_S \times \text{slope at } E = \frac{\alpha l}{3}\cdot\frac{w(\alpha l)^2}{2} + \frac{\alpha l}{2}\cdot\frac{w\beta l}{2}\cdot\alpha l$$

$$= \frac{wl^3}{24}\left(4\alpha^3 + 6\alpha^2\beta\right) \qquad . \quad . \quad . \qquad (8)$$

Dividing (8) by (7) we have

$$\frac{I_I}{I_S} = \frac{\beta^3}{4\alpha^3 + 6\alpha^2\beta} \qquad . \quad . \quad . \quad . \quad . \quad . \qquad (9)$$

Since $2\alpha l + \beta l = l$, $\beta = 1 - 2\alpha$

∴ Equation (9) becomes

$$\frac{I_I}{I_S} = \frac{(1-2\alpha)^3}{(6\alpha^2 - 8\alpha^3)} \qquad . \quad . \quad . \quad . \quad . \quad . \qquad (10)$$

From this equation can be found the requisite ratio of $\frac{I_S}{I_B}$ to give any given position of the points of contraflexure. If $I_S = I_B$, as is assumed in the ordinary formulæ for continuous beams, this result gives $(1-2\alpha)^3 = 6\alpha^2 - 8\alpha^3$, the solution of which will be found to be $\alpha = \cdot 211$, which is the familiar result for a uniformly loaded fixed beam of constant cross-section.

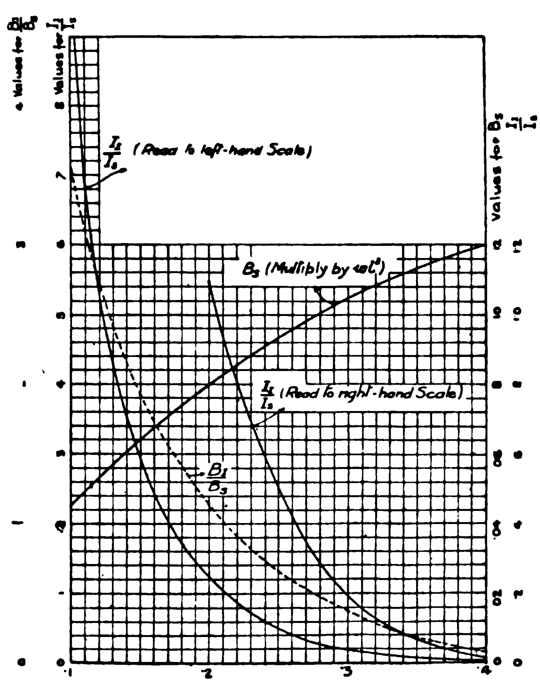

FIG. 5.

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When the value of α is known, the values of the bending moments B_I and B_S and the centre or intermediate section and support respectively will be given by

$$B_I = \frac{wl^2}{8}(1-2\alpha)^2 \quad . \quad . \quad . \quad . \quad . \quad (11)$$

$$B_S = \frac{wl^2}{2}\left(\alpha^2 + \frac{\alpha\beta}{2}\right)$$

$$= \frac{wl^2}{2}(\alpha^2 + \alpha - 2\alpha^2)$$

$$= \frac{wl^2\alpha(1-\alpha)}{2} \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

$$\therefore \frac{B_I}{B_S} = \frac{(1-2\alpha)^2}{2\alpha(1-\alpha)}$$

In *Fig.* 5 we have plotted against α the values of $\frac{I_I}{I_S}$ and $\frac{B_I}{B_S}$ and B_S from which we may obtain the quantities required for any given point of contraflexure or the bending moments and point of contraflexure for any given values of the moments of inertia. The curve for $\frac{I_I}{I_S}$ is drawn twice, the portion for $\alpha = {\cdot}2$ to ${\cdot}4$ being redrawn to enlarged scale.

WATER THE CHIEF FACTOR IN THE MAKING OF GOOD CONCRETE.

By NATHAN C. JOHNSON,
Consulting Concrete Engineer, New York City.

The following article has been reproduced from the "Engineering Record." A good many points raised in the article are, of course, well known; on the other hand it particularly emphasises facts which are frequently lost sight of.—ED.

THE improvement of concrete is an objective earnestly to be striven for. Defective concretes are within lens shot of every camera; and if their number is not to increase as the uses and applications of concrete are extended, effective rules must be established which will remove the present uncertainty as to ultimate result.

No studies are more informative, or more productive of constructive knowledge, than systematic investigations of defects. On such studies has been built the whole science of preventive and remedial medicine, with its incalculable benefits to humanity. Perfect structures, whether of flesh or of concrete, will care for themselves, but the ailing structure needs care and attention so that the ills may be remedied and their recurrence prevented.

In both sciences much has already been achieved through such study, yet even more remains to be accomplished. In ailing humanity each nerve, each muscle, each minute component part is recognised as affecting the harmony of the whole. In ailing concretes each part is equally important to mass strength and endurance, yet seldom is proper recognition given to this fact. Cement has been closely studied. Sand and stone have had most careful scrutiny. But although cement and sand and stone are not concrete without water, the functions of this essential substance are so little regarded as to have been, up to a twelvemonth ago, almost wholly neglected. But it is not idle or thoughtless to venture the prediction that within twice that span of time water in concrete will be subject to closer regulation than any other substance, through sheer impossibility of longer withholding recognition of its preponderant importance.

It is with the hope that interest and discussion in this important subject will be aroused that this article is written. It contains a recommendation regarding the wastage of the lighter parts of the mix that may arouse considerable antagonism, but which is fully justified by the facts here presented.

DAY'S-WORK PLANES.

When structures of concrete subjected to water action in any degree are examined after two or three years of service the surfaces are found to be discoloured, usually along horizontal planes. "Efflorescence" is the explanatory anodyne of apologists; but if the same structure is examined after a longer period the conditions first noticed are found to be aggravated. Surface stains and unsightliness have gone deeper. Undeniably they are become local disintegrations, with oftentimes heavy surface incrustations below them; and it is thrust upon one's notice that these surface deposits originate and these disintegrations are most pronounced at strata lines where surface staining was first noticed.

"Day's-work planes," says the advocate of any old concrete for any and every purpose. "They are natural to concrete." With the majority of concrete work as a basis of judgment such a dictum is apparently justified, but if it is justified by fact concrete may not safely be employed *when subjected to water action in any degree,* for the first surface stains, the later incrustations, and the deeper disintegrations bear witness to percolation and removal of material by water along these planes. And if the substance of such planes is examined it will be found to consist of fine, semi-solid material, chalky when dry, clay-like and slippery when wet, lying in layers of greater or less thickness and bearing little or no resemblance to concrete.

"Laitance," says the apologist. "We've had it analysed. It comes from the cement. It's part of the concrete." Unfortunately it is; and a cancer is also part of the tissues which it destroys. Yet we ignore the one and spend millions in the effort to eradicate the other.

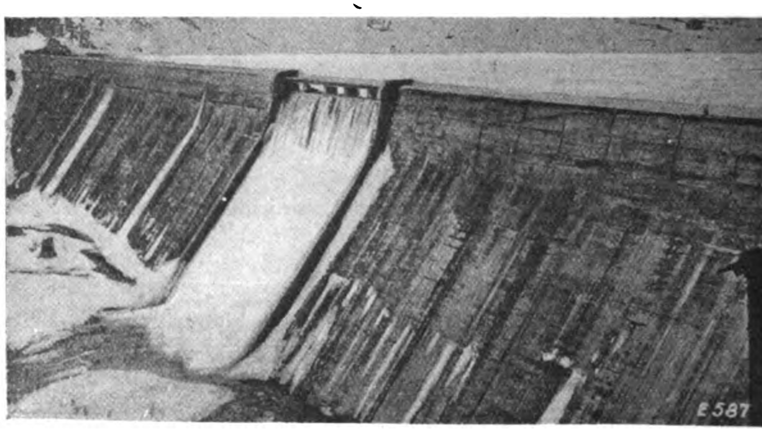

Fig. 1. Day's-work Planes showing on face of Austin Dam, Pa.
WATER THE CHIEF FACTOR IN THE MAKING OF GOOD CONCRETE

THE AUSTIN DAM FAILURE.

In 1911 the whole country was shocked at the failure of a concrete dam at Austin, Pa. Towns were swept away by the released waters, one hundred lives were lost, millions of dollars of material damage resulted.

Engineering examination subsequent to the disaster emphasised particularly the responsibility of a shale rock foundation, permitting slip of the entire dam. Two engineers laid emphasis upon certain defects noticeable in the concrete, but it is probable that the opinion accepted by the engineering fraternity at large was that the responsibility lay with a poor foundation.

Without disparaging in any sense these factors it is of interest to an analytical study of defective concretes to notice the surface appearance of this dam before failure, and to endeavour to correlate this appearance with such rupture as occurred under stress of impounded water.

In *Fig.* 1 it is seen that this dam exhibits what might be termed a characteristic concrete surface, showing the marks of form boards in well-defined horizontal lines, with here and there darker lines, indicating the height of a lift of forms, with, along and below these lines, white extrusions of greater or less extent.

It is of special interest to note that one examining expert in his report to the coroner says: "One section at the west end slid on one of these horizontal construction joints" (day's-work planes), and he adds that these "construction joints" are formed of "cement cream." A second engineer also notes that there was a laitance section, 10 by 20 ft. in surface area, near the west end that showed horizontal failure; and he states that "much of this material would have made excellent marking chalk." There was further a large section of the dam which sheared diagonally; and there was much speculation as to why massive concrete should have sheared in this peculiar way along a plane greater than that defining a least area.

Remembering, then, that "day's-work planes" are formed from laitance, or "cement cream," and remembering the characteristics of this substance: light, semi-solid, chalky when dry, slippery when wet, non-adherent to concrete above and below it; remembering, too, the unquestioned existence of at least one large area of laitance at the west end of the structure, can foundation rock, poor though it unquestionably was, be held solely responsible for this failure? And may engineers accept day's-work planes as "inevitable," "harmless," and "natural to concrete"?

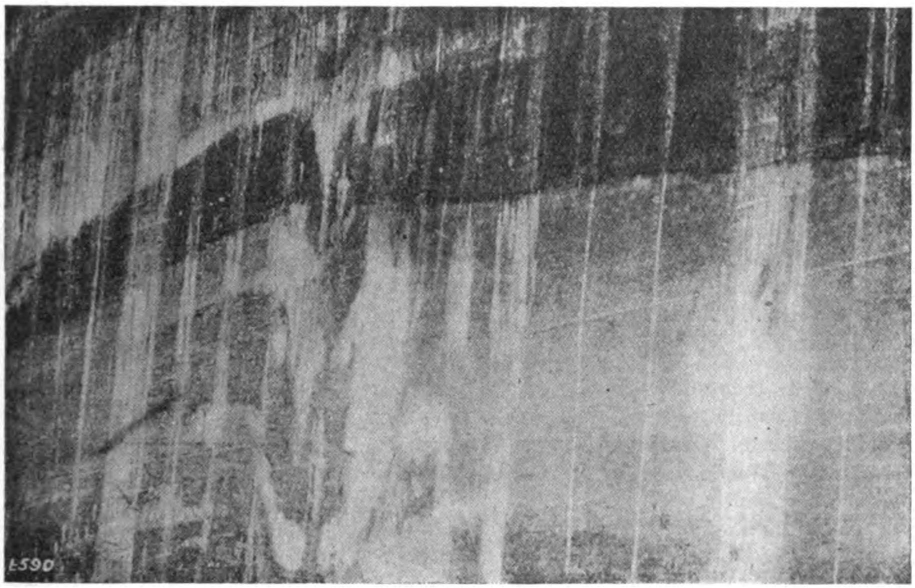

Fig. 2. The concrete in this wall was poured with excess of water, and shows thick bands of laitance.
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No condemnation of concrete ever was greater; and, if true, condemnation is also made of any engineer who recommends concrete, except in enormous mass, for any water-exposed service, whether such exposure be to high heads of water or to ground moisture brought through by negative pressure from surface evaporation.

SIMILAR CHARACTERISTICS.

Nor is this an isolated instance. In *Fig.* 2 is shown the surface of a concrete wall not unlike the Austin Dam in general section. It is noticeably stratified or banded, and at the centre there are dips or waves, as though a stream had plunged with force into a plastic substance, flowing off on either side from the point of delivery. But little imagination is needed to picture repeated batches pouring from a spout at this point, each batch forcing itself into the semi-fluid mass below. But examination reveals that each wave is outlined in a seam of laitance; that the broad dark belt extending for some distance on either side is also laitance; and at the

Fig. 3. The Result of Neglect in Precautions in Making Concrete.

extreme right is seen the same sort of white leachings so characteristic of the Austin Dam. Evidently the concretes placed in this wall must have been quite wet to flow sufficiently to form waves and belts and stratifications.

At another point in this same wall the surface skin was removed to expose successive belts and inclinations of strata; it was found that in deep layers lay almost uncemented stone, with, above each layer of stone, a layer of laitance, with percolation made evident by surface incrustations starting above the relatively dense laitance at its junction with the uncemented stone.

An inspection of the full length of this wall showed plainly the slopes and waves of successively poured batches. Unquestionably this concrete is of uncertain and variable strength; and if one of the pouring slopes found in this wall had been in the Austin or in any other dam, with a separating laitance seam at its upper boundary, softened and made slippery by percolating water, might not diagonal failure "at a section greater than the least section" have been expected?

Excess Water Responsible.

Nor can the conclusion be escaped that excess water, added to save labour of mixing and labour of compacting in forms, is responsible for such planes of weakness in concrete, whether these planes are diagonal or horizontal, or whether they occur in an Austin Dam or a countryside culvert. Of what use is the elaborate design if execution is grossly at fault? Daily and hourly, at the very moment these lines are written, concrete of which the accurately descriptive adjective is "drowned" is being placed in forms under specifications which directly provide for its ultimate failure.

Yet laitance is not the only defect resulting from excess water, nor is excess water the cause of all defects. But excess water, either as a prime cause or by aggravating initial deficiencies until they come to have an exaggerated importance in the final result, is of such importance as to be deserving of special attention and study.

Function of Water.

Concrete is a composite, 80 per cent. or more of which is sand and stone. The remaining 10 per cent. is the product resulting from chemical combination between cement and water. But in spite of its percentage minority, this cementing substance has preponderate importance. Sand and stone by themselves are but feebly coherent at best, as in *Fig.* 3, wherein is shown a commercial demonstration of that fact. On the other hand, sand, stone and hydrated Portland cement may be "artificial stone" in the truest sense of that term, if attending conditions are right. Water, therefore, both in physical and chemical action, is the key substance of concrete.

Water in concrete functions in four ways:—

First: Water forms, with cement, the binding material uniting sand and stone. This function consists in (*a*) dissolving the pulverised cement, with (*b*) formation of acids from anhydrides; and (*c*) bringing these new acids and the dissolved bases of cement into sufficiently intimate contact so that they may chemically react.

Second: Water operates to flux these cementing substances into multitudes of minute irregularities on the surfaces of sand grains and stone (or gravel) particles, rendering possible extensive adhesion through crystallisation and absorption as water is absorbed or evaporated.

Third: Water acts as a lubricant between harsh and irregular particles, rendering easy placement in moulds and forms.

Fourth: Water itself occupies space in the mass.

Chemical Function.

The function of water first cited is basic and essential. If there is insufficient water, obviously the reaction of the cement would not be complete; and if there is too much water, it is equally obvious, since for its strength cement depends to a certain degree upon the formation of interlacing crystals, that adequate crystallisation cannot take place, since crystallisation takes place only from saturated or supersaturated solution. Furthermore, cementing action is dependent to an extent upon the formation of colloids, or non-crystalline, amorphous, glue-like substances. These substances also depend for their strength upon the amount of water combined with them. Undue dilution of these colloids cannot take place without impairment of strength, just as glue (a true colloid) may be a valuable adhesive when of proper consistency, while the same glue, if too dilute (or if too concentrated) may be useless.

What quantity of water is required to properly react with a given quantity of cement is not precisely known. Furthermore, if for no reason other than variance in composition of different brands, hard and fast rules would be impossible. Much can be learned, however, as to the influence of water from observation of its effects when mixed with cement in maximum and minimum quantities.

What a Specimen Shows.

If cement alone is mixed with excess water and allowed to set, a number of very interesting things become evident with passage of time. In *Fig.* 4 is a sectioned block of cement, cast somewhat over a year ago in a beaker. Since that time and until recently split open, this block of cement has remained exposed to room temperature and atmosphere with corresponding evaporation and drying.

It will be at once noticed that this block is stratified, lighter portions being at the top and heavier portions at the bottom. Inasmuch as cement particles vary in size, the heavier ones naturally gravitate to the bottom, particularly when there is excess fluid to act as lubricant, thus repeating in miniature the segregation in concrete. And at the top is a heavy deposit of fine white material, which investigation reveals to be largely hydrated lime, and which resembles the substance of which day's-work planes are composed.

Other Things Shown.

But there are additional features in this section which compel attention. First, there is a deep crack extending from outside to the junction of laitance and solid portion at the centre, where unhydrated cement particles begin to show. The appearance and position of this crack indicate a warping of the top surface as the piece dried out, with separation from other portions. If this block were subjected to water pressure, leakage and solution, *with removal of any soluble portions of the block,* would take place along this junction plane. The same action takes place along laitance seams in concrete; and inasmuch as cement is *always soluble, even with lapse of years,* both in its unhydrated and hydrated states, the source of initial surface stains and, later, of heavy incrustations is evident.

Second, it is interesting to note that in spite of the length of time this cement has been mixed with water, a very considerable portion of it still remains quite uncombined with water. Obviously excess mixing water is not an assurance of hydration, so that no merit may be claimed in this respect.

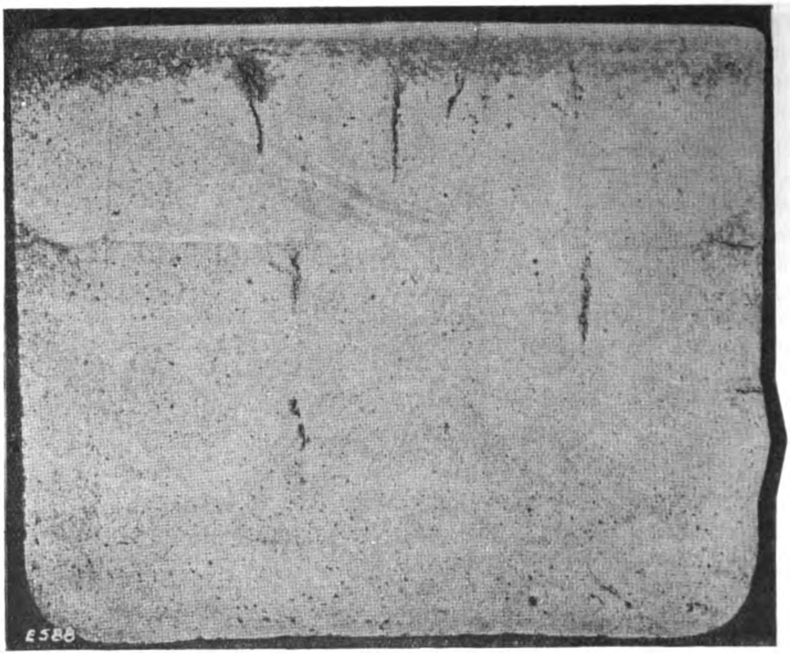

Fig. 4. Unhydrated Cement and Gradation of Particles from top to bottom are found in this Year-old Block of Neat Cement.

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WHAT EXCESS WATER DOES.

When cement is mixed to normal consistency these defects are not all in evidence. The conclusion, therefore, becomes inescapable that excess water must be responsible for segregation, laitance and cracking. In wet concrete and mortar these actions are repeated to an exaggerated extent by reason of the large excess of water commonly employed; and segregation is further aggravated by the relative massiveness of stone particles as compared with the sand and cement particles.

And so like the checking, warping and peeling of commercial surface coats is the behaviour of the upper layers of this block, that the thought occurs with the force of a blow *that in excess water may lie the solution of the baffling stucco problem, of the dusting floor problem, and of the problem of bonding new concrete to old.* With respect to this last, how puerile appears the dainty surface picking of massive deposits of concrete usually required, when the usual depth of laitance is taken into consideration.

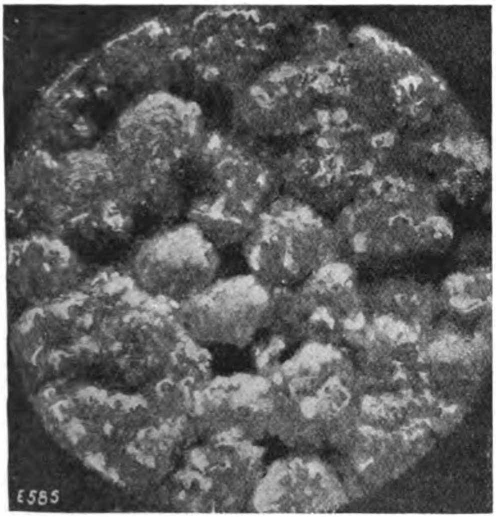

Fig. 5. Cement Particles fluxed over Surface of Sand Grain.

FLUXING AND LUBRICATING FUNCTIONS.

The second function of water—that of fluxing the cementing substance over the surface of sand, cement and stone or gravel particles—is closely related to the foregoing. Cement adheres to these substances by myriad contacts (see *Fig.* 5). If the solution is too dilute, or if these minute roughnesses are already full of water, the adhering substance can form but a meagre attachment at a relatively small number of points, with proportionate weakness.

Nor is this an imaginary condition. In detailed examinations of concrete it is found that probably not over one-third of the surface of stone particles and possibly the same relative proportion of the surface of sand particles is in contact with cement, the balance of the surface having been protected at the time of setting by an envelope of water not carrying dissolved cementing substances, or an essentially similar envelope of cementing substances in so dilute a solution that they were unable to adequately crystallise. And like relations between dilution and strength affect the amorphous constituents. The quantity of these is directly dependent upon the concentration of cementing solutions. Quantity of water and strength of concrete are therefore closely related.

The foregoing actions are also closely connected with the third function of water—that of acting as a lubricant between particles. Water is a mobile substance and has high surface tension, so that in confined space, as between sand particles in considerable mass, it may act most effectively in this regard. The advantage to be gained, however, *is not commensurate with the quantity of water.* When the water content is increased beyond a certain point, segregation of coarser from finer materials invariably takes place, so that what is gained by fluidity in one portion is lost by harshness in the other portions, with always very great detriment to the quality of the concrete.

WATER A SPACE FILLER.

All of the foregoing is intimately concerned with the fourth function of water—that of occupying space. There is no substance more incompressible than water when it is confined. Recognition is given to this fact in hydraulic presses. Forms for concrete are essentially confined spaces, care being generally exercised to see that they are made and kept tight. It follows, therefore, that each drop of water in concrete, whether combined or uncombined with cement, occupies a definite, unchangeable amount of space in the mass at the time the form is filled. It further follows, since it is impossible to conceive of this space-occupying water as otherwise than distributed throughout the mass, that dispersion of sand particles and stone particles, with proportionate lowering of mass density, must occur. And since the foregoing is true, it is evident that if any part of this water is uncombined, all evaporation or drainage subsequent to setting will leave in the rigid mass hollows of a size equivalent to the spaces occupied by the water; and since this water was evenly distributed, such evaporation or drainage must result in an essentially porous mass. Attention is called to the water voids in a first-grade commercial concrete shown in *Fig.* 6.

We are so accustomed to thinking of concrete as a solid that it is somewhat difficult to realise that it is actually porous, 17 to 40 per cent. being air and water voids. It is true that these voids may not constitute continuous passage ways, but when this simple statement of void percentages is translated into dollars and cents and it is pointed out that for every $100,000 worth of concrete, from $17,000 to $40,000 is paid for *holes*, which not only have no value of themselves, but constitute a serious menace to the integrity and usefulness of any structure, the matter is brought more closely home. Nor is this an exaggerated statement. On the contrary,

Fig. 6. Even a First-Grade Commercial Concrete shows Water Voids (four diameters).
Water the Chief Factor in the Making of Good Concrete.

initial loss is but a small fraction of the ultimate loss. "Penny wise and pound foolish" would be a fitting epitaph for many a lamented construction.

Yet to-day, in the majority of concrete structures, these or like defects exist; and the most deplorable part is that at the present time there is little general inclination to better these conditions. But if concrete is to retain its prestige a standard procedure for concrete work based on real knowledge must be evolved by those skilled in the art, adopted by engineering and architectural bodies vested with authority, and recognised and insisted upon universally.

A Suggested Remedy.

The unsightliness of day's-work planes and their potential danger may, it is true, be recognised to such an extent as to cause provisions in specifications "that if the engineer deems it advisable he may require picking or roughing of the top portion of the work last poured before pouring the next concrete, in order that they may thoroughly bond." How often does the engineer deem it advisable? Such provisions might as well be omitted so far as their adequacy is concerned.

It is virtually impossible to effect adequate removal of laitance after the mass is set. This is especially true in reinforced work, where there is a network of steel. In many such cases adequate removal of laitance would have to be done by knitting-needles. The only solution of the problem seems to be either prevention of formation of laitance, through improved methods of making concrete, *or else, after a form is filled, the removal of top boards to a point sufficiently low to allow the accumulated fine materials and fluids to flow off until coarse aggregate shows in the deposited mass, the drained materials being wasted.*

This remedy is radical. It will doubtless be subject to ridicule by the unthinking, but if the menace of day's-work planes is to be avoided there seems at present no way other than this. Certainly the cost is insignificant as compared to the integrity of a structure, and no more than the cost of an equal insurance against loss. When procedures are better perfected different conditions will obtain, but in the present undeveloped state of the art some adequate assurance is an imperative necessity.

But even granting adequate appreciation of these matters, procedures are exceedingly inconsistent. The menace of day's-work planes of laitance may be recognised by provisions in building codes that "all concrete columns should be poured continuously to the top of the form." Yet it is quite common to permit the pouring of over-wet concretes in such columns, filling them to the top, without considering of what material the column head must be constituted.

Consider wet concrete flowing into a 20-ft. column form 2 ft. square. The first rush of material will be almost liquid. The heavier materials will follow in regular order. Necessarily, the heavier stones will go to the bottom, passing through a mass of liquid that will wash off the greater portion of any cement with which the stone might have been covered in the mixing process. Other materials will build themselves up as nearly as possible in the ratios of their sizes and gravities throughout the entire column length, with always a mass of uncemented sand and stone at the bottom, where the greatest stress is to be endured; and at the extreme top a layer of laitance of exaggerated depth due to the high ratio of length to sectional area. (See *Fig.* 7.)

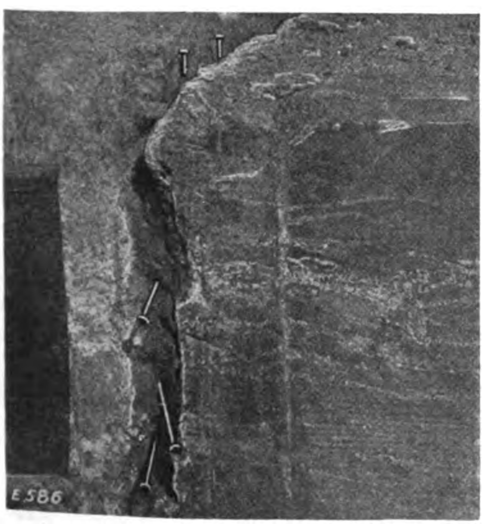

Fig. 7. Spikes Driven into Laitance at Top of Column.
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If this laitance become water-soaked, slippage or settlement to a greater or less degree is to be expected. Doubtless the behaviour of columns in concrete buildings will be cited in refutation of these statements, but it should be borne in mind that such columns are dried out soon after they are put in place, and that the stresses which they are called upon to bear are initially low. If these columns were subject to saturation or to high stress proportionate to their bulk, the result would be far different, as is evident in many a structure in distress.

SUGGESTED SPECIFICATIONS.

Advocating concretes drier than present custom sanctions should not be construed as holding any brief for very dry concretes, laboriously tamped in place. One is almost as bad as the other. Yet drier concretes should be used, and to bring about their use it is necessary to so crystallise the growing sentiment against the use of excess water as to make sure the observance of necessary precautions, and to incorporate in specifications such clauses as will as nearly as possible ensure the result desired.

Along these lines, the following specifications are suggested :—

1. Concrete shall consist of sand, stone (or gravel), cement *and water* in such quantities as shall be designated by the engineer.

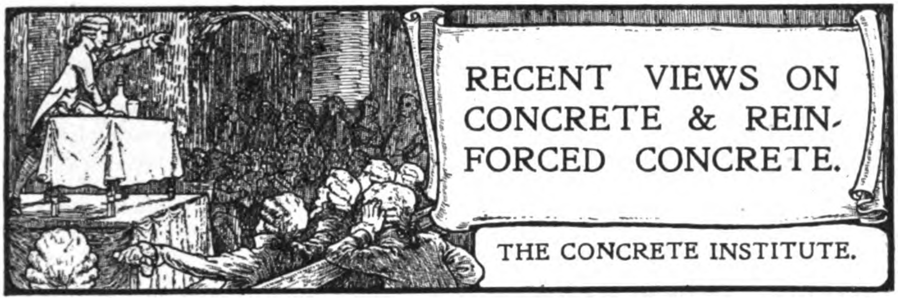
2. The proportions and quantities of all materials, *including water,* shall be as directed by the engineer, and shall be subjected at all times to such change as his tests or judgment may dictate as advisable.

3. *All* materials shall be accurately measured in measures of approved type and known capacity.

> Cement shall be measured by the standard sack or, if in bulk, by weight, 94·5 lb. being taken as an equivalent of one sack. Loose measurement of cement is prohibited.
>
> Sand and stone shall be measured in struck measures of a capacity and type approved by the engineer. Measurement in wheelbarrows of a type which do not admit of a struck measurement will not be permitted.
>
> *Water shall be measured at each mixer in containers adapted to ready adjustment and to accurate delivery of variable quantities. Supplementing the delivery of such measuring containers by additions of water, because of slowness of discharge or for any other reason, will not be permitted.*

4. *Concrete of a plastic consistency is required in all parts of the work, unless special permission be given by the engineer for the use of drier and stiffer mixtures. Sloppy and over-wet concretes are strictly prohibited. The quantity of water, therefore, will be subject to regulation at all times by the engineer according to the requirements of the aggregates in use at that time The rejection and removal of over-wet concretes either before or after placing in forms may at the engineer's discretion be required of the contractor without compensation.*

5. *After any form or lift of forms has been filled, spaded and allowed an interval of settling not greater than one-half hour, and while the concrete yet remains in semi-fluid condition, the top portion of the forms shall be removed throughout the entire length of the section to such depth as may be required by the engineer and the materials shall be allowed to flow out of the forms and be wasted. This wasting shall be carried to such a depth as will expose coarse aggregate in the mass. Concrete shall not again be deposited on the remaining concrete until the next lift of forms is ready to be filled.*



It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.—ED.

THE CONCRETE INSTITUTE.

THE RATIONAL DESIGN OF REINFORCED CONCRETE WHARVES AND JETTIES, WITH PARTICULAR REFERENCE TO THOSE FOR WET DOCKS THAT HAVE A PERMANENT WATER LEVEL.

By W. CLEAVER, M.Inst.C.E.

The following is an abstract from a Paper read before the Concrete Institute on March 22nd. A short résumé of the discussion is also given.

In my opinion the great fault usually found with designers of wharves, jetties, etc., is that they do not take a broad enough view of the matter at the commencement, and thereby omit to take into account the combination of circumstances which, to a more or less extent, affect the design. For instance :—

(1) Vertical loads on the wharf, *i.e.*, point loads or distributed loads, as the case may be.
(2) Amount of impact stresses from ships when berthed against the face.
(3) Pressure of filling at the back of the wharf, or thrust of natural ground according to circumstances.
Nature of strata for pile driving, etc., and particularly
(4) The question of moorings; and
(5) The general effect of the dredging on the design of the structure;

and the item mostly overlooked is the question of

(6) The method of dredging and its relationship to the general design of the work.

If some of the points mentioned, or similar ones, are overlooked in the case of well-established and understood methods of construction, such as timber wharves, etc., how much more easily are they lost sight of when the work is constructed of reinforced concrete, and when the designer may have very little knowledge of the many and varied conditions to be met with in the actual construction and use of such wharves, etc., such knowledge being absolutely essential, especially in work of this class.

DREDGING.

One can almost take it as a foregone conclusion that in most docks where jetties or wharves are required the first thing to be faced is to dredge out the berth.

Except in but very few instances, the work must be carried out with a bucket dredger, of the hopper type or barge-loading variety, and the engineer's first trouble is due to the method of disposition and manipulation of the dredger with reference to the section desired.

The dredging contractors, if the work is done by contract (and often the dredging master, when the work is done departmentally), will invariably attempt to carry out the work with the dredger placed parallel with, *i.e.*, broadside to the proposed face of wharf, and admittedly this is the easiest way as regards moorings, etc., and particularly as regards the placing of barges when a barge-loading dredger is used. It is, however, the very worst position with reference to the carrying out of the dredging to the best subsequent advantage, and in accordance with what the final section should be if properly designed.

If the dredger sways to right or left, as the case may be, when placed broadside, the buckets cut out of line immediately, with possibly serious results, but when placed at right angles any similar swaying causes simply a radiating cut, which is always well within the line of cut fixed.

If the dredging is carried out in benches as the result of the broadside method, it also causes the contractor for the wharf a great deal of worry and expense, owing to the difficulty of pitching the piles if the centre of same happened to coincide with the edge of the cut, which causes the pile point to kick out, and as a result it is almost an impossibility to pitch the pile correctly.

When the dredging is done properly the filling is normal in quantity and safe.

PILES.

I unhesitatingly advise that for modern requirements concrete piles having a section less than 14 in. square or equivalent area should never be used if over, say, 30 ft. long.

The extra cost of 14-in. piles is more than compensated for by the extra convenience in handling.

The point is that 14 in. square is a far more satisfactory standard section to adopt for reinforced concrete piles than 12 in. square, as the general design of the structure should be based to a great extent on the section of pile decided on in the first place.

As to whether the piles are square, round, or octagon, etc., is quite immaterial, but only that the gross sectional area shall be about 196 sq. in. in preference to 144 sq. in.

Regarding the design of reinforcement for piles, the author has no particular predilection on the matter. The designs now on the market have their own particular advantages and disadvantages; for instance, if I had any preference at all, I would, from a theoretical standpoint, vote in favour of round piles, with a fair number of bars of comparatively small section, in preference to square piles with, say, four bars of large section. On the other hand, square piles are so much easier to make and inspect that, considering how slight is the disadvantage in theory, I would prefer the square ones in practice.

PILE SHOES.

This is another very debatable point with some people—for instance, as to whether the shoe should be of uniform taper or varied, also whether sharp-pointed or blunt-nosed, whether the vertical reinforcement should rest on the shoe or not, etc., etc.—but I have always adopted one design of shoe for all circumstances, with very satisfactory results, as per the following particulars:—

> "The shoe to be of uniform taper, the faces being at an angle of about 16 degrees to the centre-line of the pile, with nose slightly blunted. The length of the cast-iron portion to be about half the total length of the taper, the area at top of the cast-iron point being about 40 per cent. of the sectional area of the pile in the case of the 14-in. square piles. The vertical rods to rest on the cast-iron point and to be kept in place by the recess. The straight portions of the wrought-iron arms always to be embedded in the concrete of the pile and not kept flush or project from the body."

HELMET.

The author is of opinion that a helmet should in every instance be used when driving reinforced concrete piles, irrespective of whether the piles can stand the driving without same or not. A concrete pile should never be needlessly punished in the preliminary driving, as it is time enough for hard driving when the pile is almost home.

When the pile is pitched and constitutes an excessively long column with reference to its section the helmet serves the purpose of taking up the bulk of the abnormal vibration, etc., due to this, and which would otherwise tend to damage the pile before it had been driven far enough to attain the requisite rigidity.

METHOD OF DRIVING PLANT, ETC.

Except in the open sea, etc., where any other method is almost impracticable, I have always strictly objected to driving piles off a floating barge which is secured only by means of rope moorings. On the other hand, it is manifest that a timber-piled temporary staging adds very greatly to the cost of the work, both in material and time.

The practice of driving the back row of piles first of all off the shore and then using same as a support for a stage to drive the next row, and so on, has many objections, not the least of which is the probability of damaging the piles, due to the inevitably long cantilever of the temporary stage or framing.

As regards the class of pile-driver to be used, an ordinary drop monkey, weighing at least two tons, with a short drop of about 5 ft., manipulated by means of the usual hand nippers, is the most efficient.

The only reasonable objection to this is the fact that the operation is a slow one, owing to the human element, *i.e.*, the difficulty of obtaining a combination of plant and men of the class that will produce the requisite number of blows per minute. Hence the endless-chain design of pile-driver is by far the best on the market, as it does away with the tediousness of the hand nippers, and yet provides a monkey with a clear drop.

DESIGN OF WHARF.

The present paper deals primarily with wharves for wet docks with a permanent water level, and for which bracings under water would present almost insuperable difficulties. One has, therefore, to depend almost entirely on the unsupported piles below water-line; and after trying various designs, the author has come to the conclusion that single-pile structures, that is, designs consisting of single independent pile supports throughout, are not very satisfactory.

It must be realised that modern ships in midship section are almost square in profile, and when berthed are liable to come in contact with any portion of the wharf-face, from water-line to almost dock bottom.

If, therefore, it was possible to introduce effective bracing a short distance below the water-line, what would be the use of same, as it would only be of service in resisting any swaying tendency in the wharf, which tendency should be almost non-existent if the structure is properly anchored by means of back piles or counterfort wall?

The net sectional area of the piles below the bracing to resist shear due to impact of the vessels (*i.e.*, the most important stress to be provided for) would still be the same.

Of course, piles of extra large section could be used, and would no doubt be effective, but the inertia of such piles, when made of concrete, increases to such an extent as compared with piles of normal section that the difficulties of driving same are by no means easily overcome.

For these reasons the author has reverted to the old original method of driving piles of normal section singly or in groups of two or more, according to circumstances, loading, etc., and then encase these with reinforced concrete cylinders and mass concrete hearting. The resulting column imposes such a large sectional area throughout its depth against shear that no fear need be entertained as to its capabilities to resist the impact even of the largest vessels.

These columns, coupled with suitably designed beams, also enable the spans at the front of the wharf to be made longer than would be the case if single piles were used.

The extra dead weight also adds materially to the rigidity of the wharf, a very important acquisition when the depth is 30 ft. or over, and in addition the designer is able to arrange the fixing of the various mooring-rings, bollards, etc., in a much more efficient manner by attaching them at or near the cylinder columns.

SURFACE OF DECKING, PERMANENT WAY, ETC.

For heavy structures subject to overturning moments, etc., such as cranes or gantries, and which have to be clipped to their permanent supports to prevent this, by far the best type of permanent way is, of course, the longitudinal timber method, with the timbers well secured into the beams of the wharf and the flange rails clipped (not spiked) to the timbers.

FENDERS.

I have always adopted and believed in the utility and economy of protecting all working faces of concrete wharves and such-like structures with timber fendering, owing to the inevitability of same being damaged by abrasion, etc., and requiring renewal, and it is far easier to renew timber under such circumstances than concrete. For the same reason I always adopt timber piles, and also longitudinal caps, on the principle first of all (as regards using piles) that no timber fendering should ever be secured to the concrete below water-line, all fastenings being built into the superstructure only.

BACK OF WHARVES.

If the strata on the site consists of good ground and the surface is above or near water-level, then I prefer to design the back of the wharf as a counterfort retaining wall. In the first place, it is a cheaper mode of construction than piles, and owing to the extra superficial area offers more resistance to impact and lateral movement of the wharf than when same is wholly supported on piles. The condition of the site must however, of necessity govern the choice between wall and piles.

WORK ADJACENT TO WHARF.

The design for a wharf of the character under discussion should always include any supports for adjacent structures, as this adds not only to the general stability of the wharf, but is also cheaper and more satisfactory than building a separate brick wall or piers at the back of the wharf.

WHARF DETAILS, ETC.

Without desiring to enter into any controversy regarding the claims of various specialists, or as to the wisdom or otherwise of employing specialists, etc., the author has been requested to give his opinion on the matter.

First and foremost, I believe in employing specialists if the work is of a reasonably extensive character on precisely the same principle as a general practitioner in medicine calls in a Harley Street specialist or a solicitor when he briefs a K.C. It stands to reason that, however competent an engineer may be as regards general experience, he cannot as an individual hope to cope with a staff of experts such as the better class of specialists employ in the working out of the general details of the reinforced concrete portions pure and simple.

As to the general design of the wharves, etc., unquestionably the whole thing should be completed by the engineer responsible for same, and the reinforced concrete specialists need not be consulted on the matter at all, but after the general design has been completed and the various loads, etc., decided on, who should be the most competent to decide on the net amount of reinforcement necessary, the best sizes and proportion of beams for those loads, etc., than specialists who are in the thick of that sort of work every day?

On the other hand, an engineer or an architect, as the case may be, should always have a sufficient knowledge of the principles of reinforced concrete calculations to be competent to make preliminary calculations and provisionally design the sizes as well as the distribution of the beams, etc., in his general design before same is submitted to the specialist. The latter can then bring his mature experience into play, and advise where and how, if any, the sizes, etc., of the various members could with advantage be modified so that the ultimate design will be absolutely up-to-date in every respect.

To a great extent there is not very much to choose between the various designs of the few trustworthy systems now in vogue, it, more often than not, being a case of which of the specialists exercises the best taste in the application of his system to the particular work in question.

One point I would like to emphasise, and that is, that whatever system is adopted I do certainly believe in the principle that all reinforcement should be as self-contained or self-supporting as possible before any concreting is done, and all important intersections wire-bound, etc., so as to avoid any risk of the various rods, shear members, or other wiring being deranged or displaced during the operation of placing the concrete, punning, etc.; in fact, I now insist on all loose members of beams, columns, etc., being individually bound with small-gauge wire to the main rods.

In order to ensure satisfactory work, and so that reinforced concrete shall hold its own with any other method of construction, all concerned must be educated to appreciate and realise the fact that all parts and material must be made as fool-proof as practicable.

PRELIMINARY PLANT AND ORGANISATION.

The great mistake usually made is to starve the job in hand at the commencement coupled with the failure to appreciate the fact that although it is admitted that the bulk of the work can be carried out by unskilled labour, the necessary small amount of skilled labour and supervision is absolutely vital, and must be efficient if the ultimate result is to be satisfactory to all concerned.

For instance, jigs and templates for bending rods and wires must be well thought out and well made.

Mechanical concrete mixers should be always used in preference to hand mixing.

DAMAGES AND ACCIDENTS.

An objection often raised to reinforced concrete is the difficulty of repairing the structure after damage by collision, etc., but so far as the author's experience extends, this idea is a fallacious one. In the first place, the damage from collision and kindred causes is generally of a much less serious character than would be the case with timber and similar construction, and the repairs are usually easier to carry out in concrete than would be the case when stripping and renewal of timber or steel work had to be carried out.

Reinforced concrete work, such as in a wharf, is so monolithic in character (in actual fact, not in theory) that any blow due to a collision is immediately transmitted over such a wide area that a good deal of the effect of it is dissipated, and the actual damage or disruption is, as a result of this, extremely localised.

The very high inertia of a reinforced concrete wharf as compared, say, with a timber one of like dimensions contributes very greatly to this result, owing to the fact (which, by the way, is generally overlooked) that the ratio between a reinforced concrete wharf and the cause of the collision (say a ship), weight for weight, is very much more in favour of the concrete wharf than would be the case if the construction were in timber or steel.

As regards the repairs after a collision, in most of the instances I have had experience of the ship or other delinquent came off second best, and very much so, and no repairs were found necessary in the case of the concrete.

DESIGN OF BEAMS, ETC.

This question of inertia brings me back to the original theme of the paper, *i.e.*, "Rational Design," and perhaps will serve to demonstrate where I sometimes differ with the specialists.

To revert to my previous statement regarding the wisdom of employing specialists, there is no doubt that under similar conditions, where, for instance, amount of head-room or similar provision is of paramount importance, or some kindred important restrictions are in force, the specialist, with his varied experience, is naturally best able to judge when to design and use double reinforced beams in preference to single ones, etc., but in the case of wharves of the kind we are at present discussing, where headroom, *i.e.*, depth of beams, is of no consequence, the same argument is applicable as in the case of the cylinders, *i.e.*, that weight is the great thing to provide, within reasonable limits, of course.

I believe, therefore, in the wisdom of designing beams with single reinforcement in every possible instance as being by far the simplest to construct, cheapest as regards quantity of steel required, and also as providing the greatest amount of concrete within economical ratios, and thereby providing as much dead weight as possible without unduly or extravagantly decreasing the ratio between dead and live loads, or spoiling the general æsthetic proportions of the structure.

SIZES OF STEEL.

Another point regarding calculations and their effect upon standardisation may be touched on. The preliminary calculations should be made to as fine a point as possible, but where I disagree is in their application when getting out the working drawings. For bars of small section below ½ in. diameter, no doubt it is necessary to specify them in $\frac{1}{16}$ths, but above ½ in. diameter I do not think it even economical in the long run to work to less divisions than ⅛ths.

If the bars are graded in ⅛ths, a man has to be grossly careless to make a mistake in measurement when selecting bars from a stock of that kind.

COVER OF CONCRETE.

In the past specialists have made a great mistake in designing beams with too little cover on the steel.

I am continually asked by those who are not in favour of reinforced concrete if I do not experience the trouble of the concrete peeling off the bars, due to the rust on same causing internal expansion and bursting the concrete.

In reply, I am bound to admit that I have experienced this to some extent. In every instance, however, where I have found this it has been due either to defective workmanship or (as above stated) to what, from a commonsense practical standpoint, I consider too little cover provided in the original design, in proportion to the size of bar used.

If reasonable care is exercised to see that under no circumstance is there ever less cover of concrete at any place, top, bottom, or sides, than 1½ times the diameter of the respective bars usually adopted in beams (when above a minimum size of, say, ¾ in. diameter), I do not think the trouble of peeling or scaling of the concrete off the bars would ever be experienced, assuming, of course, that the concrete is of the proper quality.

Designers often serenely overlook the fact that the steel reinforcement when put together does not always lie in the strict plane they designed for it.

Under the best supervision and workmanship, the steel sags or buckles to some extent, and fairly generous allowance in the concrete covering, factor of safety, and various other items, has to be made to compensate for these sundry unavoidable practical discrepancies.

In many respects I believe, therefore, in designing the work so that as many of the members as practicable can in the same way as the piles be manufactured individually and separately on the floor, then allowed to properly set, and afterwards built into the work as separate units, until subsequently the various junctions and intersections are completed, when the final work will be just as monolithic as if the job had entirely been concreted *in situ*, with the additional advantages enumerated above.

There are, admittedly, occasions when the entire work can be much better done *in situ*, but what I wish to convey is, that in designing any job the question as to whether or not the various parts can be made separate should be borne in mind, or an attempt made to design the work with that end in view, as being the preferable method.

A very important point also is to standardise the size of beams in each job as far as possible and to provide for the variation in stresses entirely by varying the sectional area of steel in each beam within practicable and reasonable limits, of course.

At the risk of being termed prejudiced, I believe in designing all work of the class under discussion with the proviso that mild steel bars only shall be used. Wharves and jetties are subject always to considerable shock, and high carbon steels are naturally much more brittle than mild steel, and subject to crystallisation through alternating stresses much sooner.

DETAILS OF FASTENINGS, ETC.

To revert to general design and to details of fastenings for bollards, etc., I believe in avoiding, wherever it is possible to do so, any Lewis bolts, or such fastenings which have to be permanently fixed into the work. All bolts, etc., should be so designed and fixed as to be quite getatable, and so as to be easily changed if broken or deteriorated to such an extent as to require renewal.

TRIAL PILES, ETC.

When designing wharves for sites where the constitution of the strata is unknown or uncertain, the driving of two or four trial piles is always to be recommended, according to the size of the job, before any material for the piles is even ordered. This usually saves a great deal of trouble and anxiety in having to cut and lengthen the piles, etc., a rather unsatisfactory undertaking at the best of times. Whether the trial piles be of timber or concrete is not of material moment.

FIRE-RESISTING QUALITIES.

I could no doubt go into many other questions *re* various aggregates for reinforced concrete, handling of cement, etc., but these do not strictly come under the head of design, and these points have no doubt in any case been well thrashed out in this Institute already. It may be well to mention one thing, however, which is to say that my primary reason for having taken up reinforced concrete in the first place was its undoubted "fireproof" quality. It may at first be wondered at why this should be considered so important in the case of wharves, etc., in docks with so much water available, and when the structure is absolutely built in the water. I would, however, point out that oil tank steamers often use these wharves, and are always liable to drain their tanks into the dock, however strict the regulations may be, leaving a dangerous film on the surface of the water surrounding the wharf. I have known such a film catch fire with almost disastrous results. Under such circumstances the "fireproof" quality of the reinforced concrete wharves is not only highly important as regards the actual wharf itself as compared with, say, a timber one, but may also be the means of saving valuable material in adjacent warehouses, etc. In fact, one never knows the immense advantages that may accrue from the fact that a reinforced concrete wharf would, by not catching fire itself, prevent that fire spreading.

In order that the concrete wharves shall, in addition to not being inflammable, be also free from damage by fire, I insist on the rough aggregate being composed of granite, or blue pennant chippings, as being absolutely impervious to fire, and for this same reason will never permit limestone or similar chippings to be used.

DISCUSSION.

***The President* (*Mr. Wentworth-Sheilds*)**, in opening the discussion, said they had much pleasure in welcoming Mr. Cleaver, who was well known to a great many of them. He had had a great deal of experience in the construction of dock work, and some of the largest coal hoists in the country were to be seen at Port Talbot—and very fine constructions they were. As a dock engineer he had been using reinforced concrete, often under very trying circumstances, and he had confidence in it and meant to go on with it.

Mr. Charles F. Marsh, M.Inst.C.E., referred to the lecturer as a specialist of high attainments, but with regard to the vexed question of the specialists he did not entirely agree with him, though some of his views might still further hurt the specialists' feelings. He considered that an engineer in practice who took up that work should be in a position to design his own, and certainly anyone who designed steel work should have no difficulty in doing so with reinforced concrete. There was still the idea in the minds of some people that there was some magic about reinforced concrete, but there was no difficulty about it, although it was very often referred to in the Press and elsewhere as if it had entirely altered the course of mechanics. With regard to damages through collision in docks, when the force of a blow was immediately transmitted over a large area the damage was naturally dissipated to a large extent. That was, of course, due to a wider area taking up the damage. Then the weight of the wall was to be taken into consideration, and it was true that the reinforced concrete would be much heavier than timber. Bulk for bulk it would be 3½ times as heavy, but taking all things into consideration, that would come almost to a balance. The lecturer was quite right as to the fictitious accuracy in the sizes of bars, and there was much danger in the use of small variations. He had known people who used 32nds. The importance of the covering of concrete under water was apparent; it had to be greater than in an ordinary building. He thoroughly agreed with the lecturer's remarks as to the standardisation of steel. Referring to piles, one advantage of the timber was that it could be sawn off if necessary. Mr. Cleaver's views as to the fire-resisting qualities of reinforced concrete were excellent and accurate. An eminent member of the Institute had said that granite was bad for use as "fire-proofing"; he had used it and found it very unsatisfactory, and preferred half-broken bricks.

Mr. J. S. E. De Vesian referred to the shrewd knocks made by the lecturer at the specialists, but thought it was hardly fair for them to instruct others like engineers in docks, who had the necessary experience. He agreed with the lecturer's remarks as to piles of 14 in. in thickness, and also that a helmet with a proper cushion and a timber dolly on the top was the best method to use for driving piles, but no formula was complete which did not take into consideration the weight and also the length of the pile under water. The modern steam head was the best thing to use for concrete piles, it kept them going. He rather agreed with Mr. Neal's conclusions as to fenders, but he thought they were more necessary to save the ship than the dock from damage. In the case quoted the repairs to the ship cost £2,000 as compared with £50 for the wharf. With regard to preliminary plant, experienced contractors knew the advantages of getting everything on the spot with expert men to work. Opinions varied as to the thickness of the covering to concrete, but it was of no use increasing the thickness of porous concrete, the first thing was to be sure of getting impermeable concrete.

Mr. Benedict, as one who had not had much experience in the work, said, with regard to the ratio of weight of the monkey and the weight of the pile, the longer the pile the shorter should be the fall and the heavier the weight used. The quickest blows with the heavier monkey helped in that direction. At Glasgow, where the firm of Sir John Jackson were engaged in dredging work, they went end on into the solid earth with the dredger. Standardisation was the line they should all take, for the simple reason that if it was not done they would be at the mercy of the navvy. It was impossible to supervise every man, but they got best results under strict supervision.

Mr. G. C. Workman thought the paper extremely useful, particularly with regard to the information so ably given with regard to different methods of dredging, which would be useful in schemes of that character. With regard to the pile-driving plant, of which an illustration had been shown, Mr. Cleaver did not show a portion of the plant which was necessary to complete it, *i.e.*, the crane. It was very necessary to have a moving crane—a locomotive, if possible. If proper precautions were not taken a considerable amount of time was lost in feeding the pile driver, and it was advisable to have a line of rails alongside the work, as this would save an immense amount of time. There was a question as to whether pointed pile shoe drivers went further than those which were blunt. He had discussed that with engineers constantly, and it was generally considered that very much depended on the structure. On the question of employing specialists, he thought it futile to discuss that, as it seemed to him that specialists who had made a study of the question should know what was useful and what was not. Experience in other kinds of steelwork should enable them to advise usefully, and the most eminent engineers might be of some use and service. Concerning the various sizes of steel, it was much better to employ bars in divisions of eighths, both from the economical and standardisation points of view, and he thought none would be more inclined to adopt standards than reinforced concrete engineers.

Mr. C. J. Jackaman, M.Inst.C.E., added his appreciation of the paper, which was one of the most practical and commonsense he had heard. Mr. Cleaver had had great experience, and every point he had made he (Mr. Jackaman) endorsed and emphasised. On the subject of cylinders it would be interesting to know how to keep them watertight. In some cases the joints were watertight and the water could be pumped out. The barge-driving plant was of some value, but left much to be desired.

THE LECTURER'S REPLY.

Mr. Cleaver, replying on the discussion, said in the illustration he had used Mr. Marsh had overlooked the fact that it was a permanent water level. That method would not apply to tidal waters. It was very easy to adjust the plant he had shown, either by the use of jacks or by packing. He agreed that engineers should design their work, but the point was, had they always the staff to do it properly? It was no use designing unless there was a staff to complete it. Specialists should be called in at the proper time and in the proper manner, and the work would be done so much better. In most cases it was a real service to call in a specialist to improve or check designs if an engineer had not ample time to do it himself. With regard to the effects of collisions, they had to remember that reinforced concrete was monolithic, and timber wharves had no chance like them in resisting damage. He certainly did not agree as to the granite not being so fire-resisting. In the case cited it must have been the fault of the cement. He was quite satisfied that granite was the best protection against fire; that was obvious because it was of volcanic origin. For example, no one would think of using limestone. He had no wish to dig at any specialists—they had their place. He never worried about the æsthetic appearance of his work, what he worried about was its utility.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

REINFORCED CONCRETE OVER-BRIDGES AND GALLERIES AT THE NEW ALEXANDRA DOCKS, BOMBAY. By R. P. Mears, A.M.Inst.C.E.

In order to connect the transit sheds and warehouses in the New Docks at Bombay, the Port Trust authorities decided to build a gallery of 10 ft. clear width along the front of the warehouses as is shown in *Fig.* 2, and a bridge 120 ft. in length connecting the transit sheds as is seen in *Fig.* 3 in course of construction, and to connnect this gallery and this bridge by means of a main bridge shown in *Fig.* 5. *Figs.* 2 and 3 were taken before the main connecting bridge was built.

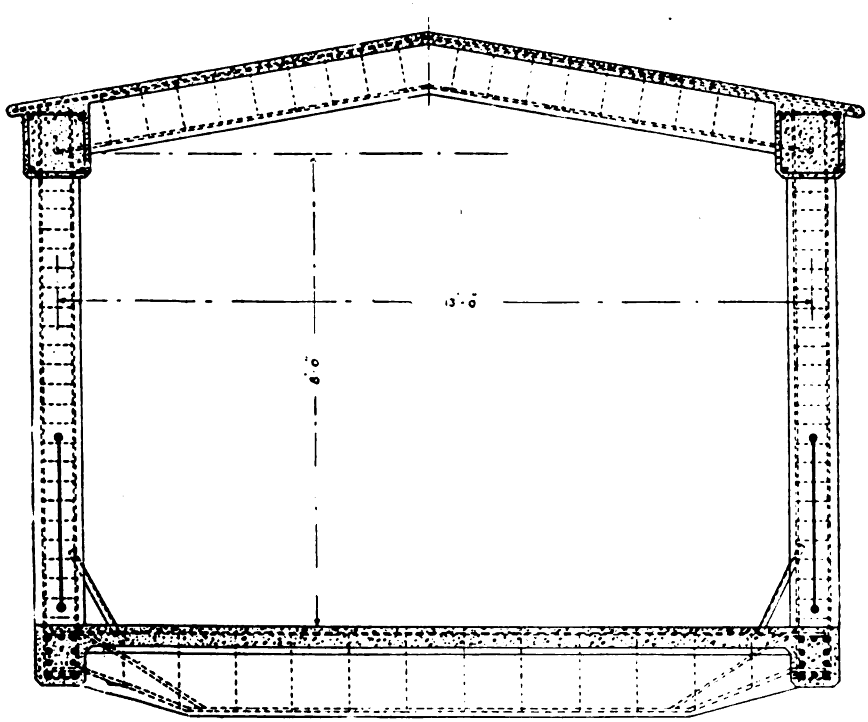


Fig. 1. Cross Section Lattice Girder.
REINFORCED CONCRETE OVER-BRIDGES AND GALLERIES AT THE NEW ALEXANDRA DOCKS, BOMBAY.

The purpose of these bridges is to permit of goods to be conveyed by hand-carts and trollies from the transit sheds to the warehouses; they have a clear width of 12 ft. and are designed to carry a load of 2 cwt. per ft. super, and are so arranged that there is little obstruction to the roadway and railroads below. The principle of the design is lattice girders supported on double cantilevers.

The ruling feature in the design of the bridges is the manner in which the several parts are entirely disconnected; the main bridge merely butting against the bridge connecting the transit sheds and the warehouse gallery at either end, there being in each instance a 1 in. clear space between, also the component parts of both the bridge between transit sheds and the main bridge are free and independent of each other, each lattice girder being supported on cast iron rocker bearings carried on the ends

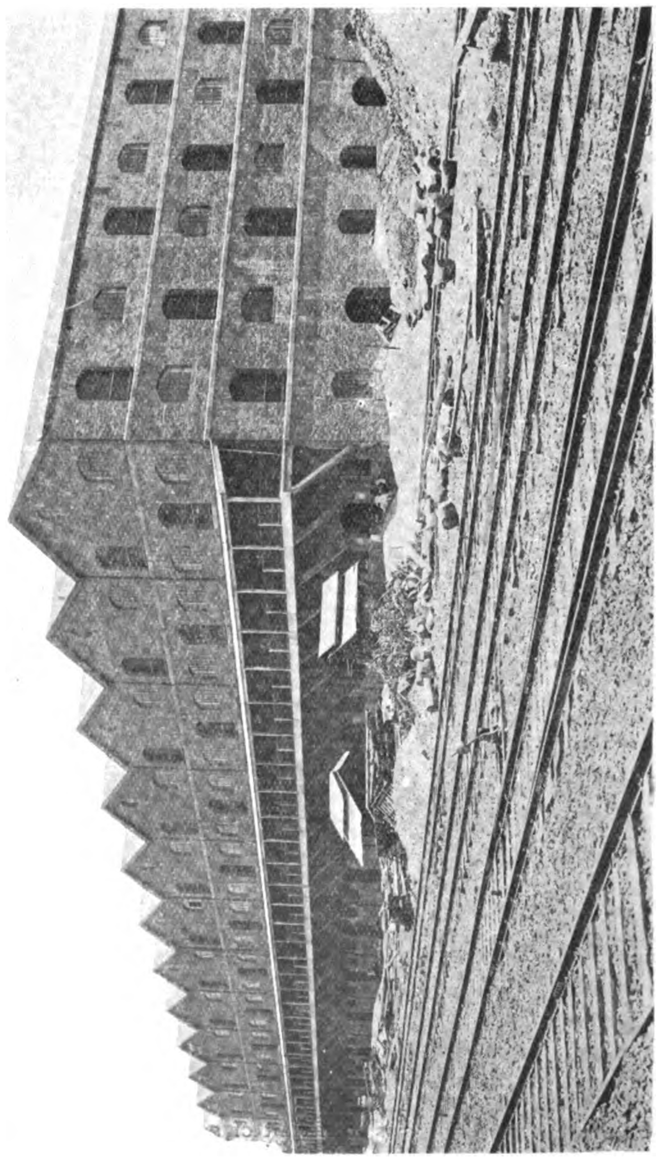


Fig. 2. View of Warehouses.
REINFORCED CONCRETE OVER-BRIDGES AND GALLERIES AT THE NEW ALEXANDRA DOCKS, BOMBAY

of the double cantilevers. This was considered expedient, as some of the foundations were piled and some carried merely on filling, consequently unequal settlement was a contingency to be reckoned with. *Fig.* 4 shows part of the main bridge in elevation, the height of the decking being about 20 ft. above rail level and the longest span lattice girder about 60 ft. *Fig.* 1 shows the lattice girders in section. *Fig.* 6 shows the end of the main bridge where it connects with the bridge between transit sheds, where it will be seen that the lattice girder is supported at the near end on the rocker bearings on the double cantilever; but at the further end, where it leads into the bridge between

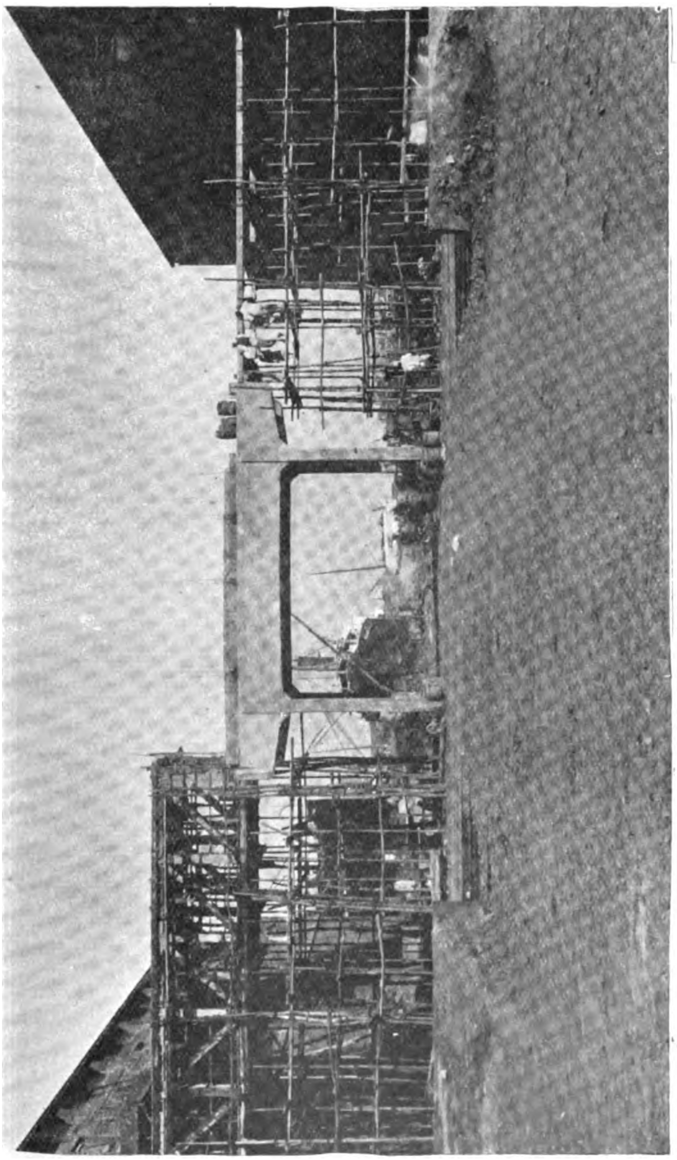


Fig. 3. Bridge connecting Transit Sheds.
REINFORCED CONCRETE OVER-BRIDGES AND GALLERIES AT THE NEW ALEXANDRA DOCKS, BOMBAY.

transit sheds, it overhangs by some 18 ft. a single column. There is a crossing over the permanent way here, and as cart traffic at times becomes exceedingly congested this arrangement was adopted as giving the least obstruction.

As already stated, the bridges are designed for 2 cwt. per ft. super, but by the

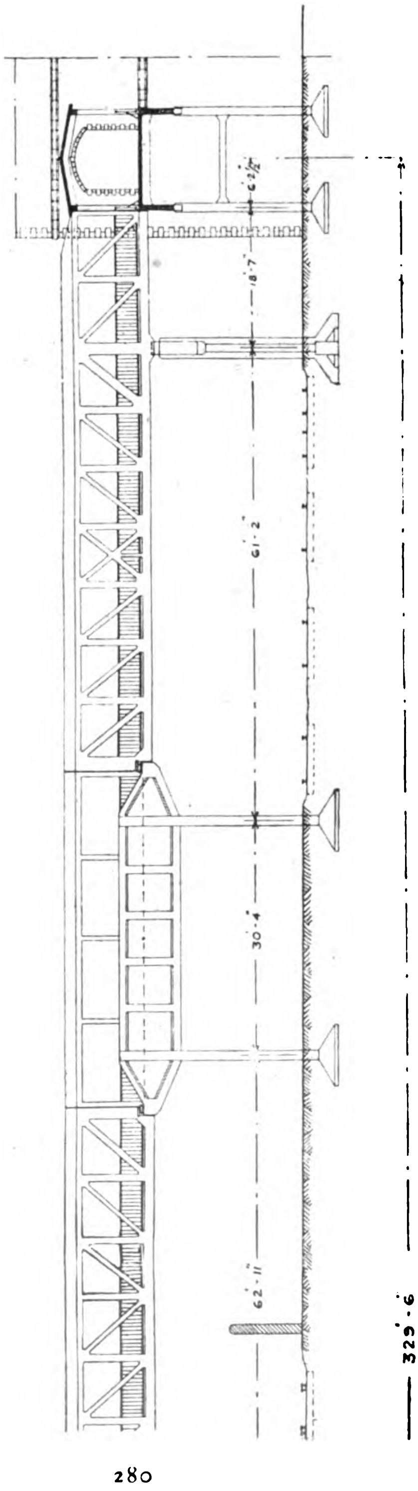


Fig. 4. Part of Main Bridge in Elevation.

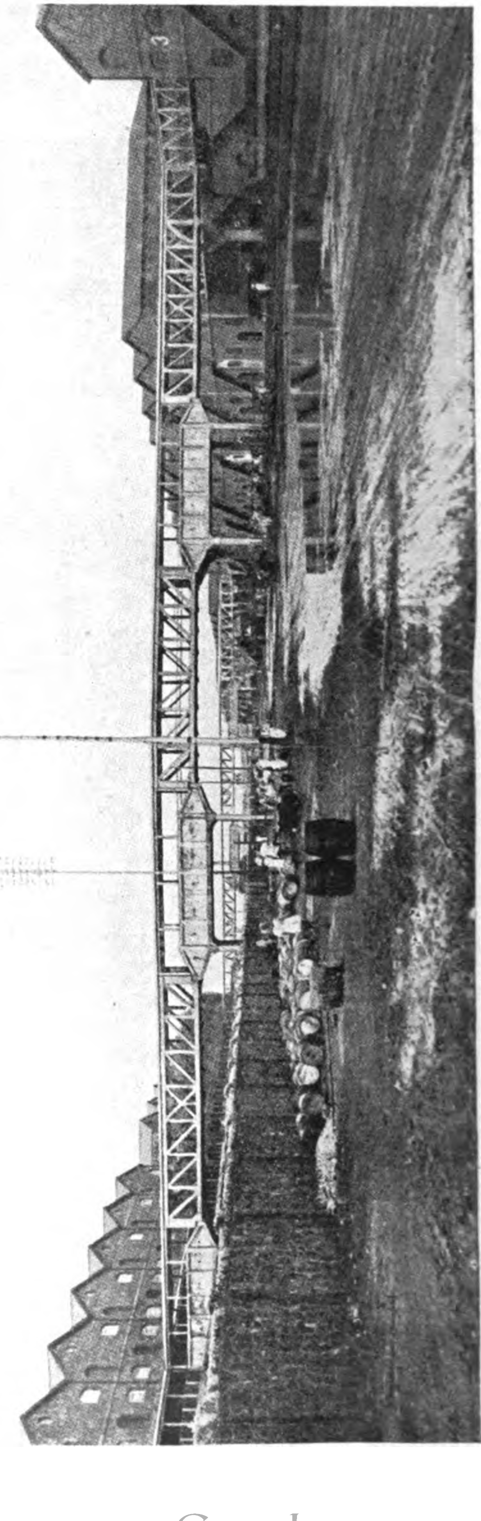


Fig. 5. View of Main Bridge.
REINFORCED CONCRETE OVER-BRIDGES AND GALLERIES AT THE NEW ALEXANDRA DOCKS, BOMBAY.

terms of the contract they were to be capable of sustaining a test load of 3 cwt. per ft. super on any parts selected for test. A portion of the gallery was tested to this overload, the maximum deflection being 1/25 in. and the permanent set nil. The centre portion of the bridge was also tested to 3 cwt. per ft. super, the girder deflection being 1/10 in. and the permanent set negligible.

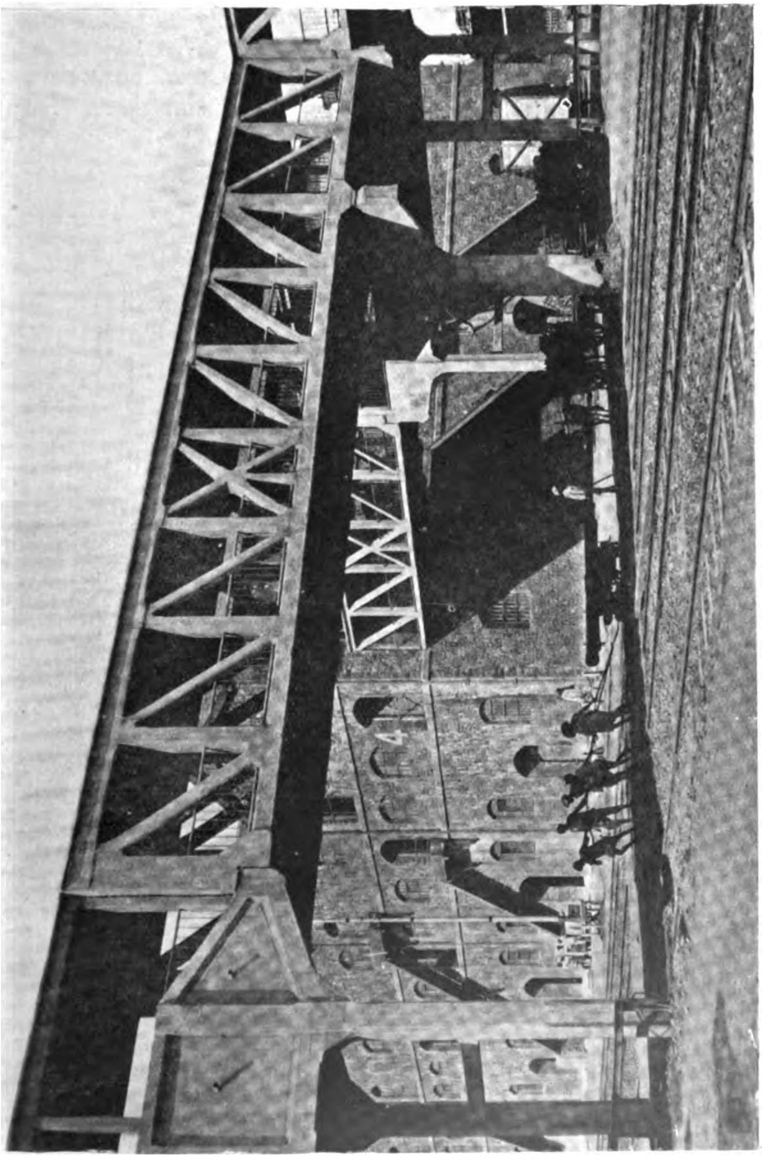


Fig. 6. End of the Main Bridge.
Reinforced Concrete Over-Bridges and Galleries at the New Alexandra Docks, Bombay.

The work was designed and erected by the contractors, Messrs. Marsland, Price and Co., Ltd., reinforced concrete engineers and contractors, of Bombay, under the direction of Mr. P. Glynn Messent, M.Inst.C.E., chief engineer, and Mr. L. H. Savile, A.M.Inst.C.E., deputy chief engineer, of the Bombay Port Trust.

INDUSTRIAL NOTES.

These pages have been reserved for the presentation of articles and notes on proprietary materials or systems of construction put forward by firms interested in their application. With the advent of methods of construction requiring considerable skill in design and supervision, many firms nowadays command the services of specialists whose views merit most careful attention. In these columns such views will often be presented in favour of different specialities. They must be read as ex parte statements—with which this journal is in no way associated, either for or against—but we would commend them to our readers as arguments by parties who are as a rule thoroughly conversant with the particular industry with which they are associated.—ED.

CONCRETE PIPE-MAKING BY CENTRIFUGAL FORCE.

CENTRIFUGAL force has recently been made use of for manufacturing cement mortar pipes on extensive drainage works at present under construction by a British company in the Argentine Republic. The machine which has been invented to give effect to the idea of using centrifugal force for compressing the material is

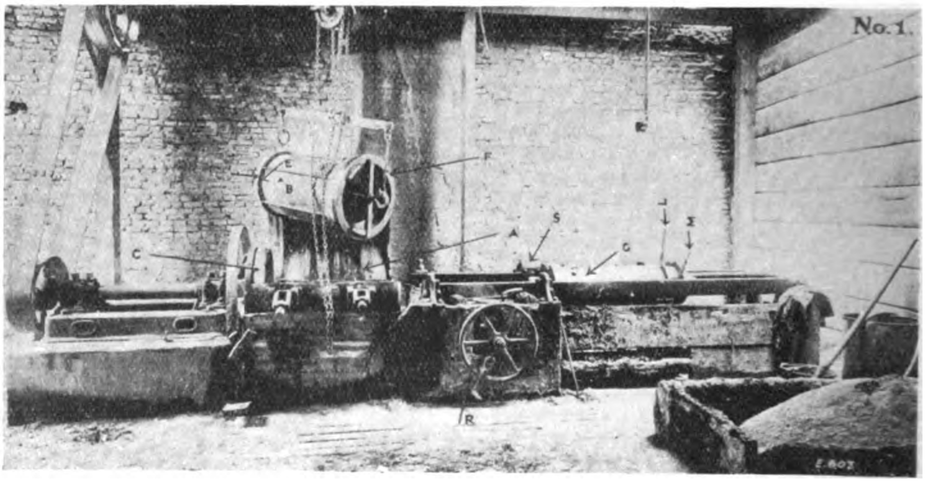


FIG. 1. FRONT VIEW OF MACHINE FOR MAKING 15-IN. INTERNAL DIA PIPES.

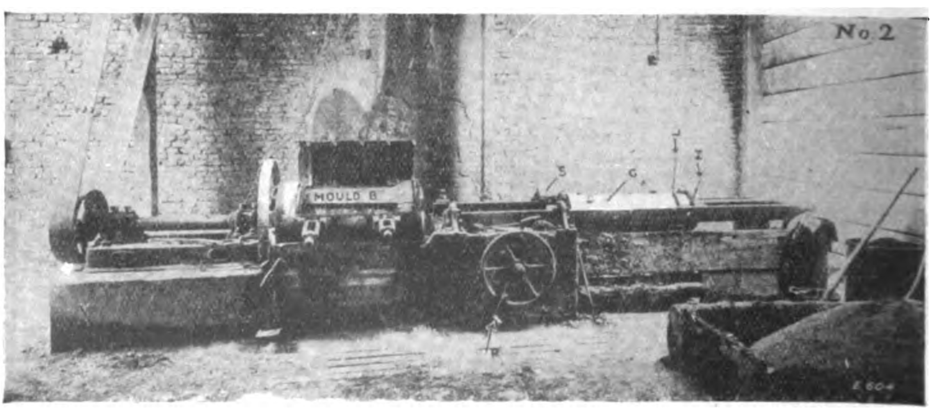


FIG. 2. SHOWING MOULD LOWERED INTO POSITION.

illustrated in the accompanying photographs. As will be seen from the illustrations, the essential feature of the machine is a drum rotating in a horizontal position about its longitudinal axis, this drum being so made that its upper half opens for the reception of a thin sheet steel mould in which the pipe is formed.

Fig. 1 is a front view of a machine for making 15-in. internal diameter spigot and socket drainage pipes, the drum (marked *A*) in this view being open for the reception of the mould (marked *B*), which is in course of being lowered into the drum. The lower half of the drum is securely bolted to the disc *C*, which in turn is keyed to the driving shaft, operated by a belt drive from an overhead pulley. The mould is made in a single piece with a longitudinal joint, which is closed and kept in position by the end rings *E* and *F*. *Fig.* 2 shows the mould lowered into position, and in *Fig.* 3 the drum with its contained mould is closed and locked and ready to run. The cement mortar of which the pipe is composed is inserted into the open end of the revolving mould by means of the long bucket marked *G*. *Fig.* 4 gives a clear view of the open end of the mould and of the

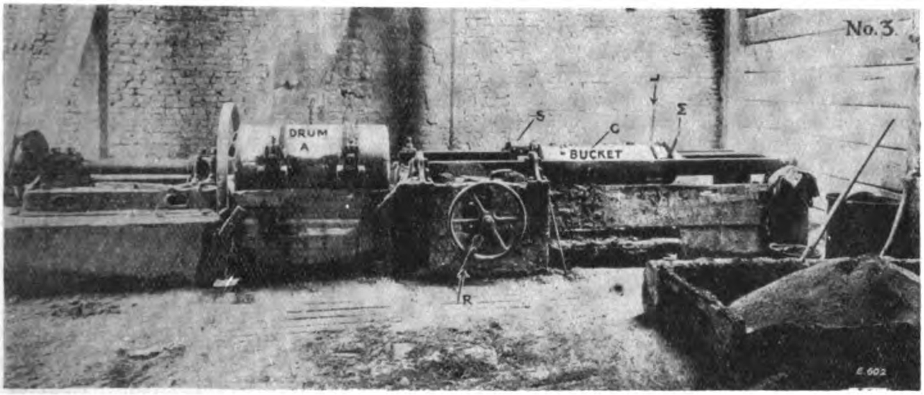


FIG. 3. DRUM WITH ITS CONTAINED MOULD CLOSED AND READY TO RUN.

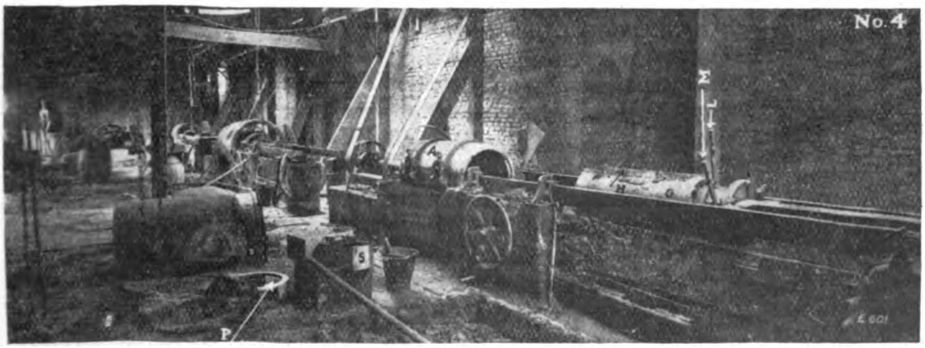


FIG. 4. SHOWING OPEN END OF MOULD AND BUCKET.

bucket, the latter of which is provided with a bottom segmental door running its whole length, and also with a scraper and straightedge, *H* (*Fig.* 4). The segmental door in the bottom is opened or closed by the lever, *L*, and the straightedge, *H*, is raised or lowered into the bucket by the lever, *M*. The straightedge is shown raised in *Fig.* 4. The socket of the pipe is first formed by throwing mortar on to the socket part of the mould and finishing to the proper thickness by means of a hand scraper. The machine is then stopped for a few seconds to insert the socket ring, *P* (lying on the ground in front of the machine), in *Fig.* 4; this ring forms the shoulder in the socket. After the socket ring, *P*, is inserted the bucket is then drawn home into the mould by turning the handwheel, *R* (*Fig.* 1), the mortar being gradually and uniformly distributed along the revolving mould by operating the lever, *L*, which opens or closes the door in the bottom of the bucket.

When a slightly greater thickness of mortar than that actually required is formed on the inner surface of the mould the scraper or straightedge, *H*, is raised by the lever, *M*, and thus removes the slight excess of material into the bucket, which is then withdrawn from the rotating mould now containing the formed pipe. The scraper or straightedge bears on the inner circumference of the end ring, *E* (*Fig.* 1), and on the inner part of the socket ring, *P* (*Fig.* 4), and thus leaves the interior surface of the pipe flush with these rings. The pipe is now virtually finished, but before removing the mould and its contained pipe from the drum a few handfuls of dry cement are thrown into the pipe (which is still revolving), and a polisher, *S*,* which can be slipped on the end of the bucket, is then passed to and fro along the interior of the revolving pipe by means of the handwheel in front of the machine. This final operation gives a good finish to the interior surface of the pipe, which is then removed in its mould to the drying yard. The mould, after a period varying from 24 to 36 hours, can be easily removed by taking off the end rings and lifting the mould vertically from the pipe; it is found that on removing the end rings the moulds practically spring away from the pipes. It is stated that after the mortar has been in the revolving mould for only a few minutes it shows no signs of collapsing into the bottom of the mould, nor even in the somewhat rough handling which the mould and contained pipe receives in course of transit to the drying yard; and it is claimed that the whole success of the process is due to this fact of the material adhering so rigidly to the mould when rotation ceases. At any stage of the building up of the pipe the machines can be stopped to insert, if required, reinforcing material, such as a spiral of steel wire, the machines being then restarted for the completion of the pipe in the manner outlined above. A very thin concentric layer of specially watertight material can also be placed in any part of the pipe's thickness or on its inner surface if desired.

The machines should prove not only suitable for permanent establishment, as in a factory for turning out pipes for general sale, but also for temporary use on new constructions in remote localities, where freight, cartage, and breakage are heavy items in considering the actual cost of a pipe at its ultimate destination. As each machine only requires a small amount of power, this could, in the case of remote districts, be obtained from a small internal combustion engine or the like motive power. The pipes now being made are composed of 1 part cement to 2½ parts sand without reinforcing of any kind, and although only a few handfuls of dry cement are used for finishing off a pipe they are said to be watertight even up to pressures of 80 ft. of water.

Further particulars regarding these machines can be obtained from Mr. R. Neilson, Dalblair, Granville Street, Helensburgh, Scotland.

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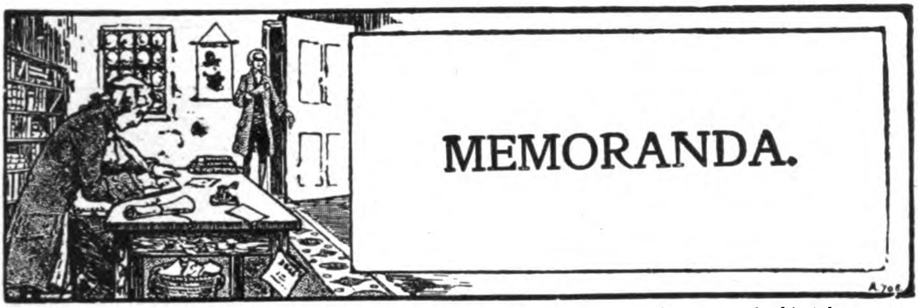
* This polisher is shown fixed on the bucket in *Figs.* 1, 2, and 3; in *Fig.* 4 it is detached from bucket and will be seen close to the bucket in front of the machine.



Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Timber Substitutes.—Concrete as a War Economy.—The following questions were put and replies given in the House of Commons on Monday, April 2nd, on the above subject (see Parliamentary Debates, Vol. 92, No. 35, columns 954, 955).

SIR E. LAMB asked the Financial Secretary to the War Office whether any steps are to be taken by the Director of Timber Supplies to obtain a substantial reduction of the timber employed in the United Kingdom by encouraging the use of such substitutes as concrete and reinforced concrete in the construction of temporary buildings used for war purposes; and whether any similar steps will be taken to encourage a more general use of reinforced concrete for telegraph poles, fence posts, railway sleepers, and pit props, etc., by circulating particulars of the satisfactory experience obtained in the United States and several Continental countries.

MR. FORSTER: The use of concrete and ferro-concrete as a substitute for timber in the construction of buildings, and for railway and colliery purposes, has been receiving careful attention for some time past. I will consider the suggestion made in the last part of the question.

SIR E. LAMB asked the Chancellor of the Exchequer whether he can see his way to notify the various spending Departments of His Majesty's Government of the advantages of utilising wherever possible concrete, comprising local aggregates with home-made binding materials, in lieu of timber, which has to be largely carried by sea or rail; whether he is aware that the life of concrete is naturally longer than that of timber; that the cost of maintenance of temporary buildings constructed of concrete is a negligible item, whilst the cost of maintaining timber structures is often heavy; and that concrete fence posts, telegraph posts, and similar accessories are to-day cheaper than timber fence posts, telegraph posts, etc.; and whether he can see his way to set up a small technical committee to advise the spending Departments, the railway companies, the factory owners, and the public generally how best to effect substantial economies by using local aggregates and home-made binding materials, whereby money would be kept in the country and a substantial amount of tonnage, railway freight, and cartage released for purposes of national importance.

SIR ALFRED MOND: My right hon. friend has asked me to reply to this question. The various Departments of His Majesty's Government concerned in the erection of permanent or temporary buildings are well aware of the advantages of concrete, both as regards initial expense and the subsequent charges for maintenance. A Cabinet Instruction has already been issued as to the necessity of avoiding the use of timber wherever possible. In view of the fact that all building operations are now restricted to those sanctioned by a Government Department and that all the Departments concerned are alive to the necessity for utilising substitutes for timber in the cases mentioned, I do not think that any useful purpose would be served by the appointment of a technical advisory committee such as is suggested.

SIR E. LAMB asked the First Commissioner of Works whether he can see his way to take steps to employ, to a greater extent than heretofore, concrete and reinforced concrete for the numerous buildings which are being erected by his Department for war purposes, so that a substantial economy may be effected in the amount of timber utilised; and whether he is aware that concrete hollow blocks, concrete, and reinforced concrete are non-proprietary products, comprising to the extent of about

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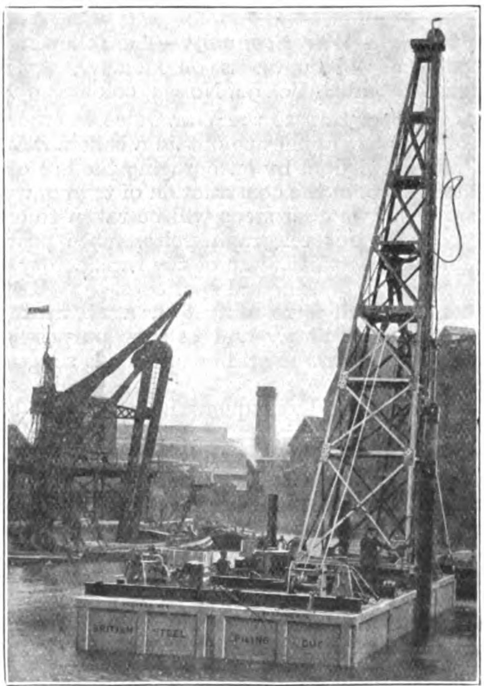

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Photograph shows one of a number of PILE DRIVERS ON PONTOONS we have lately built to order. When travelling cut of gear the pontoons are united "ends on," and the pile driving frame lowered so as to lay lengthwise along the decks of the two pontoons so united.

Dock House, *Billiter Street,* LONDON, E.C.

two-thirds of their bulk local aggregate, such as gravel, ballast, or stone, and that a material economy in transportation would be effected by a more general use of such materials in lieu of timber.

SIR A. MOND: My Department has for many years past resorted to the use of reinforced concrete for buildings erected under its supervision, and since the War has used not only that method of construction, but also concrete slabs and brickwork for constructional purposes in suitable instances in lieu of timber, and from inquiries which I have made I am satisfied that no further substantial economy can be effected in this direction. The reply to the latter part of the question is in the affirmative.

New Materials as Influencing Design.—The Conference of the members of the Royal Institute of British Architects on "New Materials as Influencing Design" was held on March 21st. The chair was occupied by Mr. E. Guy Dawber. The following are some extracts from the discussion:

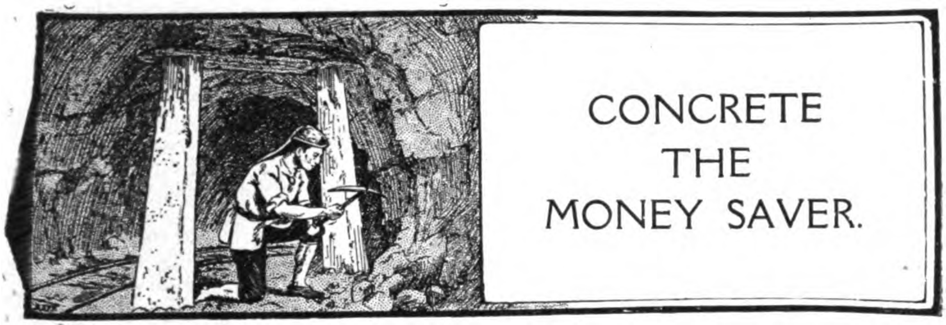
Mr. *H. D. Searles-Wood* said that after a diligent search he could find no new materials, but some of the methods now in use might be of interest. He described the construction of a number of munition works, and pointed out that the big stores, 1000 ft. by 120 ft., were roofed by Belfast trusses of 60 ft. span, formed with 4 in. by 1½ in. battens, fixed with cut nails clinched, which were found to be better than bolts. The flooring is generally cement concrete. A shell factory now being erected in reinforced concrete construction. covering two acres, was started on January 15th, and one-fifth was finished on March 3rd. The speed of the work was not due to anything new in the application of the reinforcement, but simply to the foresight shown in having the materials on the site. He was afraid the only new material which would afford much subject for discussion was reinforced concrete, and in this connection he quoted largely from a paper he read some time ago by Professor Beresford Pite.

Mr. *Kempton Dyson* said there were certain new applications of old materials which must influence design. The first was reinforced concrete, which was a material possessing distinct advantages as regarded fire resistance, freedom from decay, and hygienic properties, whilst under certain conditions it was more economical than other materials. If logically developed, it must affect design. Its use affected the whole fenestration of buildings, and as regarded the treatment of its surface, he did not think mouldings of the type of the past were appropriate. Another new factor in the use of the material was the ease with which cantilever projection could be made, and in its monolithic character and continuous beam construction it gave opportunities of treatment which were lacking in the past. There were also great possibilities in connection with the use of precast work, and he thought it would be proved to be economical. He saw no objection to casing reinforced concrete construction. Concrete was a nasty colour and it was quite appropriate to put on a better material. They put plaster and tiles on walls to cover up the bare brickwork, and why not do the same with reinforced concrete? They might clothe exteriors with a veneer of richer materials, but should show it as a veneer. In factories the cost would prevent such a thing being done, but there were various methods of treating surfaces, such as chiselling and hammer dressing, which would give good effects. Mr. Dyson proceeded to point out that the opportunity given by reinforced concrete to construct thin walls must affect design, whilst so far little attempt had been made to treat the reinforced concrete dome, although it was a very appropriate material for roofing over a large space. Steel framework construction also permitted large windows and altered the whole intercolumniation of a building. As to clothing, what was appropriate for reinforced concrete would also probably apply to steel. Mr. Dyson next touched on the influence which the extended use of plate-glass and the developments in the way of reflecting glass, pavement lights, etc., must have on design, and expressed the opinion that buildings in the future would be carried to a greater depth below the surface, as it would be possible to get full use of the basements. He reviewed the various waterproofing materials now open for use, and pointed out that asphalt was already largely taking the place of lead and zinc. In regard to its use on flat roofs, he thought it quite possible that the kitchen garden might be placed on the roof, whilst with the rapid advances made with the aeroplane, a continuous flat roof might be constructed to serve as landing-places for privately-owned aeroplanes. The advent of new finishing materials, plaster substitutes, jointless floors, and so on, would all influence design.

Sir Henry Tanner said what they had heard of were adaptations of old materials which had been in use for many years. What everyone was endeavouring to do was to adapt their old materials to modern uses. Wood was almost impossible to get, and they had to turn their attention to getting something else which would be economical and serve their purpose. He did not think it any use trying to depend on African hard woods unless they could get a very good market in this country. He would not be surprised if central heating came in London; but the expense of subways would be enormous. Reinforced concrete was bound to alter the construction of buildings; but whether it would alter their general appearance was another matter. What was required was a modification of the building by-laws of London in regard to the use of reinforced concrete—for the present factor of safety was quite unnecessary, and working outside the by-laws he had cut it down to one-third.

The Chairman said that the only really new material introduced of late years which they had to deal with was reinforced concrete, and it was going to revolutionise the building of commercial and public buildings. He considered that it would be a great mistake to attempt to make what was practically a plastic material like concrete to imitate in its decorative treatment stone or brickwork. They had to treat it entirely and frankly as new material, and he considered they got a dignity and character out of the mere use of any material if it was rightly adapted to its ultimate end and purpose. If a concrete building was clothed with a richer material, treated frankly as a veneer, he thought it was legitimate, but not if the purpose of the veneer was to disguise the building or to make it imitate something else. The lack of wood in one way was helpful, as it would cause them to build in a material which was "fire proof" and economical in space. The enormous amount of building in the last two years had brought out in a wonderful way the resourcefulness and ingenuity of their designers. One way in which he thought light reinforced concrete construction would affect them was with regard to hospitals. With the progress of medical science and change of methods of treatment he had always thought it wrong to erect the expensive permanent hospitals they had in the past, and he believed in future they would have more economical buildings for the purpose which could be removed when their purpose was served.

Reinforced Concrete for Strong Rooms.—Reinforced concrete has been most successfully used for strong rooms for banks, jewellers, and other firms. Some strong rooms have recently been designed and carried out by Messrs. Edmond Coignet and Co., Ltd., in this country.



CONCRETE AS A SUBSTITUTE FOR TIMBER.

(Continued from last issue.)

FOR MINE WORK.

In this country concrete has not made such rapid strides as a material for use in mines as might be expected, but we have many instances of its practical use in the mines of U.S.A. and other countries.

Some Reasons for Using Concrete.—The increasing cost of timber and the difficulty experienced in securing same, combined with its comparatively short life, should rank as important factors influencing its discontinuance in mining practice.

Concrete may have exceeded timber work in some cases in first cost in pre-war days, but when once constructed a concrete lining, for example, is practically indestructible throughout the ordinary life of a mine, and as no repairs are necessary it has a decided advantage over timber, as there are no delays with their consequent loss of output and extra expense of maintenance.

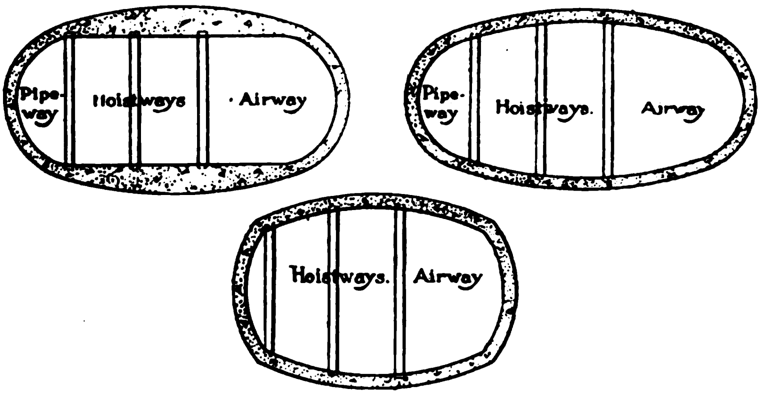


Fig. 1. Early Examples of Concrete Shafts in America.

Another factor is the great strength of linings made of concrete as compared with those of timber. Further, concrete can even be employed where neither stone nor brick are applicable and to greater advantage than timber.

For sleepers in mines where the wear and tear is very considerable reinforced *concrete* is an ideal substitute for timber; such sleepers are practically indestructible. Generally speaking the following are some of the instances where concrete may be used in mine works:—(1) Shaft linings, (2) Elliptical shafts, (3) *Re*-lining of timber shafts, (4) Lining of drifts and gangways, (5) Pillars and supports (pit props), (6) Stoppings and overcasts, (7) Stringers and ties, (8) Strengthening weak roofs, (9) Underground tanks, (10) Sleepers, (11) Stairways, etc.

Some early designs of concrete shafts in America are shown in *Fig.* 1.

SOME INSTANCES OF THE APPLICATION OF CONCRETE IN MINE WORK.

Pit Insets, etc.—Some applications of concrete at the Sneyd Collieries, Burslem, included pit insets, and these have proved very successful. Many of the main roads, airways, and water lodges have been lined with concrete at this colliery. Stables and motor houses have been constructed of concrete.

By the courtesy of the Institution of Mining Engineers we are able to reproduce some illustrations from their Transactions (Vol. XLVI., Part 1) showing the use of concrete at these collieries, taken from a paper read by Mr. John Gregory. *Fig.* 4 shows a pit inset. *Fig.* 15 is a section of a motor house, with pit rails used for reinforcement.

Concrete Lining.—An instance of a concrete applied to mine shafts in this country is to be found at the Plenmeller Collieries, Haltwhistle, Northumberland. In this instance segmental slabs of concrete reinforced with expanded steel were used to replace the usual brick lining.

Mine Galleries.—An interesting example of a reinforced concrete mine gallery is to be found at one of the principal South Wales mines where considerable subsidences had occurred, and it was decided to construct an experimental gallery. The system of reinforcement which was employed was the Coignet system, and the method adopted is shown in *Fig.* 5.

The inside diameter of the experimental gallery was 10 ft. Briefly, the method consists in making on the surface a certain number of reinforced concrete segments,

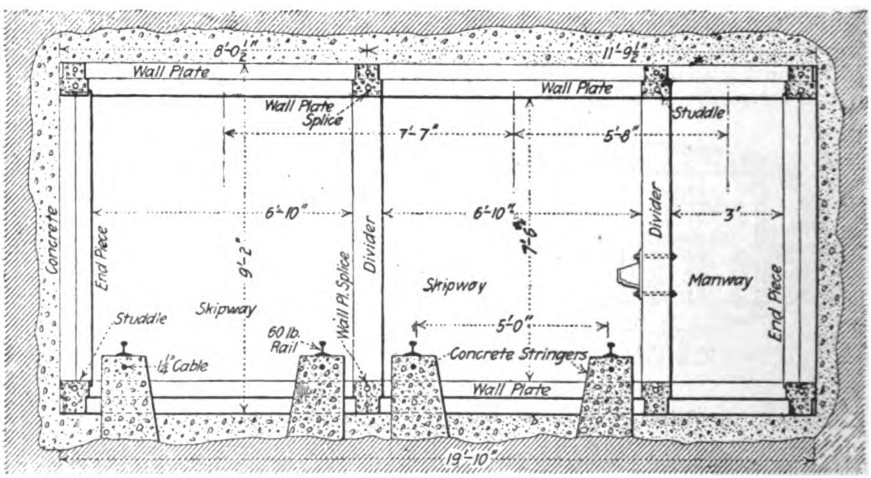


FIG. 2. A CONCRETE LINING AS CONSTRUCTED BY THE AHMEEK MINING CO., MICHIGAN.

each segment having on its outer edges a steel angle frame, in order to ensure the true shape of each segment and to enable the bolting of consecutive segments by means of holes left in the flanges. Each segment was 18 in. wide by 4 ft. 11½ in. external curved length. The thickness of each segment was 8 in. Special pockets were left at each end of the segment, and also laterally, to enable the bolts to be properly placed in position, after which the pockets were filled with cement grout. The segments of each consecutive ring were staggered, in order to break joint in a longitudinal direction. This method has so far proved successful. In order, however, to reduce the initial cost, it was decided in a similar job, also for a mine in South Wales, to suppress the steel angle frame of each segment, and the following method was adopted. A certain number of segments were made on a surface having

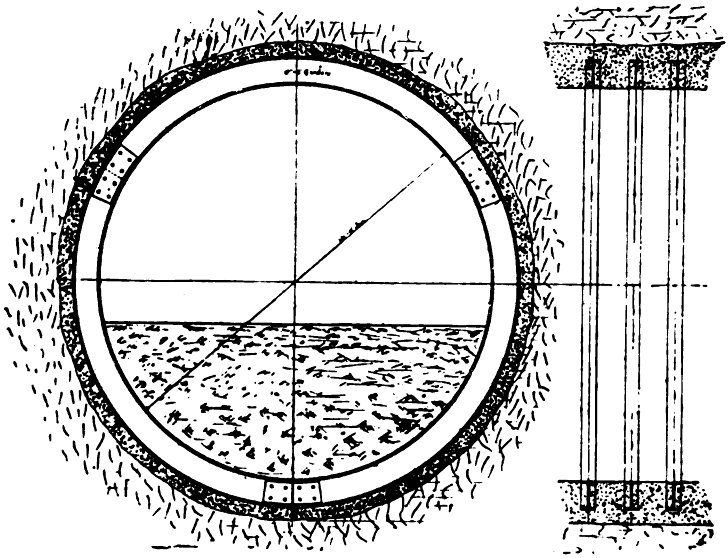


Fig. 3. Pit-Bottom Arch. Internal Diameter, 14 ft., at the Sneyd Collieries, Burslem.

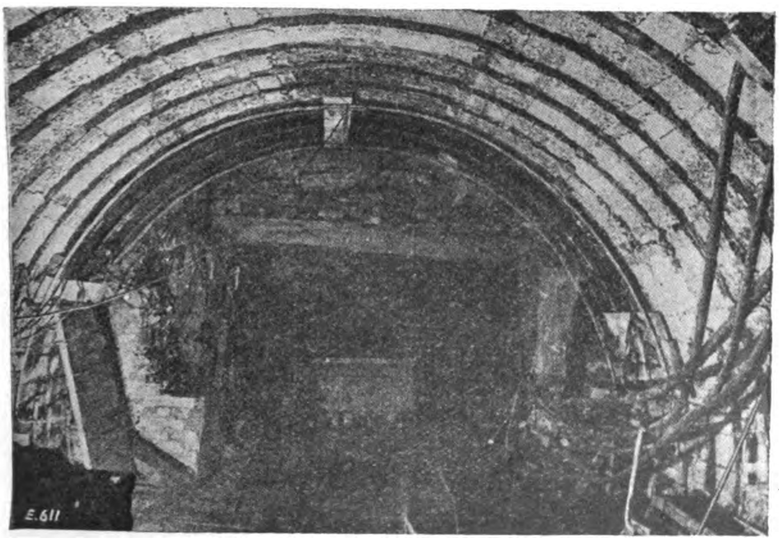


Fig. 4. Steel and Concrete Replacing Timbered Inset Barrel Arch, 14 ft. in Diameter, at the Sneyd Collieries, Burslem.

Reproduced by courtesy of the Institution of Mining Engineers from their Transactions.

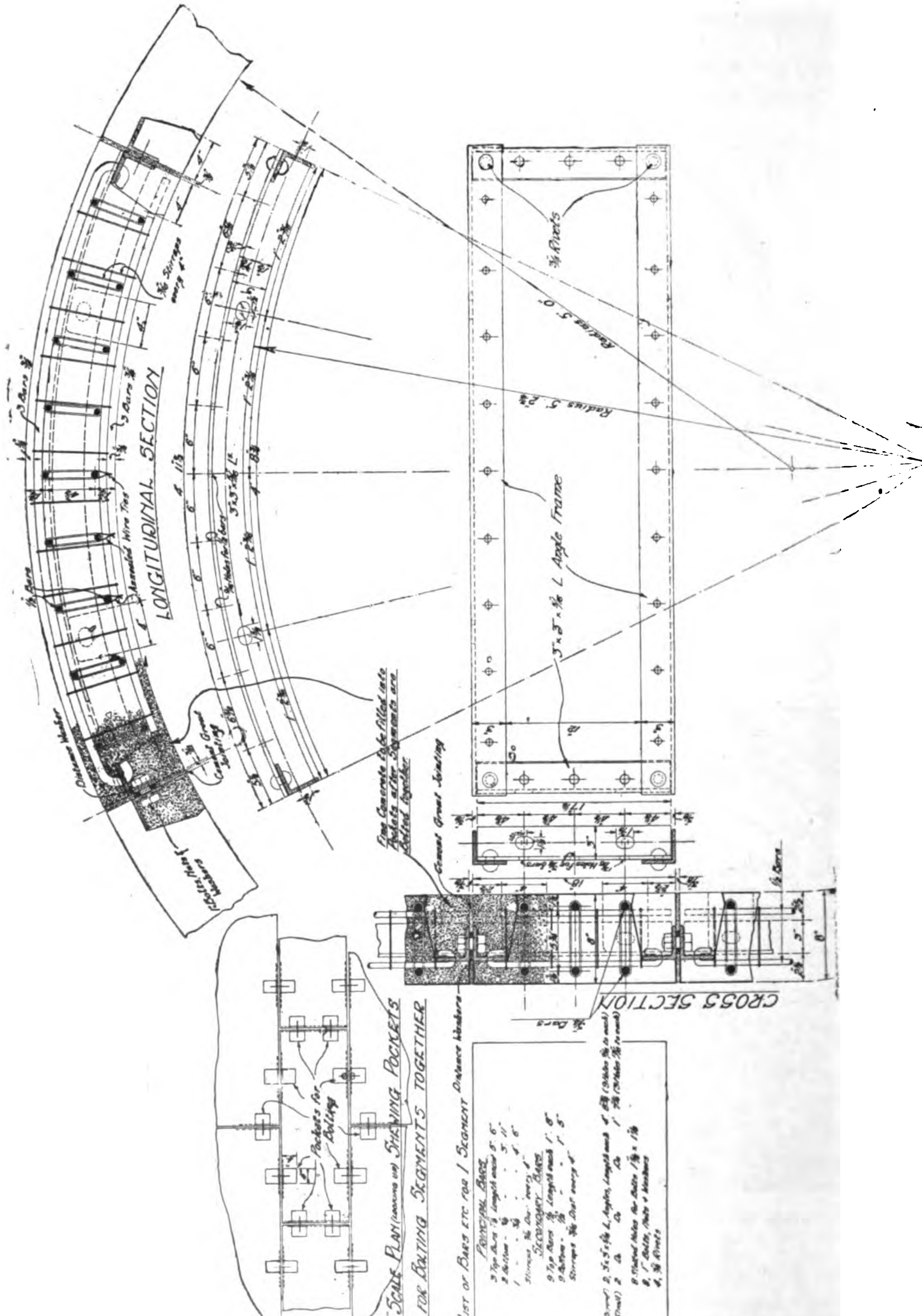


FIG. 5. LINING TO MINE GALLERIES.

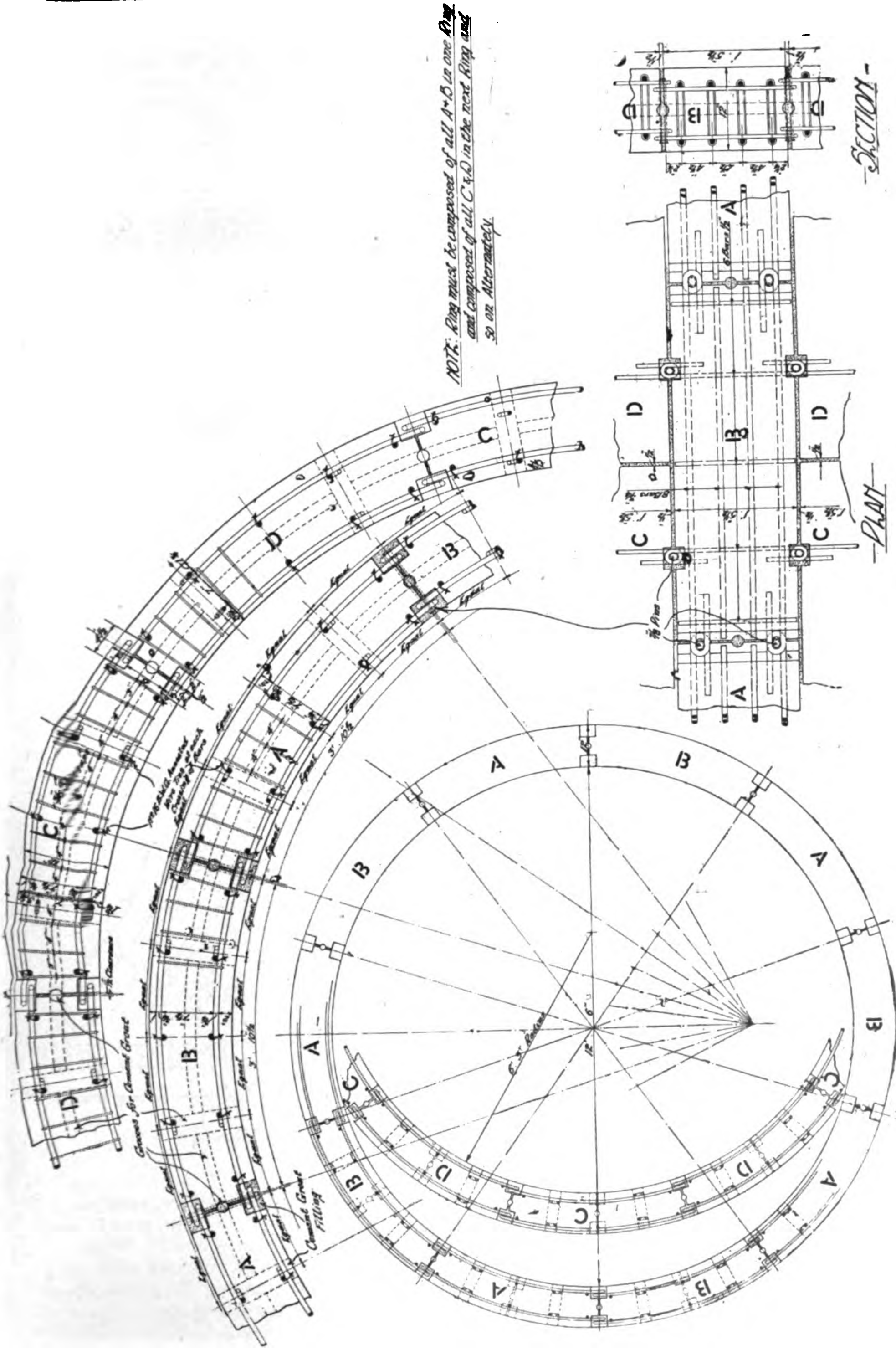


FIG. 6. LINING TO MINE GALLERY.

approximately the same dimensions as the former ones, and composed of a reinforcement of round bars, as shown on plan, *Fig.* 6. In this case, however, the thickness of each segment was 12 in. instead of 8 in. The method of fixing the segments longitudinally and laterally was carried out by bending the longitudinal and lateral bars forming the reinforcement into hooks at each end, through which gudgeons were placed, as shown in the figure. Suitable pockets were also provided to fix the gud-

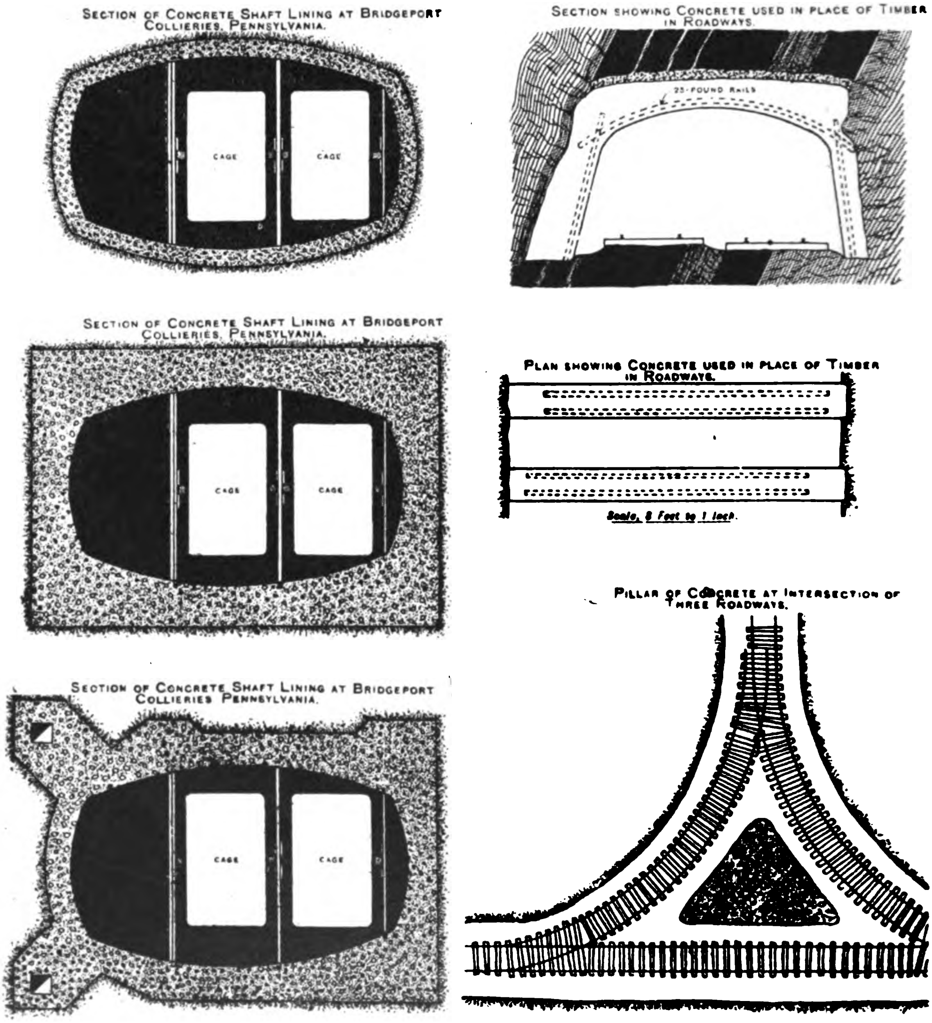


FIG. 7. VARIOUS PLANS AND SECTIONS.

geons or pins through the overlapping hooks of the consecutive members, and once the various rings were fixed together the pockets were grouted up with sand and cement.

This method was adopted for a mine gallery in South Wales over 100 ft. long and 12 ft. 6 in. inside diameter, and the work has now been standing for over three years and submitted to very considerable efforts, and has so far given good results.

The latter method has also been patented by Messrs. E. Coignet and Co., Ltd., of 20, Victoria Street, S.W., and will, no doubt, be extensively used, particularly in mines, where the ground is continually in motion, and where timber and brick-work cannot cope with the enormous efforts due to earth pressure.

Concrete shafts and stringers have been used to good advantage in the Bantjes Consolidated Mines, South Africa, and with reference to this equipment an article

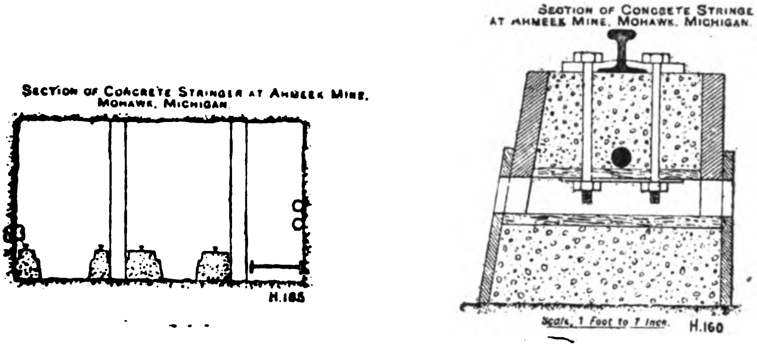


Fig. 8. Concrete Stringers.

appeared some time ago in a South African journal by Messrs. W. W. Laurie and G. Hildick Smith, and they state, with regard to the employment of concrete for this purpose, that they have arrived at the following conclusions :—

Provided always that there is no danger of movement of the footwall of a shaft, concrete stringers as shaft rail foundations are preferable to timber sills in incline shafts with any angle of dip up to 45 deg., because

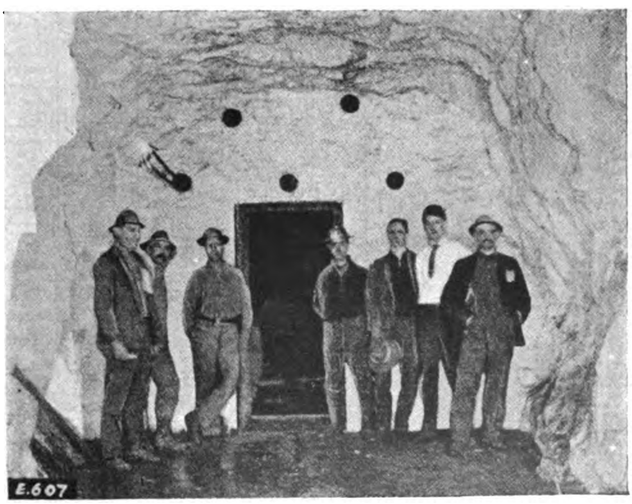


Fig. 9. Application of Concrete in Underground Powder Magazine.

(1) A longer life can be obtained from the rails, which can be allowed to wear down with safety to a greater extent on a continuous concrete foundation than they can when laid across timber sills.

(2) Skip derailments do much less damage with concrete than with timber.

(3) Concrete is a much more permanent foundation than timber, requires no repairs or renewals and appears to suffer no damage from any cause whatever.

(4) In deep shafts considerable time is saved during the equipment of the shaft, there being no long timbers to handle.

(5) Less damage to rails from corrosion by acid water.

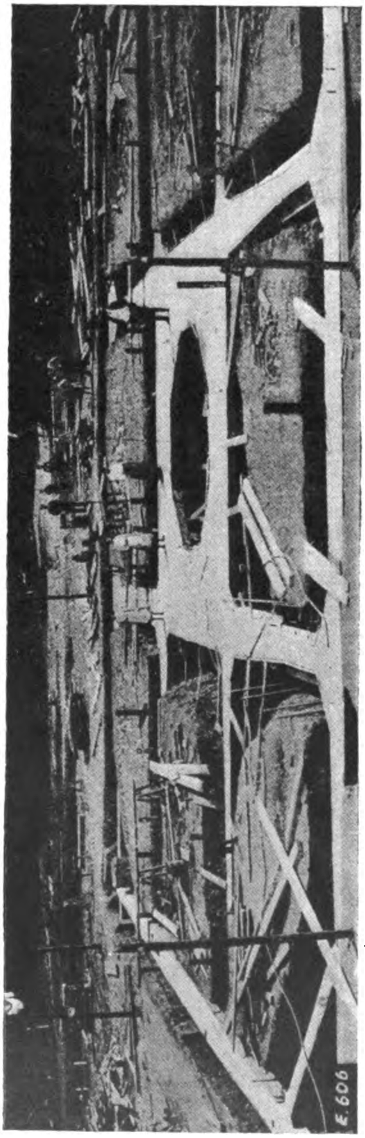


Fig. 10. Showing Concrete Pithead Structure in France as Completed.

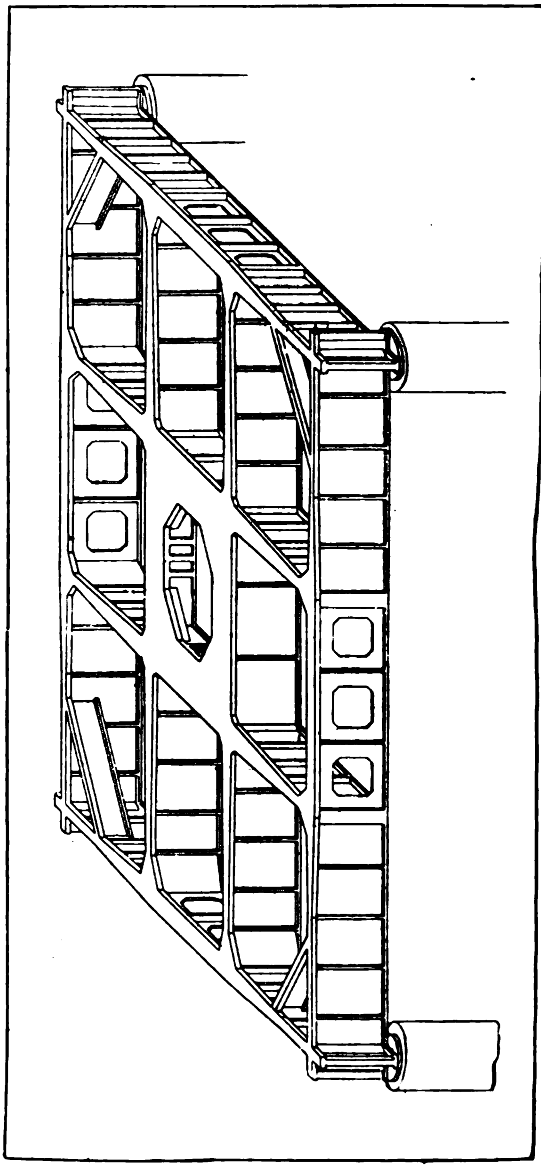


Fig. 11. Perspective Drawing of Pithead Structure in France.

With regard to the maximum inclination at which concrete stringers can be used in incline shafts, it is thought by pegging the footwall at inclinations from 45 deg. up to 60 deg. concrete stringers could be safely held in position.

Some illustrations of shaft linings and concrete timbering in roadways in American mines is shown in *Fig.* 7.

Concrete Stringers.—One of the most important uses to which concrete has been put in America, apart from linings, is for stringers for tracks in inclined shafts. In the case of the Ahmeek shaft, Michigan, there is a dip of 42 deg. from the horizontal. Preparatory to placing the stringers the footwall, or floor of the shaft, is cleared of all loose material and the mould timbers are placed. Before placing the concrete the space between the walls of the mould is flushed out to bed-rock, thus ensuring a clean face for the concrete. The depth of the stringers is about 22 in. when measured normal to the dip of the shaft. The construction of these stringers and method of attaching track

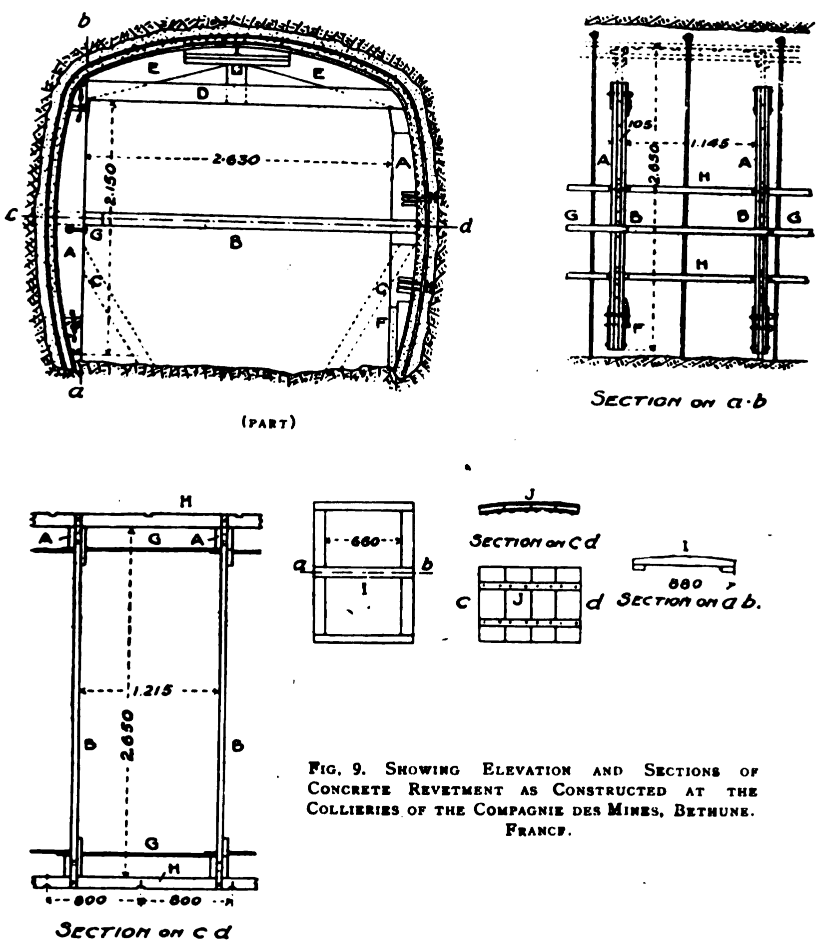


FIG. 9. SHOWING ELEVATION AND SECTIONS OF CONCRETE REVETMENT AS CONSTRUCTED AT THE COLLIERIES OF THE COMPAGNIE DES MINES, BETHUNE. FRANCE.

are shown in *Fig.* 8. The concrete for this work was composed of 1 part Portland cement, 3 parts sand, and 5 parts broken stone.

Posts.—On the Rand concrete is used largely in connection with kingposts for batteries.

Concrete Timbering.—Separately moulded concrete members to be substituted for framed timbers have been used by the Ahmeek Mining Co., Michigan. *Fig.* 2 shows such a lining as installed at this company's mine.

Concrete in Airways.—The use of concrete may be extended to replace timber in airways. The Bethune Co., in France, have lined their gangways with reinforced concrete made of burned shale, boiler ash, cement and water. This mixture requires fifteen days to set. The reinforcement consists of 4 in. arched rods placed 32 in. apart, and further strengthened by round 2 in. rods placed lengthwise 9 in. apart. This method not only prevents interruption in hoisting (which has been great owing to falls of roof), but also reduces cost of timbering and continual repair which, of course, is wanted when timber is employed.

Concrete Stoppings.—Recently the Bureau of Mines, U.S.A., in their Bulletin No. 99 reported on some investigations that had been made with various types of stoppings. Board stoppings, brick stoppings, monolithic concrete, concrete blocks, slate or gob dry wall, and slate or gob faced with cement, were used for these investigations. The following is a short abstract from that bulletin in regard to concrete stoppings :—

"In many mines concrete is the most suitable material for use in the construction of efficient stoppings in the cross-cuts between main air passage ways. Concrete stoppings may be constructed at a reasonable first cost. They have low maintenance charges, they are durable, incombustible, and unaffected by water, and they have a

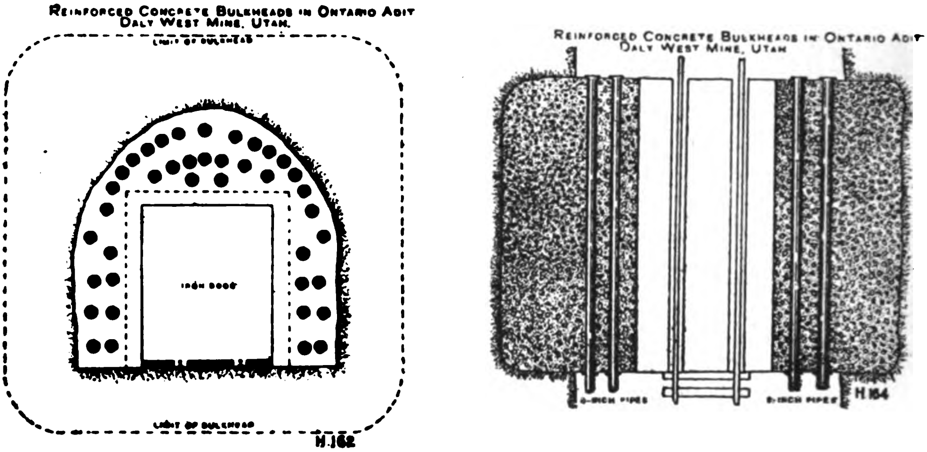


Fig. 13. Reinforced Bulkheads.

high bearing strength to assist in supporting the roof." . . . "Renewal repairs are unnecessary in concrete stoppings, because under ordinary mining conditions the life of a concrete stopping is longer than the period during which service is required."

Reinforced Concrete Pit Props.—These are used to a considerable extent in America, and have also been used in this country, one of the most recent instances being those constructed at the Arley Colliery, near Coventry, to which we referred in our March issue, on page 166.

Pithead Structures.—The Société des Mines de Houilles de Marles, France, when desirous of reconstructing their No. 2 shaft some considerable time ago, found it necessary to suspend the new shaft to a structure having its points of support outside the radius of the old pithead. Four masonry blocks were built situated 28 m. centre to centre for this purpose, and it is upon these points that the new main beams of reinforced concrete are resting. The shaft, weighing about 200,000 kgs. (about 197 tons), is supported by the secondary beams by means of suspension bolts placed round the opening, which measures 6 m. dia. This structure is also used for the foundations of the pithead building and machinery. The masonry blocks are 3 m. dia., and the beams transmit upon them a load not exceeding 2 kgs. (4½ lb.) per sq. cm. This work was carried out on the Coignet system of reinforced concrete. The accompanying illustrations, *Figs.* 10 and 11, give some idea of the work.

Underground Powder Magazines.—A number of the large mines in America have powder magazines underground, which is the case particularly with the copper mines of Northern Michigan. As a usual thing the magazines consist of blind drifts or old stopes walled off from the rest of the workings, and provided with thawing racks and

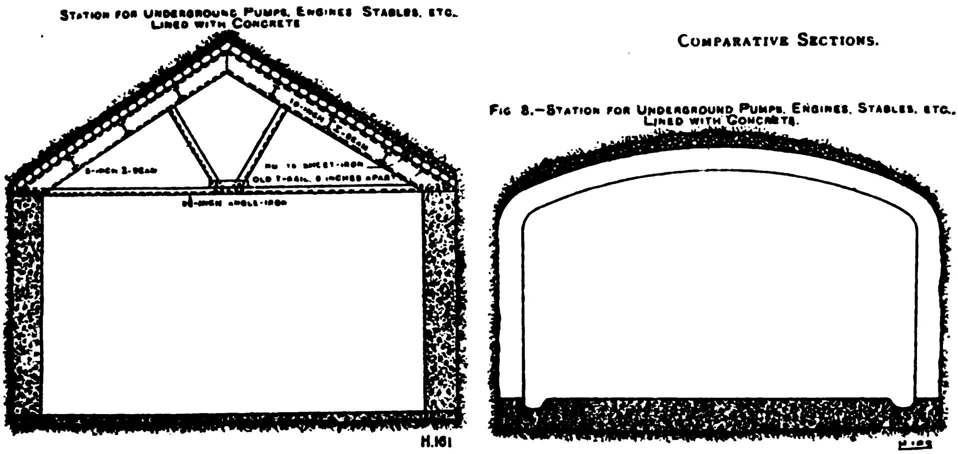


Fig. 14. Sections of Underground Pumps, &c., in American Mines.

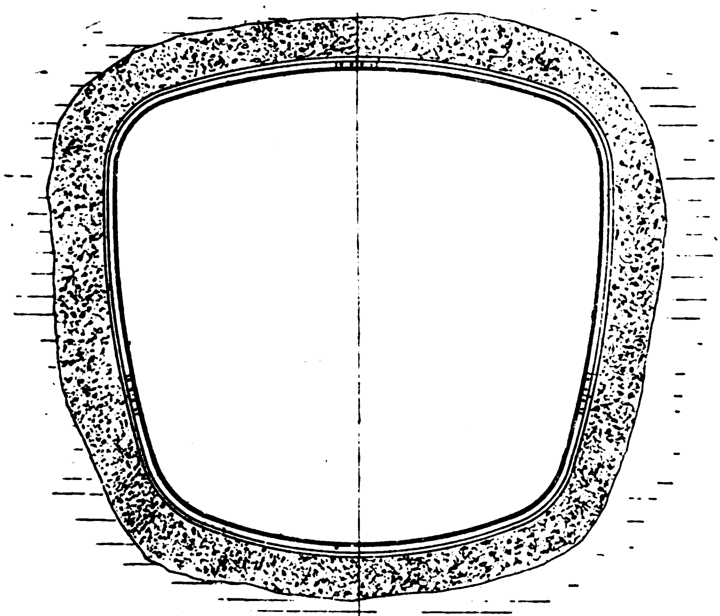


Fig. 15. Section of Motor-House with Pit-Rails used for Reinforcement at the Sneyd Collieries, Burslem.

Fig. 15 is reproduced by courtesy o the Institution of Mining Engineers from their Transactions, Part I., Vol. XLVI

steam pipes. Such a magazine is shown in *Fig.* 9, and is in the Mohawk Mine. The floor is concrete with a drain which leads to and under the door sill. The open end of the drift has been walled off with an 18 in. concrete partition in which are provided ventilation openings, also others for steam pipes, electric lighting wires, etc. A heavy iron door effectively closes the magazine and guards against interference with powder and appurtenance.

Mine Gallery Revetments.—At the collieries of the Compagnie des Mines de Bethune concrete mine gallery revetments have been constructed. The revetments are executed in sections 5 m. long by the aid of moulds. The drawings, *Fig.* 12, show an elevation and sections of the centering used for the construction of revetments in galleries measuring 2·60 m. high by 2·90 m. wide. The reinforcement consists of steel bars 10 mm. sq. bent to the form of cross section of the gallery and disposed normally to its axis in pairs, each pair of bars being spaced 80 cm. apart centre to centre and connected by bolts passing through eyeholes formed at the termination of the curves.

The advantages obtained by the employment of reinforced côncrete for the revetment of galleries have induced the above company to extend its application to the lining of shafts.

Bulkheads.—An illustration showing the application of concrete for bulkheads is seen in *Fig.* 13.

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CONCRETE AND CONSTRUCTIONAL ENGINEERING

JUNE 1917. VOL. XII. No. 6.

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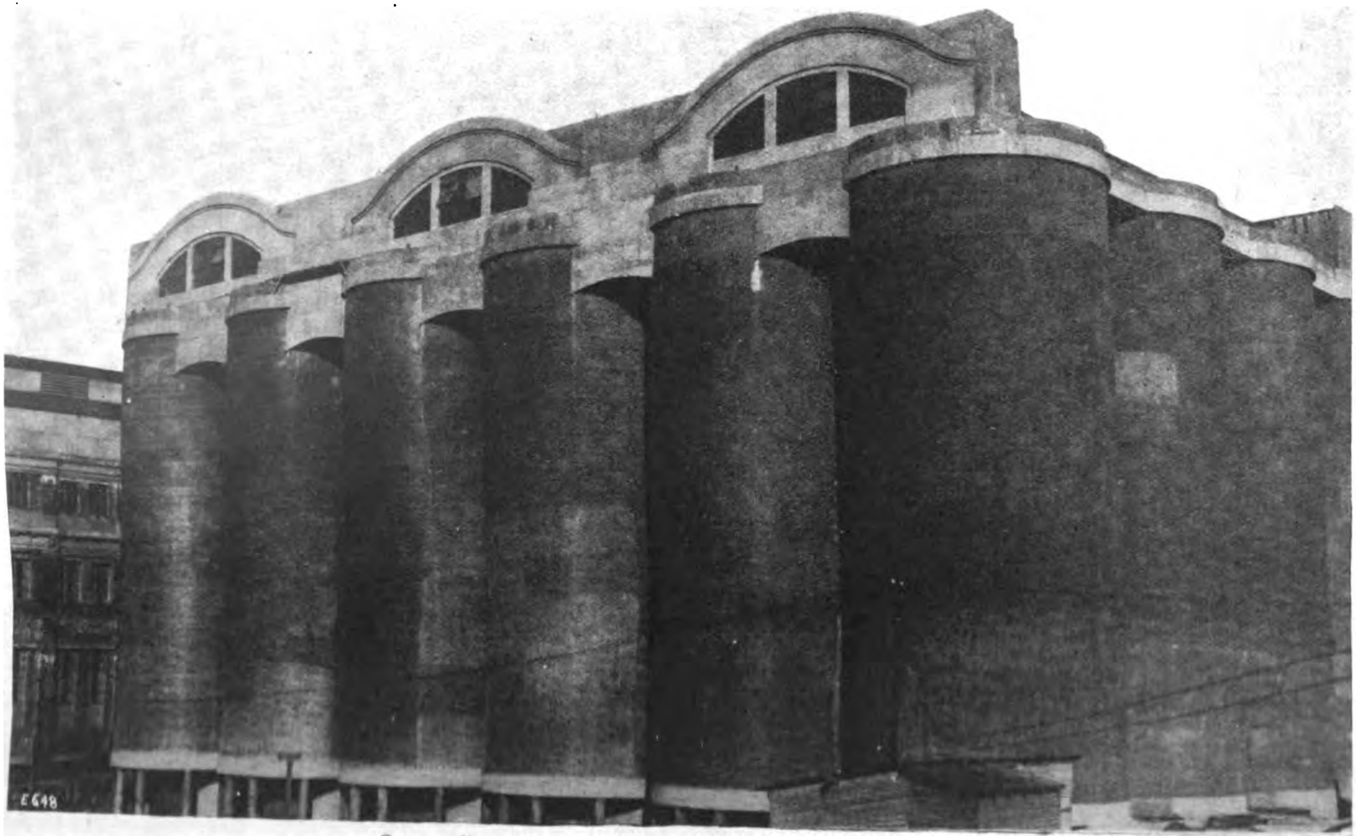


GENERAL VIEW OF REINFORCED CONCRETE NUT SILOS AND WAREHOUSES.

(*For description see page* 304.)

CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume XII., No. 6. LONDON, JUNE, 1917.

EDITORIAL NOTES.

PROPORTIONING MATERIALS FOR CONCRETE.

THE importance of getting the correct proportions for the component parts of any concrete cannot be overestimated, and it is satisfactory to note that the subject is being considered by some engineers with the object of improving the conditions which exist generally at the present time.

A very interesting paper was read before the Concrete Institute by Mr. H. C. Johnson in April last, describing the method proposed by him to ensure a constant percentage of cement in the finished concrete, and an extract of the paper, together with the discussion that followed, is given on pages 325 to 335 of this issue. There appears to be considerable difference of opinion as to many of the points dealt with in the paper, and it is quite evident that further investigation is necessary before the usual method of proportioning concrete is dispensed with. Valuable work has been done by Mr. Johnson, and it should form an excellent basis for such further investigation, but the results obtained cannot be taken as quite conclusive.

The number of test specimens made, although satisfactory for preliminary work, is insufficient to create certainty, and as the subject is an important one, a thorough and systematic programme should be drawn up by the Concrete Institute in order to provide data which would result in a perfect proportion of the materials used, and concrete made according to such revised rules could well be designated as "Standard Concrete." There certainly is no guarantee at present that the percentage of cement in the ordinary 1 : 2 : 4 mixture is uniform throughout the work, and the engineer has no real knowledge of the quantity of the actual strength-conferring material which will be used unless some such method as that advocated by Mr. Johnson is adopted.

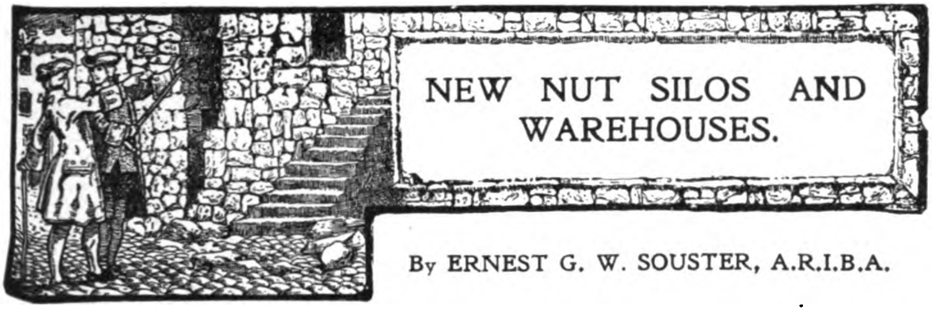
In the majority of cases it will be seen that there was an increase in the strength in "corrected concrete," as it is termed, as compared with the ordinary mixture, even when less cement was used; but, at the same time, the increase was not in any sense constant, and in some cases there is actually a decrease. Now this cannot be considered as a satisfactory state of affairs because, although we may know exactly what percentage of cement is being used in the concrete, this will be a poor consolation if such knowledge is only gained by a possible decrease in strength. Such a condition may be advantageous to the contractor, but it does not confer an advantage on anyone else. What is really required is a specification for a method which will result in a known definite percentage of cement and a uniformity of strength if such percentage is adopted. This may seem somewhat difficult of attainment at first sight, but when the results of concrete tests are studied it will be seen that a very large variation always occurs, due to many causes. The general method is to take the average of a number of tests, but it must be remembered that the weakest part is the strength of the whole, and if sections of the finished work are only equal to the poorest of the tests, then the structure is dependent on a smaller factor of safety than the engineer admits. In reinforced concrete work the actual strength of the concrete is not the only factor that has to be considered, and there are some cases in which a little sacrifice of strength may result in more satisfactory work, and by this we refer to the consistency of the concrete when mixed.

It is now an established fact that the quantity of water used has a great effect on the strength of concrete, and that if more than a certain percentage is used then there is a distinct falling off in the resistance to compression; but in reinforced work, where the bars are complicated and close together, it is sometimes necessary to make the mixture more fluid than theoretically ideal in order to ensure the material flowing properly round all the rods. If this method is not adopted, air pockets are liable to be formed, and in addition the appearance of the work will be unsatisfactory when the shuttering is removed, even when the tamping is thoroughly done. This is an example of what is meant by making a little sacrifice of strength in order to obtain satisfactory work.

In the case of the "corrected concrete" it would appear that this condition is likely to be met with to some extent because the desired volume of wet concrete was made up generally by adding large aggregate, and the proportions as given for the gravel concrete show that considerably less sand was used than with the 1 : 2 : 4 mixture. This concrete would consequently be liable to prove difficult to use satisfactorily in some classes of reinforced work, and therefore the possible increase in strength has a serious set-off against it. What actually appears to be the results of the tests described by Mr. Johnson may be explained in a simple manner. In the case of stone the proportions of 1 : 2 : 4 were so near to those called for that nothing was gained by making an alteration; while in the case of the gravel, which contained less voids, the same quantity of cement was used as with the stone, but less sand, and thus it resolved into a question of the proportions to be adopted between the two materials which fill the voids in the large aggregate.

The whole subject will raise questions among engineers who are responsible for concrete work, and these cannot be satisfactorily settled until some more extensive tests have been made, and no changes are likely to be effected in the present methods until the knowledge we now have is supplemented by something more definite.

The very simplicity of the usual method of proportioning concrete is one of the strongest points in its favour, and it will need some very strong evidence to get this displaced by any other. If, however, it can be shown that an increase of strength is obtained without the loss of any other merit, then it will fully repay engineers and architects to support such new method, and there is no doubt that support would be given. The tests should cover, as far as possible, all kinds and sizes of large aggregate and sand, and if made on an extensive scale the results would be very valuable to engineers in this country. The exact influence of a varying percentage of cement could also be investigated and some definite information on this point would be extremely useful.



NEW NUT SILOS AND WAREHOUSES.

By ERNEST G. W. SOUSTER, A.R.I.B.A.

The buildings here described consist of nut silos and warehouses, and are entirely constructed of reinforced concrete.—ED.

THESE buildings form part of a large scheme recently completed, which comprises silos, warehouses, factory and jetties, the latter of which we hope to be able to deal with in a later article.

THE SILOS.

The silos, of which there are thirty-nine, cover an area of 130 ft. by 200 ft., and are of two types—A, twenty-four circular ones, and B, fifteen smaller ones filled in the spaces between the free arcs of the circular ones. See Plans, *Figs.* 1 and 2.

Foundations.—The foundations of the structure consist of reinforced concrete piles spaced in groups of three to four under each column, and it may be of interest to state, as showing the size of the undertaking, that the whole works have necessitated some 1,100 piles, which together have a length of 6¼ miles. Upon these pile foundations are formed 48 rings of columns, the outer 24 rings tangential to each other and consisting of 12 columns at a radius of 16 ft. 5 in. and the inner rings of 6 columns at a radius of 8 ft. 3 in.

These columns are of three sizes: In the centre of the block, where the weight to be carried is uniform on all sides they are 1 ft. 8½ in. diameter; at the outer edge, where weight is, of course, less, the columns are 1 ft. 5½ in., and where a greater length is required, owing to the duct for transporter bands, these columns are increased to 2 ft. 2 in. diameter. The duct is 6 ft. below the general foundation level, and being below water level, was treated with waterproofing material.

The reinforcement principle for all the three above-mentioned columns is the same, and consists of six vertical rods placed hexagonally and tied together at intervals, the rods being ⅝ in. diameter for the smaller, ¾ in. for the middle, and 1 in. for the largest columns.

Upon these columns are formed two circular beams to carry the hoppers, and the intersection of the outer rings with each other forms the ends of stiffening beams running the whole height of the silos.

The Superstructure.—The large circular silos are 32 ft. diameter and 88 ft. high with enclosing walls between the vertical beams 4 in. thick reinforced with ½ in. and ⅜ in. rods.

Above the silos proper an open floor is formed for the necessary machinery, and, as will be seen from *Fig.* 8, the smaller divisions are completely covered over and runways formed over the large circular ones.

This floor is roofed with three reinforced arched spans, the arches being

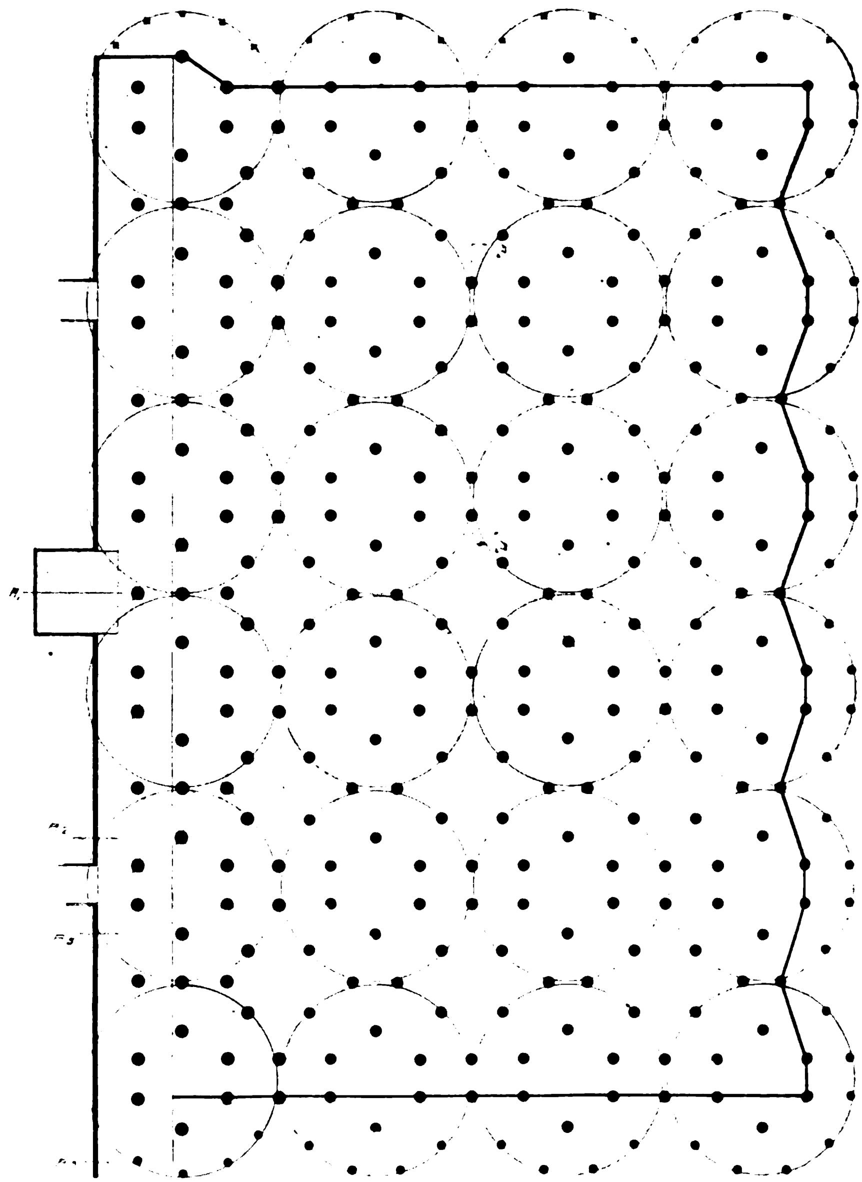


Fig. 1. Column Plan of Silos

NEW NUT SILOS AND WAREHOUSES.

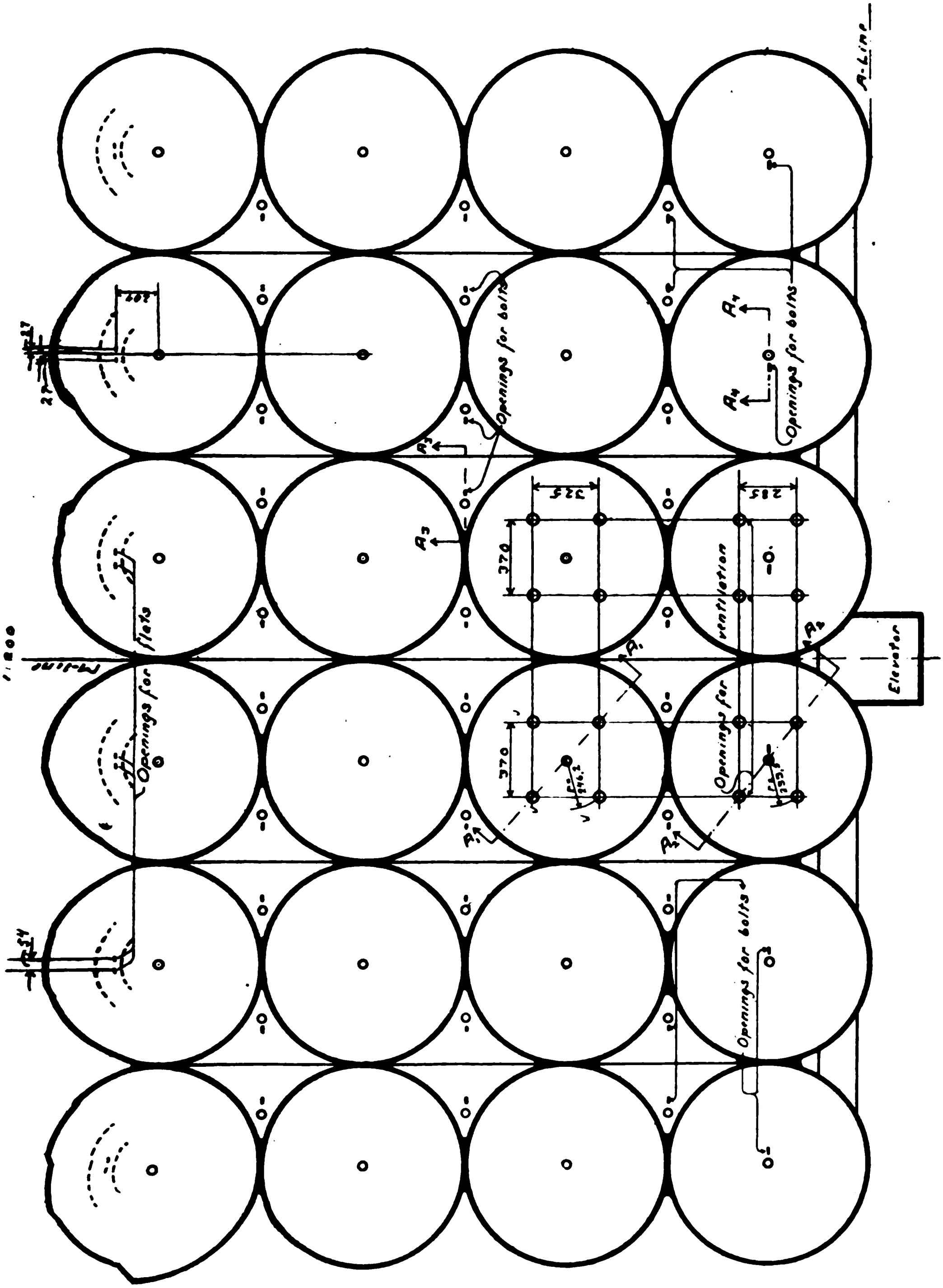


Fig. 2. Plan through Silo.

New Nut Silos and Warehouses.

45 ft. span and varying from 5 in. thickness at the springing to 3½ in. at the crown, and it may be noted that no beams are used for this roof.

In order to prevent excessive height, these arches spring from the top

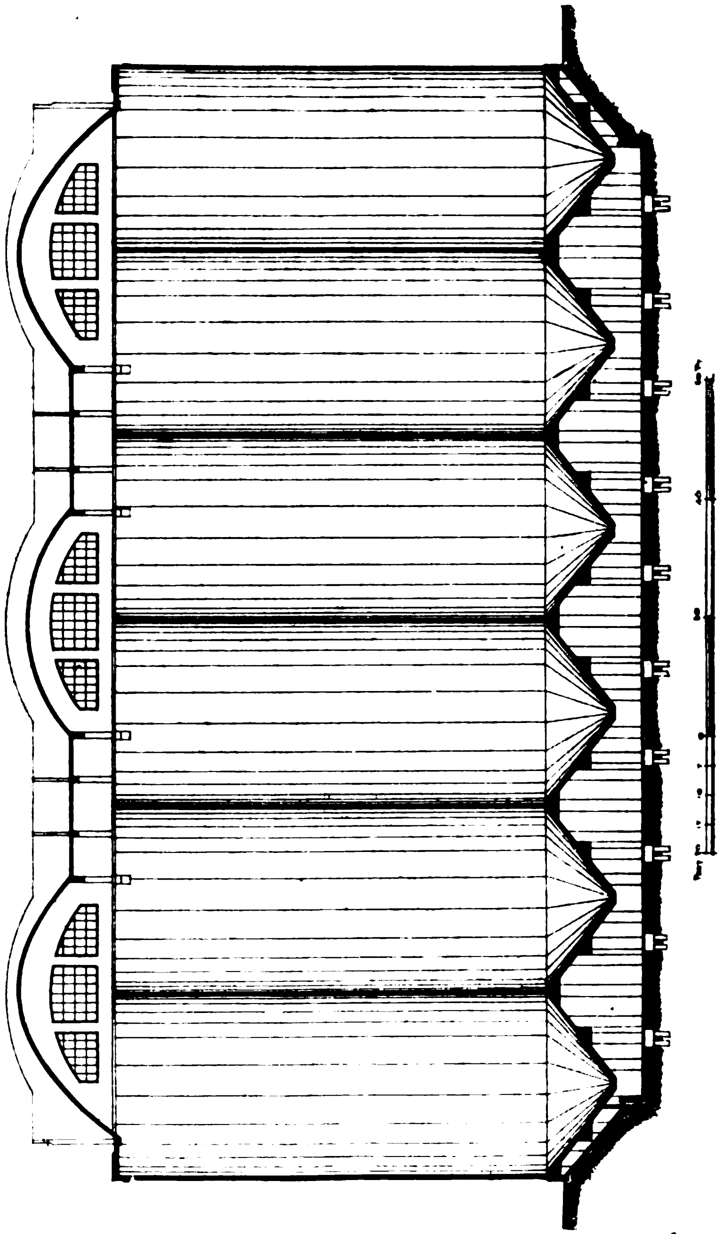


Fig 3. Section of Silos.
New Nut Silos and Warehouses.

level of the silos, but to gain access over the whole area and to allow the necessary height for belt conveyors which are used throughout the building, flats are formed between the arched spans, as will be seen from the section, *Fig.* 3.

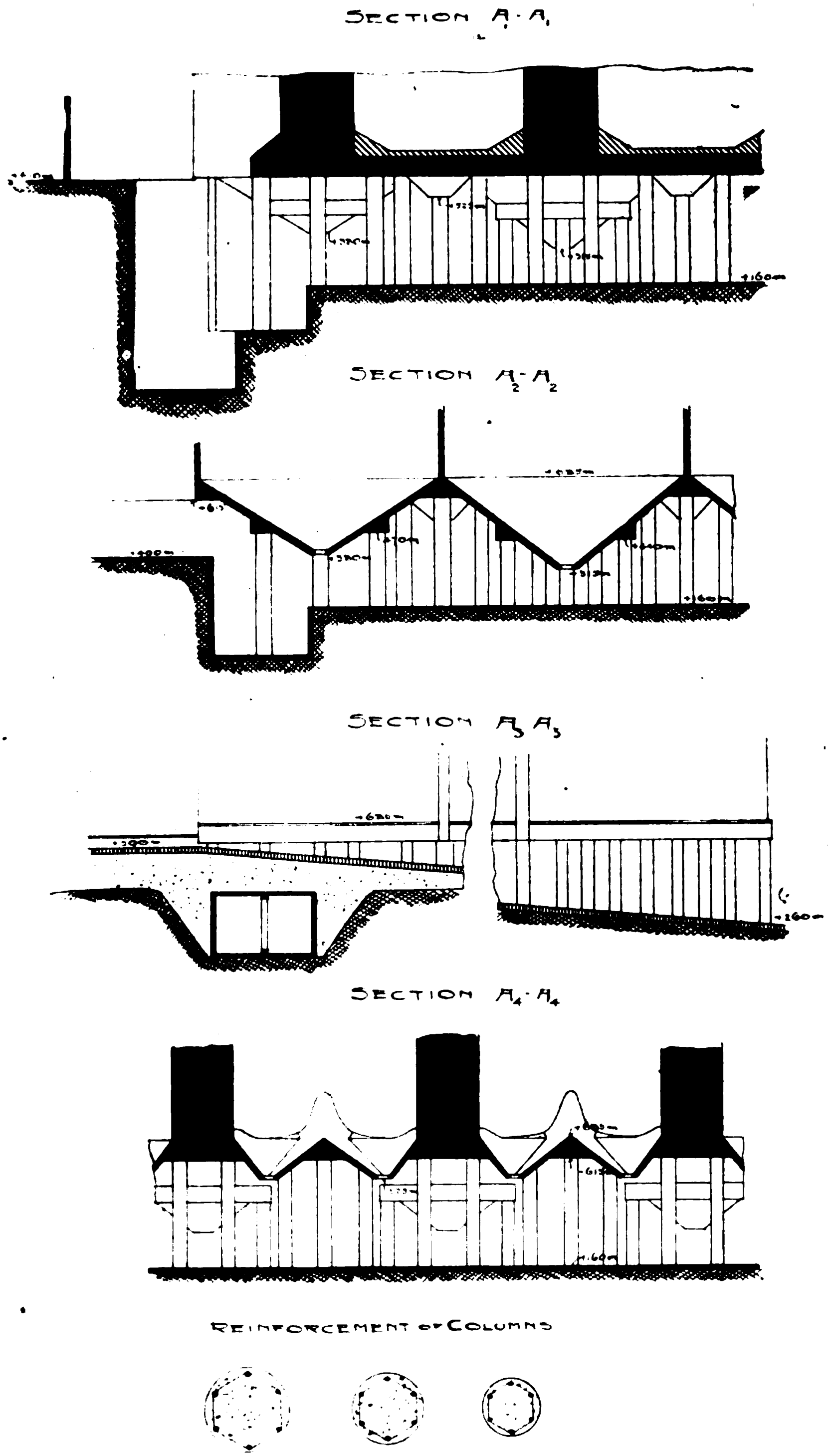


Fig. 4. Details of Silos.
NEW NUT SILOS AND WAREHOUSES.

Expansion owing to variations of temperature has been provided for by two expansion joints running across the roof and can be clearly seen in *Fig.* 8.

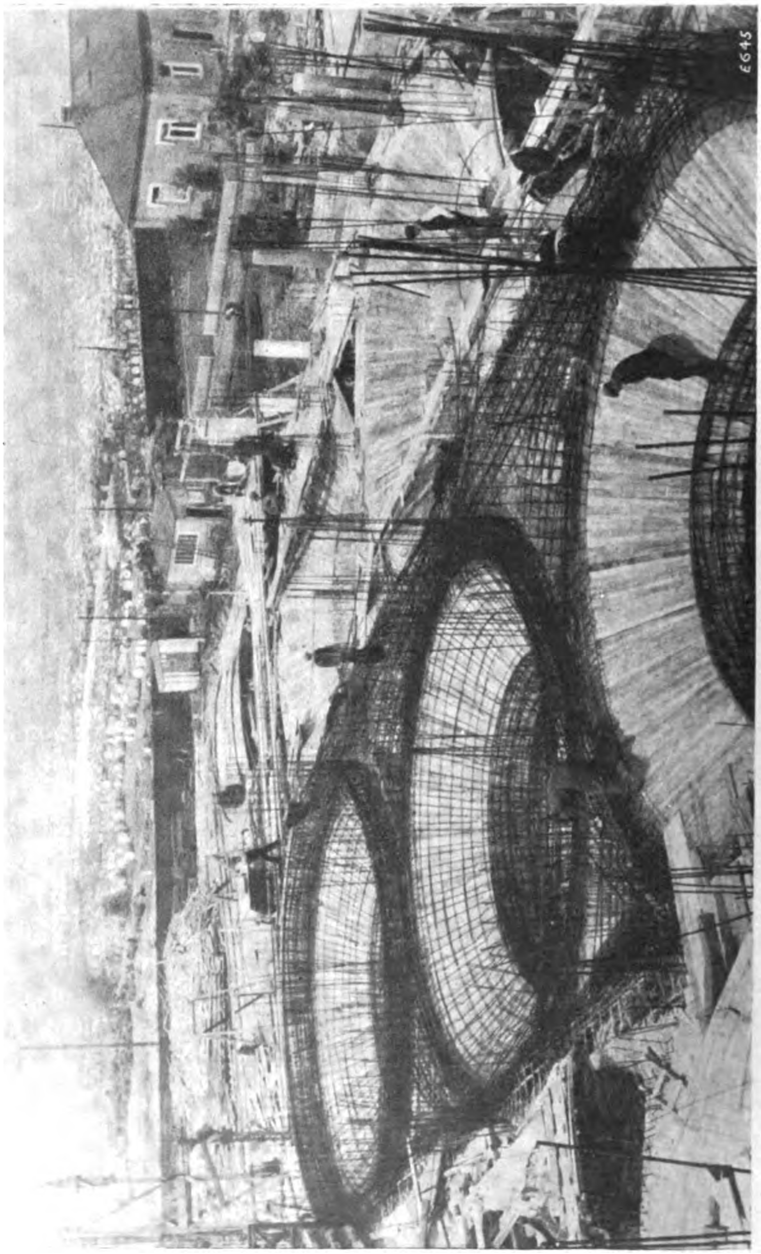


Fig. 5. Hopper Bases during Construction, showing Reinforcement.
NEW NUT SILOS AND WAREHOUSES.

The method of construction of this block was very interesting from the fact that a movable system of shuttering was used. The space to be occupied by the building was divided into two sections, and one block,

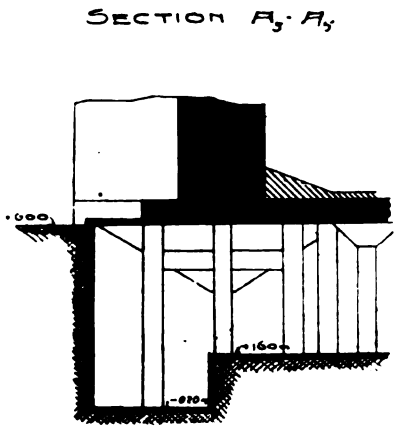


Fig. 6.

consisting of twelve circular silos, was first erected. After the conical hopper bottoms and columns supporting them had been completed, a large shuttering for the walls and beams was constructed to a height of 5 ft. This covered half the whole area and on it a working floor was formed. As the work proceeded this shuttering was raised by means of screw jacks and tackle working upon a number of vertical rods in the walls.

It was, of course, necessary to synchronise the movement of the whole construction, but this was successfully carried out and a great economy in the use of timber was effected.

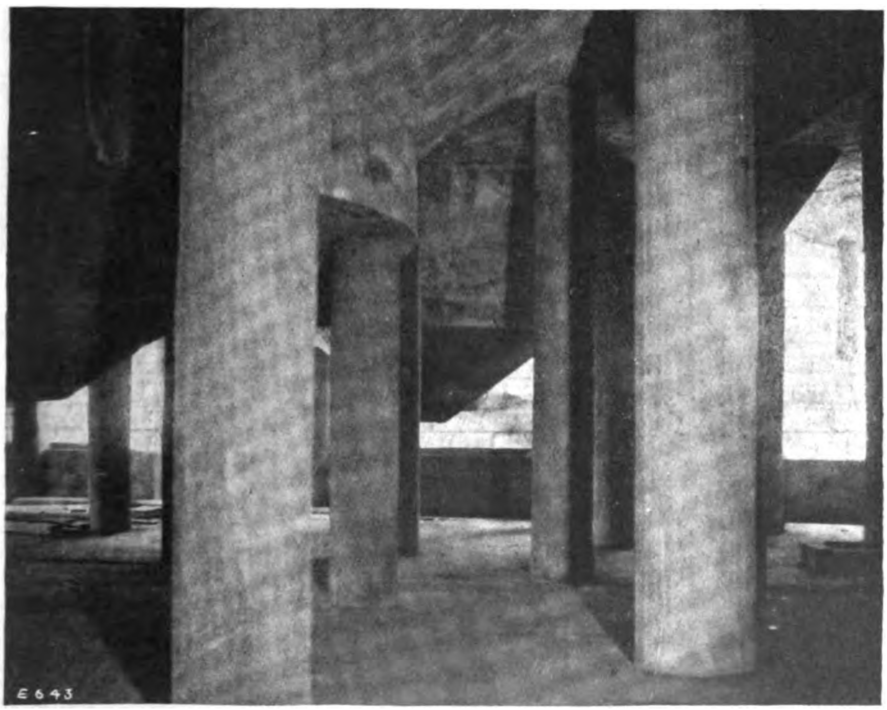


Fig. 7. Columns supporting Hoppers of Silos.
NEW NUT SILOS AND WAREHOUSES.

To facilitate drying, portions of the working floor were left open, as will be seen from *Fig.* 9, and lattice timber hoists were erected with rising platforms that allowed the concrete to be delivered direct to the level required.

The whole building is supplied with sprinkler installation as a means of protection against fire, and to supply the water for this and for the factory a large reinforced water tank, the base of which is 15 ft. above tops of silos, has been formed.

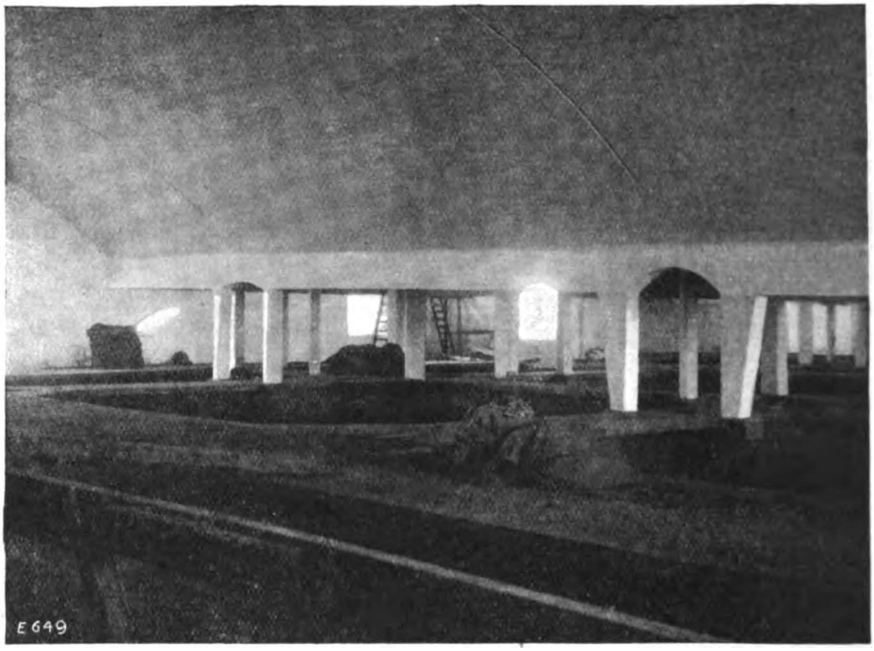


Fig. 8. Floor and Roof over Silos.

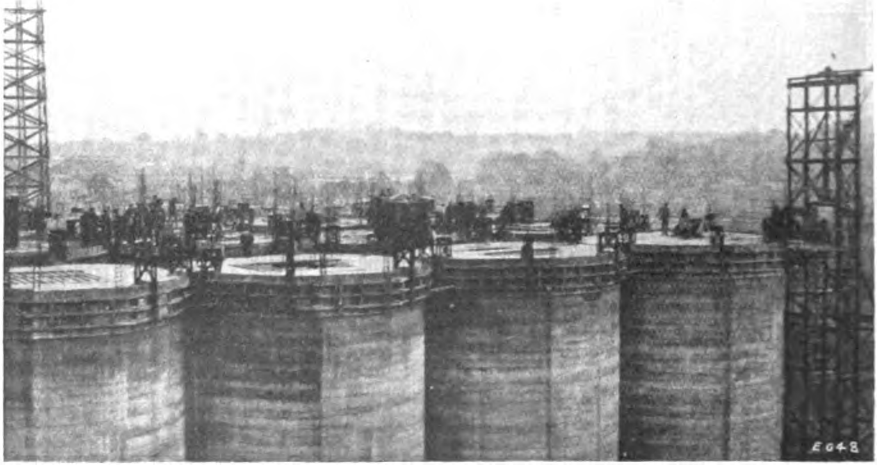


Fig. 9. Showing Centering for Silos.
NEW NUT SILOS AND WAREHOUSES.

This tank forms the roof of, and rests on, the tower which contains the belt elevators and which is built between the silos and the warehouse. Its height from foundation to top of tank is 150 ft.

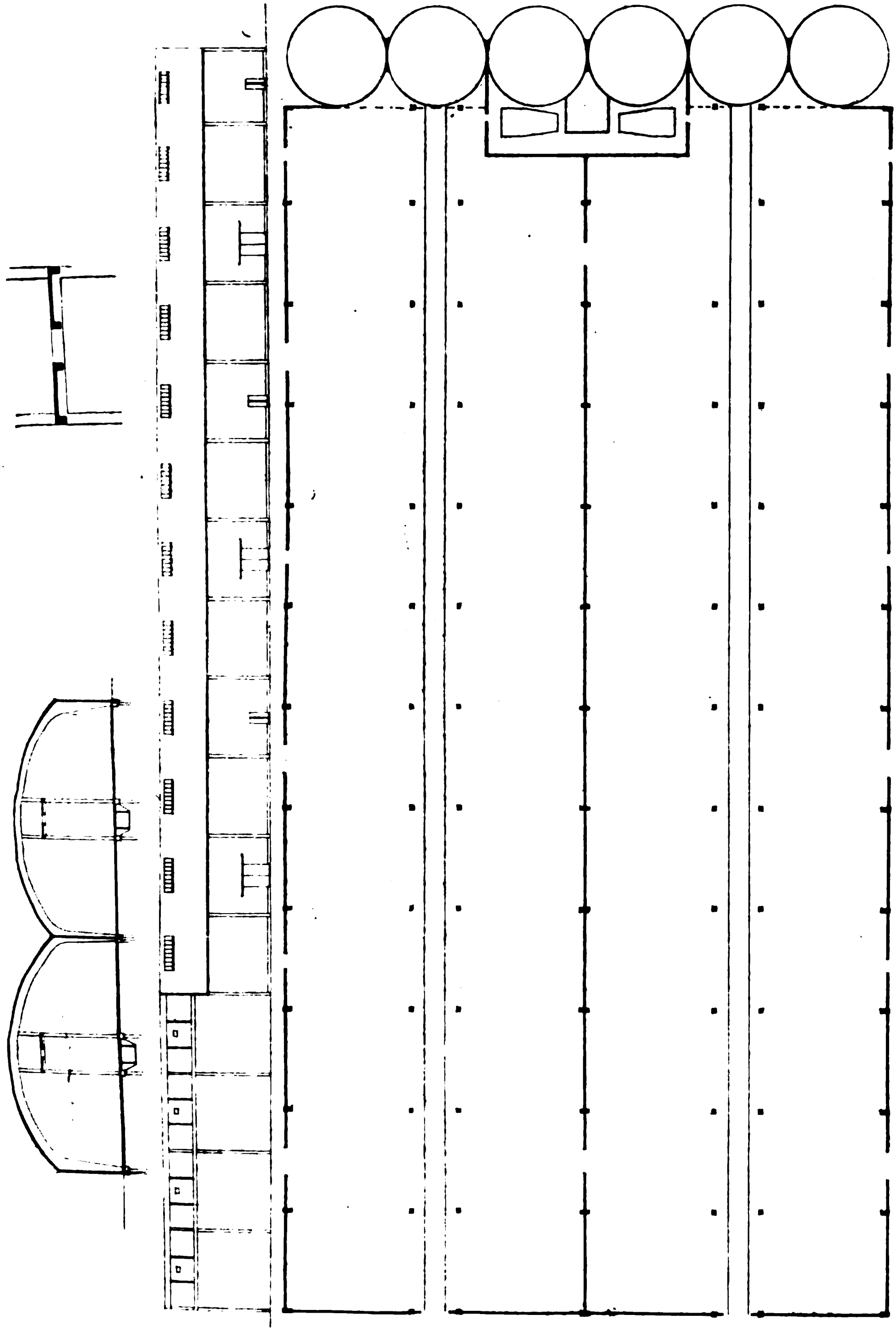


Fig. 10. Plan of Warehouse.

NEW NUT SILOS AND WAREHOUSES.

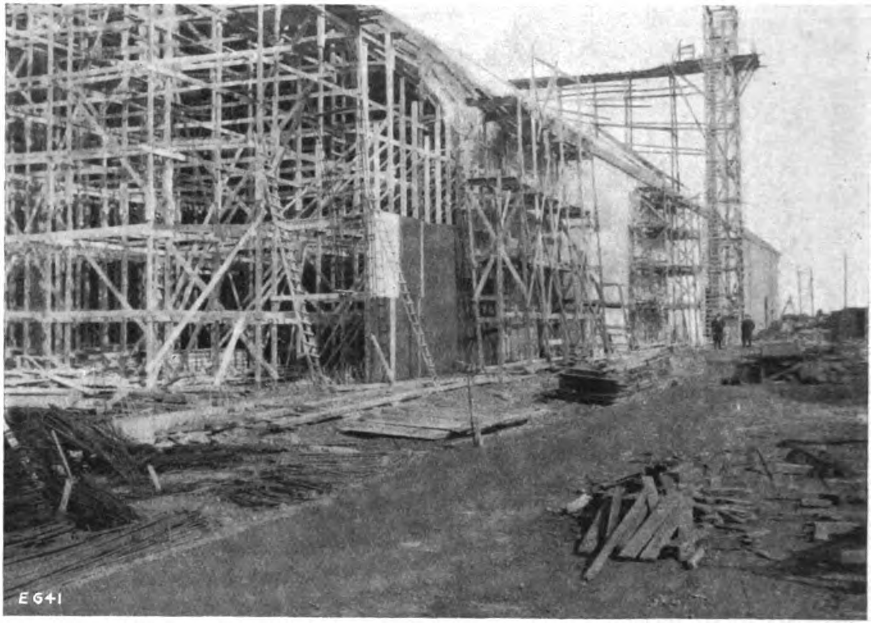


Fig. 11. Warehouses during Construction.

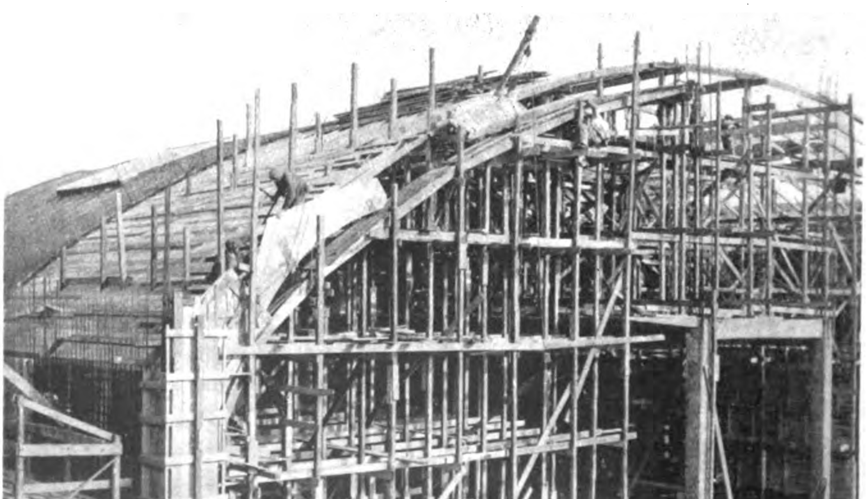


Fig. 12. Warehouses during Construction.
NEW NUT SILOS AND WAREHOUSES.

THE WAREHOUSE.

The warehouse, see *Fig.* 10, covers an area of 200 ft. by 400 ft. At one end it abuts upon the silo block and at the other upon the jetty, which will form the subject of another article.

It consists of two large halls with reinforced concrete floor slabs, each arched in a single span with reinforced concrete 4 in. thick stiffened with ribs at 33 ft. centres.

Piles were used for the foundations, and on them rests a continuous beam with piers every 33 ft., from which spring the roof ribs. These piers are 2 ft. 1 in deep and 1 ft. 2 in. wide at floor level, and regularly increase to 4 ft. 2 in. by 1 ft. 2 in. at the springing, where they continue round as roof ribs 4 ft. deep by 1 ft. 2 in. wide.

The wall filling, which is 26 ft. 3 in. high, consists of 4 in. reinforced concrete panels.

Along the centre of each hall a transporter bridge has been erected, carried by 14 in. square reinforced piers, spaced 15 ft. centres, and 33 ft. apart. The floor of this bridge is 33 ft. above level of floor of warehouse, and beneath in the warehouse floor is formed a duct for belting 8 ft. deep and 7 ft. 9 in. wide.

Iron sliding doors at ends and sides and between halls give access to the building, and lighting is effected by skylights on the roof.

The architect for the work is Mr. Percival M. Fraser, F.R.I.B.A., of 11, New Court, Lincoln's Inn, W.C., and the whole of the reinforced concrete work has been designed and carried out by Messrs. Christiani and Nielsen, of 25, Victoria Street, S.W.

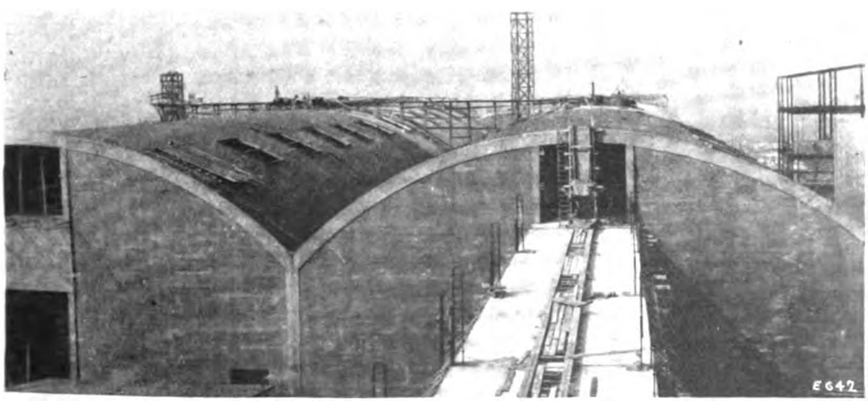
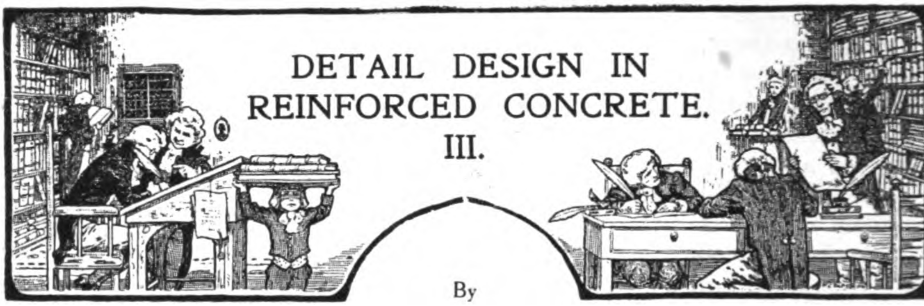


Fig. 13. Warehouse nearing Completion.
NEW NUT SILOS AND WAREHOUSES.



DETAIL DESIGN IN REINFORCED CONCRETE. III.

By

EWART S. ANDREWS, B.Sc.Eng., M.C.I.

Continued from April issue.—ED.

DESIGN OF FLOOR OF A WORKSHOP BUILDING (*contd.*).

Design of Main Beams.—In designing the main beams we have to make separate calculations for those which connect the first pillars from the walls of the building and those which connect other interior pillars, because the reactions from the end spans of the continuous secondary beams will be greater than those from interior spans.

Referring to *Fig.* 1, which we reproduce here for convenience, the beam *AD* will have to carry a heavier load than the beam *BC* because the secondary beams on the left-hand side are end spans; we will take the length of these end spans as the same as the others, namely, 25 ft.

Beam AD.

Centre dead load from reaction of right-hand secondary beam $= \frac{1}{2}$ (weight of secondary beam + weight of floor slab carried thereby)

$$= \tfrac{1}{2}\left(3{\cdot}0 + \frac{25 \times 60 \times 9}{1000}\right)$$

$$= 8{\cdot}25 \text{ kips.}$$

Ditto from reaction of left-hand secondary beam $= \frac{1}{2}$ (weight as before) $+ \dfrac{\text{Reverse B.M.}}{\text{Span}}$

$$= ({\cdot}5 + {\cdot}1)\text{ (weight as before)} = \frac{8{\cdot}25 \times 6}{5} = 9{\cdot}9 \text{ kips.}$$

$$\text{Total centre dead load} = W_d = 18{\cdot}15 \text{ kips.}$$

Centre live load from reaction of right-hand secondary beam $= \frac{1}{2}\left(\frac{25 \times 112 \times 9}{1000}\right) = 12{\cdot}6$ kips.

Centre live load from reaction of left-hand secondary beam $= \dfrac{12{\cdot}6 \times 6}{5} = 15{\cdot}1$ kips.

$$\text{Total centre live load} = W_e = 27{\cdot}7 \text{ kips.}$$

$$\text{Total load} = \text{dead load} + \text{live load} = W_t = 18{\cdot}1 + 27{\cdot}7 = 45{\cdot}8 \text{ kips.}$$

$$\text{Distributed load due to weight of beam} = \frac{20 \times 9 \times 18}{1000} = 3{\cdot}2 \text{ kips.}$$

We keep the live and dead loads separate, because in Regulation 35 we are given the maximum bending moments for distributed loads only, and these are not applicable to our case, in which the loads are central; we must, therefore, make use of Regulation

36, according to which "beams may be designed for the exact positive and negative bending moments which will occur at every cross-section, whether all the spans be loaded, or alternate, or any of the spans be unloaded."

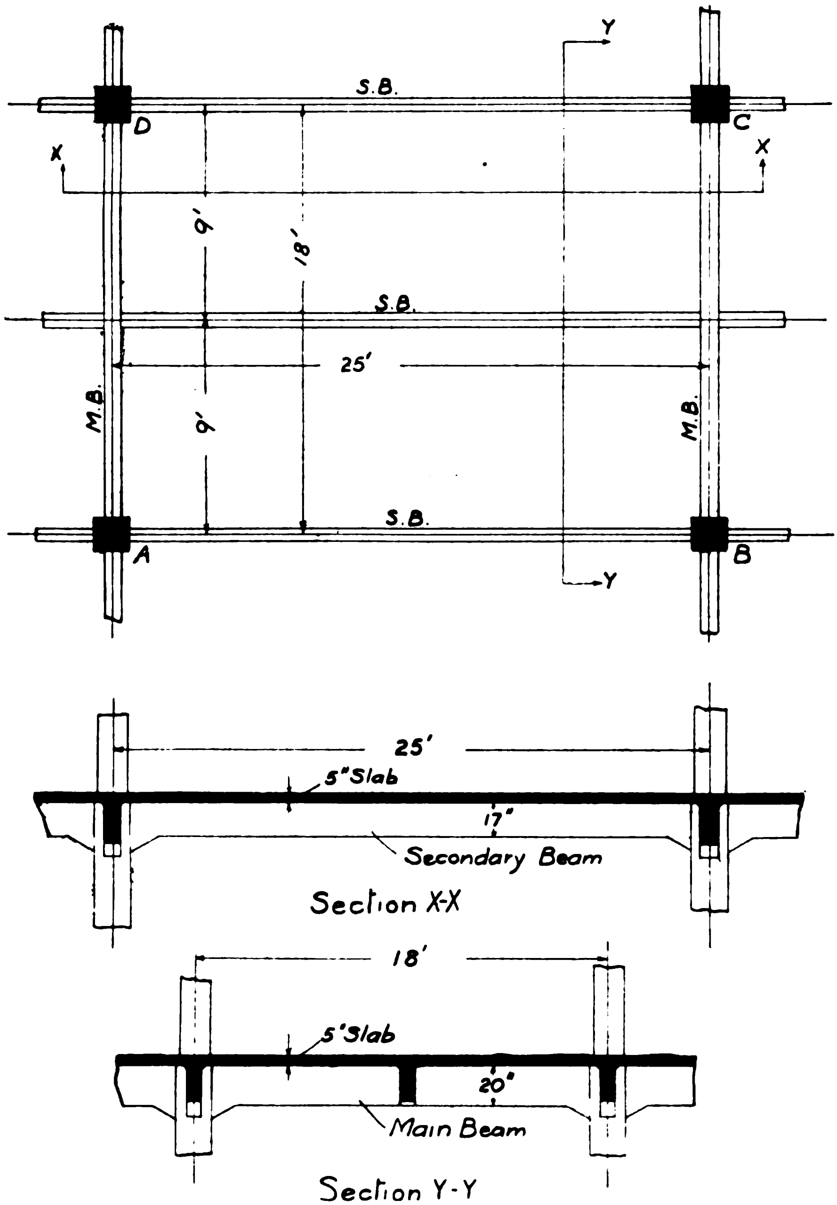


Fig. 1.
DETAIL DESIGN IN REINFORCED CONCRETE.

Before dealing further with this point we will make a preliminary calculation of the breadth of the beam, upon which we estimate the weight of it.

$$\text{Approximate end shear} = \cdot 6 \times \text{load carried} = \cdot 6 \times (18 \cdot 1 + 27 \cdot 7) = 27 \cdot 5 \text{ kips.}$$

By Regulation 66 $\frac{S}{b_r d}$ must not exceed 180 lb. per sq. in.

$\therefore \frac{27 \cdot 5}{b_r d}$ must not exceed ·18

$d = 23$ in. approx.

$\therefore b_r$ must be at least $\frac{27 \cdot 5}{\cdot 18 \times 23} = 6 \cdot 6$ in. approx.

It will be noted that we have not allowed for the splay in the value of d; this is because on account of central loading the shear is practically constant to the centre, and so the last value of d must be taken. Since this is only approximate and makes no allowance for the weight of the beam itself, and will prove narrow for getting the bars in, we will adopt $b_r = 9$ in. and check it later for the more accurate value of S.

Maximum Bending Moments to be designed for.

(*a*) *Due to Centre Loading.*—The most reliable simple formulæ for this case are those given in Faber and Bowie's book upon "Reinforced Concrete Design,"* and we have to consider separately the mid-span and end-span sections.

For mid span we have:

$$\text{Maximum positive B.M.} = +B_c = \frac{l}{16}(3W_t - W_d) = \frac{18 \times 12}{16}(137 \cdot 4 - 18 \cdot 1) = 1610 \text{ in.-kips.}$$

$$\text{Maximum negative B.M.} = -B_c = \frac{l}{16}(3W_d - W_t) = \frac{18 \times 12}{16}(54 \cdot 3 - 45 \cdot 8) = 116 \text{ in.-kips.}$$

For end-span we have:

$$\text{Maximum negative B.M.} = B_E = \frac{l}{24}(4W_t - W_d) = \frac{18 \times 12}{24}(183 \cdot 2 - 18 \cdot 1) = 1490 \text{ in.-kips.}$$

For a freely-supported span with a central load W_t we should have $B_c = \frac{W_t l}{4} = \frac{45 \cdot 8 \times 18 \times 12}{4} = 2470$ in.-kips, and some designers take the same proportion of this for continuous beams as is specified by the regulations for uniform loading. The figure $\frac{Wl}{10}$ is $\frac{4}{5}$ of the free bending moment $\frac{Wl}{8}$, and on this approximate method we should have

$$B_c = -B_E = \tfrac{4}{5} \times 2470 = 1980 \text{ in.-kips.}$$

We see, therefore, that our more accurate method of calculation allows us to adopt lower bending moments, and, therefore, results in economy of material.

(*b*) *Due to Distributed Load.*

$$\text{In this case we have } B_c = -B_E = \frac{Wl}{10} = \frac{3 \cdot 2 \times 18 \times 12}{10} = 70 \text{ in.-kips approx.}$$

*Published by Mr. Edward Arnold, London.

$$\therefore \text{ Total} + B_c = 1610 + 70 = 1680 \text{ in.-kips}$$
$$-B_c = 116 - 70 = 46 \text{ in.-kips (negligible)}$$
$$\text{Total } B_B = 1490 + 70 = 1560 \text{ in.-kips.}$$

We are now in a position to draw approximate positive and negative bending-moment diagrams for the central loads on span; these are shown in *Fig.* 11. The positive

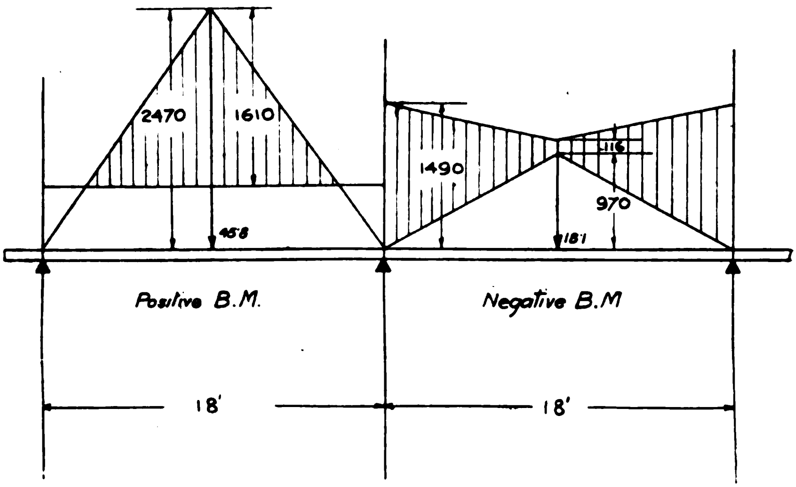


Fig. 11.
DETAIL DESIGN IN REINFORCED CONCRETE.

bending-moment diagram is shown on the left-hand side and is taken as occurring when the span is fully loaded at the centre, and the negative bending-moment diagram is shown on the right-hand side and is taken as occurring when the span carries the dead load only at the centre. The closing line of each diagram is assumed to be straight, and this assumption will not lead to serious error.

Steelwork Required.

(*a*) *Centre Section.*—We may take $d = 20 + 5 - 2 = 23$ in.; $b = 54$ in. (¼ span, in accordance with regulation 82 (*a*)).

$$\therefore \frac{B}{b_r d^2} = \frac{1680 \times 1000}{54 \times 23 \times 23} = 58{\cdot}8$$

By means of the diagram of *Fig.* 7 (see April issue, p. 190) for $s_t = \frac{5}{23} = {\cdot}218$, we see that the stress in the concrete will be within safe limits, and that the lever-arm ratio a_1 may be taken as ·912.

$$\therefore \text{ Area of tensile reinforcement required} = A = \frac{B}{ta_t d}$$

$$= \frac{1680}{16 \times {\cdot}912 \times 23} = 5 \text{ sq. in. approx.}$$

From Table 1 we see that 5 − 1⅛ϕ, giving $A = 4{\cdot}97$, or 8 − ⅞ϕ, giving $A = 4{\cdot}81$, will be suitable; we will adopt the smaller bars, because they will give us more bars to bend up for shear.

Checking back the effective depth from the necessary cover, and taking two rows ⅞ apart, to enable the bars from the secondary beams to pass through, we shall have $d = 25 - (1 + \frac{7}{8} + \frac{7}{16}) = 22{\cdot}7$ in.; this is near enough for all practical purposes to the 23 in. which we have taken in our calculations.

(*b*) ***End Section.***—In this case, allowing for the splay we may take $d=30$ and $b=9$, and we have to design for a bending moment of 1560 in.-kips.

$$\therefore \text{ We have } \frac{B}{bd^2} = \frac{1560 \times 1000}{9 \times 30 \times 30} = 192$$

This is above the figure of 150 which we have previously given as representing the approximate limit of economy in allowing for the strength of the concrete in accordance with Regulation **61**; but, as the method of calculation in accordance with that regulation is of interest, we will explain how to proceed in the present case.

Assuming that the steel is stressed to 16000 lb. per sq. in., and the concrete to 600 lb. per sq. in., we shall have the stress diagram shown in *Fig*. 12, the depth of neutral axis being $\cdot 36d = 10\cdot 8$ in., and, as the centre of the compression steel will be about 2·3 in., the stress in concrete at that point will be equal to $\frac{600 \times 8\cdot 5}{10\cdot 8} = 472$ lb. per sq. in., and the distance between reinforcements = 27·7 in.

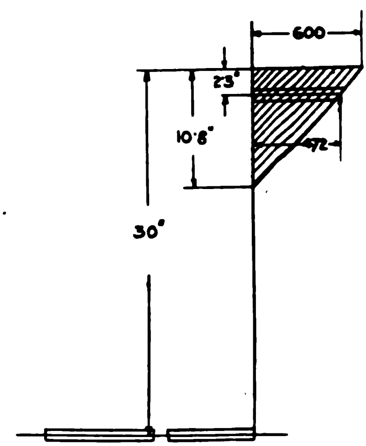


Fig. 12.

DETAIL DESIGN IN REINFORCED CONCRETE.

$\therefore$ Stress in compression steel $= 15 \times 472 =$ 7,100 lb. per sq. in. $= 7\cdot 1$ kips per sq. in.

B.M. carried by concrete $= 95\ bd^2 = \frac{95 \times 9 \times 30 \times 30}{1000}$ $= 770$ in.-kips.

$\therefore$ B.M. to be carried by compression steel = 1,560 − 770. = 790 in.-kips.

$\therefore$ Area of compression steel required $= \frac{790}{7\cdot 1 \times 27\cdot 7}$ $= A_c = 4$ sq. in.

Total compression $= \frac{9 \times 10\cdot 8 \times 600}{2} + 7100 \times 4 =$ 57600 lb.

$$\therefore \text{ Area of tension steel required} = A_T = \frac{57600}{16000} = 3\cdot 6 \text{ sq. in.}$$

This method is not quite exact, since the additional steel adopted to strengthen the section will alter the position of the neutral axis. Since this is a question of considerable interest and some divergence in practice, we will find the true position of the neutral axis for this case and then determine the safe bending moment.

The writer's method of determining this neutral axis depth is as follows: Find the position of the centroid of the combined reinforcement; this gives us the equivalent depth of beam.

$$d_e = 2\cdot 3 + \frac{4}{7\cdot 6} \times 27\cdot 7 = 16\cdot 8 \text{ in.}$$

$$\text{equivalent reinforcement ratio} = r_e = \frac{7\cdot 6}{16\cdot 8 \times 9} = \cdot 0503$$

equivalent neutral axis depth ratio:

$$= n_{ce} = \sqrt{(m^2 r_e^2 + 2\, m r_e)} - m r_e \qquad \text{[Regulation 87]}$$

$$= \sqrt{15^2 \times \cdot 0503^2 + 30 \times \cdot 0503} - 15 \times \cdot 0503$$

$$= \cdot 69$$

$$\therefore n = \cdot 69 \times 16\cdot 8 = 11\cdot 6 \text{ in.}$$

This is in place of the 10·8 in. which we have assumed in our calculations.

To calculate the safe bending moment we find the equivalent moment of inertia about the neutral axis; this gives

$$I_B = \frac{9 \times 11{\cdot}6^3}{3} + 15 \times 3{\cdot}6 \times (30 - 11{\cdot}6)^2 + 14 \times 4 \times (11{\cdot}6 - 2{\cdot}3)^2$$
$$= 27810 \text{ in. units.}$$

$$\therefore \text{ Safe B.M. for concrete} = \frac{cI_B}{n} = \frac{600 \times 27810}{1000 \times 11{\cdot}6}$$
$$= 1440 \text{ in.-kips.}$$

$$\text{Safe B.M. for steel} = \frac{tI_B}{m(d-n)} = \frac{16000 \times 27810}{15 \times 18{\cdot}4}$$
$$= 1610 \text{ in.-kips.}$$

This gives the result, as we should expect, that the lowering of the neutral axis throws higher stress on to the concrete.

As we have pointed out, we should not in general practice go into this calculation at this length because $\frac{B}{bd^2}$ exceeds 150, but we should avail ourselves of Regulation 62.

By this method of calculation we shall have equal compression and tension steel at a lever-arm of $a = 30 - 2{\cdot}3 = 27{\cdot}7$ in.

$$\therefore \text{ Steel required at top and bottom} = \frac{1560}{16 \times 27{\cdot}7}$$
$$= 3{\cdot}52 \text{ sq. in.}$$

$$\therefore \text{ Adopt } 6 - \tfrac{7}{8}\phi \text{ giving } A = 3{\cdot}61$$

This value of a will err on the safe side.

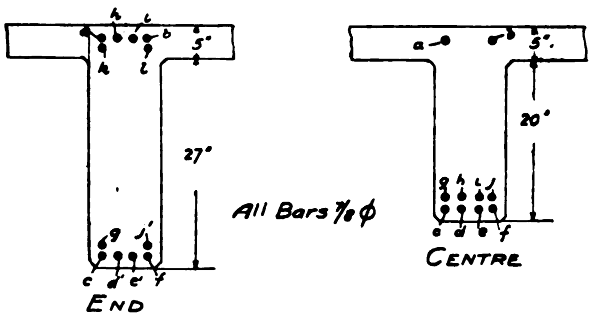


Fig. 13.
Detail Design in Reinforced Concrete.

Fig. 13 shows the section at centre and ends.

Shear.—In this case the shear diagram for a loaded span comes as shown in *Fig.* 14 and the design of the shear reinforcement will follow the same method as described for the secondary beams. Restrictions of space prevent us from giving these calculations in detail, but it may be noted that the spacing of the shear members should be practically constant.

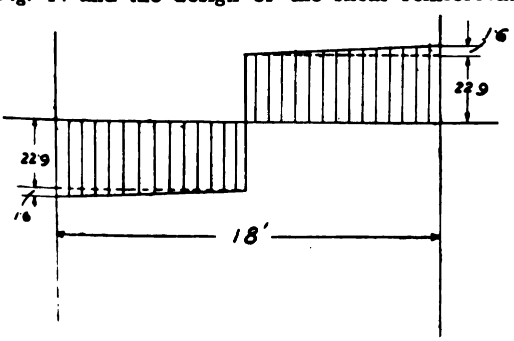


Fig. 14.
Detail Design in Reinforced Concrete.

In the detail arrangement of the steel, two top bars, a, b, and three bottom bars, c, f, g, could go right through, the remaining bottom bars at the end projecting through from the previous span. The bar

j could be bent up for shear, the bars h, i bent up and pass right through, while the bars k, l could be bent down for shear and pass right through the next span.

Beam B C.—As we have previously stated, the central loads on this beam will be less because the secondary beams running into it are not end spans.

We shall have:

$$\text{Centre dead load} = W_d = 2 \times 8{\cdot}25 = 16{\cdot}5 \text{ kips.}$$
$$\text{Centre live load} = W_e = 2 \times 12{\cdot}6 = 25{\cdot}2 \text{ kips.}$$
$$\text{Total centre load} = W_t = 41{\cdot}7 \text{ kips.}$$
$$\text{Distributed load as before} = 3{\cdot}2 \text{ kips.}$$

Max. positive B.M. at centre due to centre load

$$= \frac{l}{16}\left(3\,W_t - W_d\right)$$
$$= \frac{18 \times 12}{16}\left(125{\cdot}1 - 16{\cdot}5\right)$$
$$= 1470 \text{ in.-kips.}$$

Mag. negative B.M. at ends due to centre load

$$= \frac{l}{24}\left(4\,W_t - W_d\right)$$
$$= \frac{18 \times 12}{24}\left(166{\cdot}8 - 16{\cdot}5\right)$$
$$= 1350 \text{ in.-kips.}$$

The B. M. for the distributed load comes approximately 70 in.-kips as before, so that we have

$$\text{Design B.M. at centre} = +1540 \text{ in.-kips}$$
$$\text{Design B.M. at ends} = -1410 \text{ in.-kips.}$$

Similar calculations to the previous will show that $8 - \frac{7}{8}\phi$ are required at the centre, but that we can do with $5 - \frac{7}{8}\phi$ at top and bottom at the ends.

We will consider next the design of a pillar for the same building.

(*To be continued.*)

CONCRETE AS A WAR ECONOMY.

What the Government Thinks.

Questions were asked in the House of Commons on April 2nd and on May 1st, May 3rd, and May 15th on this important matter: On April 2nd (see Parliamentary Debates, Vol. XCII. No. 35, columns 954, 955); on May 1st (see Parliamentary Debates, Vol. XCIII. No. 48, columns 200, 201); on May 3rd (Vol. XCIII. No. 50, column 474); on May 15th (Vol. XCIII. No. 58, columns 1,467, 1,468, 1,469).—ED.

It is very rare to find a special interest taken in a technical subject in the House of Commons, either in debate or at question time, but the great necessity of economising our timber supplies has brought forth a series of most interesting questions and replies on the matter of timber substitutes, and having very special bearing on the use of concrete. These questions and replies, as far as we have been able to gather them, we present below, and it is with great satisfaction that we observe the encouraging attitude taken by the various Departments of the Government in applying concrete to general uses in these times of stress. It will be easily realised that once the introduction of concrete has become general its economy and advantages will be fully recognised, and there is no likelihood of our reverting to antiquated materials.

THE CHANCELLOR OF THE EXCHEQUER.

Sir E. Lamb asked the Chancellor of the Exchequer (April 2nd) whether he can see his way to notify the various spending Departments of His Majesty's Government of the advantages of utilising wherever possible concrete, comprising local aggregates with home-made binding materials, in lieu of timber, which has to be largely carried by sea or rail; whether he is aware that the life of concrete is naturally longer than that of timber; that the cost of maintenance of temporary buildings constructed of concrete is a negligible item, whilst the cost of maintaining timber structures is often heavy; and that concrete fence posts, telegraph posts, and similar accessories are to-day cheaper than timber fence posts, telegraph posts, etc.; and whether he can see his way to set up a small technical committee to advise the spending Departments, the railway companies, the factory owners, and the public generally how best to effect substantial economies by using local aggregates and home-made binding materials, whereby money would be kept in the country and a substantial amount of tonnage, railway freight, and cartage released for purposes of national importance.

Sir Alfred Mond, Bart. (for the Chancellor of the Exchequer): My right hon. friend has asked me to reply to this question. The various Departments of His Majesty's Government concerned in the erection of permanent or temporary buildings are well aware of the advantages of concrete, both as regards initial expense and the subsequent charges for maintenance. A Cabinet Instruction has already been issued as to the necessity of avoiding the use of timber wherever possible. In view of the fact that all building operations are now restricted to those sanctioned by a Government Department and that all the Departments concerned are alive to the necessity for utilising substitutes for timber in the cases mentioned, I do not think that any useful purpose would be served by the appointment of a technical advisory committee such as is suggested.

THE WAR OFFICE.

Temporary Buildings, etc.

Sir E. Lamb asked the Financial Secretary to the War Office (on April 2nd) whether any steps are to be taken by the Director of Timber Supplies to obtain a substantial reduction of the timber employed in the United Kingdom by encouraging the use of such substitutes as concrete and reinforced concrete in the construction of temporary buildings used for war purposes; and whether any similar steps will be taken to encourage a more general use of reinforced concrete for telegraph poles, fence posts, railway sleepers, and pit props, etc., by circulating particulars of the satisfactory experience obtained in the United States and several Continental countries.

Mr. Forster (War Office): The use of concrete and ferro-concrete as a substiture for timber in the construction of buildings, and for railway and colliery purposes, has been receiving careful attention for some time past. I will consider the suggestion made in the last part of the question.

Sir E. Lamb asked the Financial Secretary to the War Office (May 1st) whether any steps have now been taken to notify to the railway companies conducted under War Office control that a Cabinet Instruction has been issued as to the necessity of avoiding the use of timber wherever possible; and whether any steps have been taken to point out the advantages of using concrete in lieu of timber for railway sleepers (on sidings), signal and telegraph posts, gate posts, and fence posts, as successfully applied on several of the railway companies in the United Kingdom, in the United States, and in certain Continental countries.

Mr. Forster (War Office): The necessity of exercising economy in the use of imported soft wood for railway purposes has been impressed upon the Railway Executive Committee, and the Committee has lately pointed out to the various railway companies the desirability of substituting concrete for timber wherever possible.

Sir E. Lamb asked the Under-Secretary of State for War (on May 15th) whether, having regard to the Cabinet Instruction that timber is to be economised, he will explain why timber is still being employed for the extensive external wall surfaces of the various aircraft supply stores now being erected for the Royal Flying Corps in the North-West of London and in various provincial centres; and, having regard to the purpose to which these buildings are to be put, he will consider the advantage of utilising a material of some fire-resistance, such as a non-proprietary concrete slabbing, rather than timber weather boarding.

Mr. Macpherson (War Office): Fire-resisting material is, as far as possible, being substituted for timber in all buildings in course of construction for the Royal Flying Corps except in cases where the work was nearing completion or the contract too far advanced before the issue of the instruction to which my hon. friend refers.

H.M. OFFICE OF WORKS.

Sir E. Lamb asked the First Commissioner of Works (April 2nd) whether he can see his way to take steps to employ, to a greater extent than heretofore, concrete and reinforced concrete for the numerous buildings which are being erected by his Department for war purposes, so that a substantial economy may be effected in the amount of timber utilised; and whether he is aware that concrete hollow blocks, concrete, and reinforced concrete are non-proprietary products, comprising to the extent of about two-thirds of their bulk local aggregate, such as gravel, ballast, or stone, and that a material economy in transportation would be effected by a more general use of such materials in lieu of timber.

Sir A. Mond, Bart. (Office of Works): My Department has for many years past resorted to the use of reinforced concrete for buildings erected under its supervision, and since the War has used not only that method of construction, but also concrete slabs and brickwork for constructional purposes in suitable instances in lieu of timber, and from inquiries which I have made I am satisfied that no further substantial economy can be effected in this direction. The reply to the latter part of the question is in the affirmative.

THE BOARD OF TRADE.

Concrete Railway Sleepers, Pit Props, etc.

Sir E. Lamb asked the President of the Board of Trade (May 1st) whether he is aware that a Cabinet Instruction has been issued as to the necessity of avoiding the use of timber wherever possible; whether any steps have been taken to advise the railway companies of this instruction and the advantages of substituting concrete for timber for railway sleepers on sidings, signal and telegraph posts, gate posts, and fence posts; and whether other corporations coming within the purview of his Board during the war have received recommendations on this point.

The Parliamentary Secretary to the Board of Trade (Mr. G. Roberts): I understand that the Railway Executive Committee and other bodies have been approached on behalf of the War Office with a view to secure that substitutes shall be used for timber whenever possible.

Mr. Fell asked the President of the Board of Trade (May 3rd) if he has come to any decision with regard to the encouragement of the making of pit props of reinforced concrete for collieries; and if he proposes to accept the offer made from Great Yarmouth to make such concrete pit props at cost price, and load them in the coal wagons which have conveyed coal to that port, so that these wagons should not return empty to the collieries.

Mr. Roberts (Board of Trade): The Controller of Coal Mines is fully alive to the desirability of extending the use of concrete pit props as widely as possible, but there are various technical difficulties to be considered. The whole subject is being investigated, and the offer to which the hon. member refers has not been overlooked.

Mr. Fell: Cannot a decision be given shortly, because it is nearly a month since this question was raised?

Mr. Roberts: It is being closely watched. In certain mines the substitutes are already in use, and as soon as we can get a suitable type we shall get into communication with the available sources of supply.

THE GENERAL POST OFFICE.

Concrete Telegraph Poles.

Sir E. Lamb asked the Postmaster-General (May 1st) whether he is aware that a Cabinet Instruction has been issued as to the necessity of avoiding the use of timber wherever possible; whether he is aware that concrete poles are now cheaper than timber poles; whether any steps have been taken to utilise concrete in lieu of timber for the large numbers of telegraph poles annually erected or re-erected in the United Kingdom by his Department; and whether he is aware that such telegraph poles are largely used in France, Switzerland, Italy, and in the United States.

The Postmaster-General (Mr. Illingworth): I am aware of the Cabinet Instruction to which the hon. member refers. The use of concrete or ferro-concrete poles in place of wood poles has been considered several times, but hitherto it has been found that the cost is prohibitive. It has not been necessary to reopen the question since the outbreak of war because the construction of pole lines has been so limited that the existing stocks of poles have been generally sufficient to meet Post Office requirements. I do not expect to make further purchases for some time to come, but I will not fail to keep in mind my hon. friend's suggestion.

THE HOME OFFICE.

Mines.

Sir E. Lamb asked the Secretary of State for the Home Department (May 1st) whether he is aware that a Cabinet Instruction has been issued as to the necessity of avoiding the use of timber wherever possible; and whether any steps have been taken to encourage mine owners to use concrete pit-props, etc., in lieu of timber, as largely used in the United States.

Mr. Brace (Home Office): Yes, sir; the question of economy in the use of timber in mines has been receiving attention for some time. Owners have been urged to use substitutes, such as concrete, as far as possible, and I understand this is being done to a considerable extent.

THE MINISTRY OF SHIPPING.

Concrete Sea-Going Barges.

Sir E. Lamb asked the Parliamentary Secretary to the Shipping Controller (on May 15th) whether he is aware of the Cabinet Instruction as to limiting the use of timber wherever possible; whether he is aware that reinforced concrete sea-going barges have been used to a considerable extent in Italy and that reinforced concrete ships are being built in Norway; and whether any endeavour is being made that any new barges or minor hulls which may be required, both for sea, river, and harbour, should in future be constructed of reinforced concrete rather than of timber.

The Parliamentary Secretary to the Ministry of Shipping (Sir Leo Chiozza Money): The Shipping Controller is aware of the necessity for limiting the use of timber, and due regard has been had to this fact in connection with his shipbuilding programme. The possibilities of reinforced concrete are being carefully examined, and tenders and plans for the construction of barges of various types are already in preparation.

THE CANALS COMMITTEE (Board of Trade).

Concrete Canal Barges.

Sir E. Lamb asked the President of the Board of Trade (on May 15th) whether the Committee on Canals is aware of the Cabinet Instruction that has been issued as to the necessity of avoiding the use of timber wherever possible, and has taken steps to arrange for such new barges as may be required to be constructed of reinforced concrete in order to save timber; and whether he has particulars of reinforced concrete barges used in Italy and could have information circulated among those concerned.

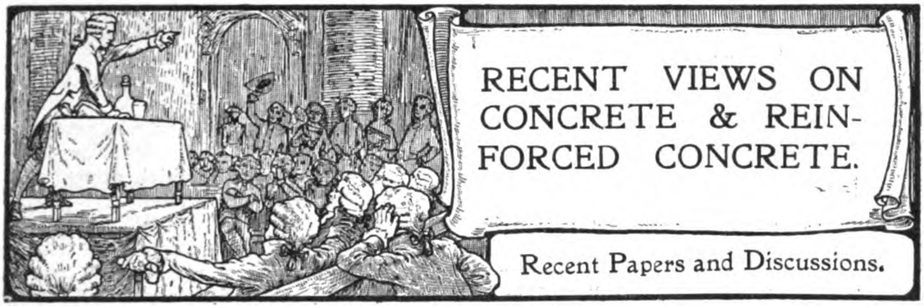
Mr. Roberts: The Canal Control Committee are, I think, fully aware of the desirability for economy in the use of timber and of the possibility of substituting reinforced concrete for timber for certain purposes, including the building of barges.

THE MINISTRY OF MUNITIONS.

Minor Uses of Concrete in Factories.

Sir E. Lamb asked the Minister of Munitions (on May 15th) whether, having regard to the Cabinet Instruction that economy is to be practised in the use of timber, any endeavour is being made to circulate information or popularise the use of concrete and reinforced concrete for the simple minor uses in controlled factories, as well as for the construction of the actual buildings, as, for example, for railway sleepers used on sidings, electric transmission poles, fence posts, shelters, latrines, and troughs.

The Parliamentary Secretary to the Ministry of Munitions (Sir L. Worthington Evans): The Ministry of Munitions have pressed for the use of concrete and reinforced concrete wherever possible, in order to economise the use of steel for constructional purposes, and the present scarcity of timber, as well as of steel, renders the necessity of employing concrete still more urgent. I may add that, in making application for a building licence applicants have to state their readiness or otherwise to use reinforced concrete, and this is one of the points taken into consideration in dealing with these applications.



It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.—ED.

THE CONCRETE INSTITUTE.

A METHOD OF PROPORTIONING MATERIALS FOR CONCRETE.

With the report of tests of the method compared with the usual style of giving proportions of materials.

By H. C. JOHNSON, University College, Cork.

The following is an abstract from a Paper read before the Concrete Institute at their meeting of April 26th, together with a short report of the discussion which followed. We would also refer our readers to our issue of February, 1915, vol. X., p. 85, in which an article was published by Mr. Johnson entitled, "What is a 1:2:4 Concrete," and to which this paper is complementary.

OUTLINE OF METHODS AND TESTS RESULTS.

A COMPARISON is here made of the usual 1 : 2 : 4 method of proportioning concrete with one in which, no matter what the aggregates may be, the quantity of cement in the finished material remains the same for any given volume.

The percentage of dry cement, by volume, contained in the extremes of 1 : 2 : 4 concrete will vary all the way from 18 per cent. to as high as 24 per cent.

The proposed method ensures a constant percentage of cement in the neighbourhood of 20-21 per cent., and a specification based on the method would do at least two things :—

(*a*) Demand that exactly the same quantity of cement should enter a structure, whether it be built with gravel as the aggregate, or with broken stone as the aggregate. (Such would not be the case when it is specified that 1 : 2 : 4 must be the proportions.)

(*b*) Give a contractor or any other person the correct volume, and therefore the correct weight, of cement, that the volume of the concrete in the structure will demand.

Another part of the method is that some large aggregates are given less sand than others, therefore the ratio of sand to large aggregate is not in the proportion of 2 to 4, but depends on the " workability " and weight per cubic foot of the concrete. It demands that actual tests to determine the proportions shall be made of those materials which it is intended shall go into the job, and therefore prevents an excess of fine stuff being used, as would otherwise be the case.

The tests show that the weight per cubic foot is increased from 2 to 3 lbs., while in one or two cases the addition in strength is as great as 500 lbs. per sq. inch at 28 days. In other cases there is an addition in strength even when less cement is used.

DETAILS OF METHOD AND TESTS.

It is well known that gravel and some other concretes, when mixed 1 : 2 : 4 are not as strong as hand broken stone concretes, also that the larger the aggregate, other things being equal, the stronger the concrete.

A. 1 : 2 : 4 gravel concretes are, on the average, about 12-15 per cent. weaker than stone concretes. They contain also, on the average, 10-15 per cent. less cement.

B. ¾ inch aggregate concrete is stronger than ¼ inch aggregate concrete, while 1½ inch aggregate concrete is stronger than either. The ¼ inch aggregate has 500 per cent. greater surface for its volume than the 1½ inch aggregate.

It was because of the above differences, A and B, that the writer was prompted to make the tests included in this paper, and the first outlet for results was found by writing an article, entitled, "What is a 1 : 2 : 4 Concrete?" which appeared in the February, 1915, issue of CONCRETE AND CONSTRUCTIONAL ENGINEERING. In that article it was pointed out that by mixing concrete for two jobs of exactly the same size and volume, one, using gravel as aggregate, would call for 100 tons of cement, while the other, using broken stone as aggregate, would require 130 tons of cement. In spite of this there are a great many who believe that all 1 : 2 : 4 concretes contain the same amount of cement per unit volume, and therefore ought to be, in so far as cement content is concerned, of the same strength.

Since the article mentioned above was written to describe the results of tests made to determine the different percentages of cements in 1 : 2 : 4 concretes in which different aggregates were used, and therefore thoroughly covers the ground leading up to the actual crushing tests mentioned later, the author quoted some parts of the article almost word for word.*

In summing up the points contained in the table No. 1 no use will be made of Nos. 1, 8 and 9, because they are not 1 : 2 : 4 concretes in the strict sense, although many have been guilty of so considering them—guilty because even departures from rule-of-thumb methods, which are often satisfactory, must not be made to satisfy theory without first proving theory to be correct practically. The table illustrates the following facts :—

(*a*) 1 : 2 : 4 concrete No. 10 contains 29 per cent. more cement than 1 : 2 : 4 concrete No. 2.

(*b*) Stone concretes on the average contain 10 per cent. more cement than gravel concretes. It is therefore not fair to expect gravel concretes to be as strong as stone concretes. ("American Civil Engineer's Pocket Book" notes that gravel concretes at one year are 9 per cent. weaker than stone concretes.)

(*c*) The percentage of voids in gravel being smaller than in stone, less sand should be used: 1½ parts sand (on the average) to 4 parts gravel will produce a concrete worked as easily as, if not more easily than, 2 sand to 4 stone.

(*d*) Gravel passed through and retained on screens as used for stone *always* have less voids; the popular idea is that they would be the same. It can be admitted that if stone could be "hand placed" into a receptacle, a very small percentage of voids would result. This indicates that stone concretes, unless they had considerable sand (2 to 4), would not be so reliable as gravel in the matter of density.

(*e*) Gravel concretes mixed 1 : 2 : 4 are 3 lb. per cubic foot lighter than stone concretes. Proper proportioning will easily make up this 3 lb., in spite of the fact that the specific gravity of gravel is only 2·51, as against 2·70 for stone.

GRAVEL AGGREGATES *versus* STONE AGGREGATES.

I speak of gravel concrete having suffered for years because when mixed 1 : 2 : 4 it is not usually so strong as broken stone concrete; this is because many engineers will not look at gravel as an aggregate if they can get broken stone. If I have succeeded in showing that it is not fairly treated in the matter of cement content, and if, later on, I also succeed in showing that it is unfairly treated in the matter of sand in combination with it, I shall believe that it will be considered equally as good as, if not better material than, broken stone.

That it is as efficient as it is, is due to the fact that it adjusts itself and "flows" more easily than broken stone and is, therefore, the more reliable material where used by unskilled labour since it is less liable to form "pockets."

It would seem, from the above, that I am out in the interests of gravel aggregates, but if we were to confine ourselves to a comparison between hand or large broken stone and the usual form of machine crushed stone, I would feel called upon to defend

* We refer our readers to our issue of February, 1915, page 85 (Vol. X.).

the crushed stone in a somewhat similar manner, because it would have a smaller percentage of voids than the other and in a mixture of 1 : 2 : 4 would produce more concrete and therefore contain less cement. It is well known that the larger aggregates have higher strength—the greater cement content is one reason for this, while the fact that the surface area (to be cemented together) is less for an equal solid volume is the other reason.

LARGE AGGREGATES *versus* SMALLER AGGREGATES.

If we can, let us consider ourselves small enough to be able to wander about in the interstices of two different mixes of concrete—in one case a large aggregate concrete and the other a smaller aggregate concrete.

We would find in each case that small globules of air had attached themselves to the surfaces of all the materials making up the concrete, we would also find that owing partly to the "bridging" of all the particles and partly to insufficiency of very fine material there would be other passages and cul-de-sacs, then there would be some particles of cement engaged in sticking to the surface of the inert material, while still other particles would be sticking together in pairs and in threes and fours.

In the large aggregate concrete we would find that owing to the smaller surface area per unit volume of each piece there would be less cement adhering to the inert material and more cement particles in contact with one another. There would also be a smaller total length of passages and cul-de-sacs.

Now I suggest we assume that each cement particle where it comes into contact with inert material has an *adhesive* value of one, but where it comes into contact with another cement particle it has a *cohesive* value of two or thereabouts. If then we have a smaller surface area per unit volume in one aggregate than another we must have a greater *cohesive* value and therefore greater strength.

The above would suggest the use of particles of aggregate as nearly spherical as possible, and while this, providing they were properly graded to fit into corresponding interstices, would be a reasonable thing to do, there still remains the fact that more or less slab-like material, if strong, has a reinforcing action and is, perhaps, of considerable value. On the other hand, this same slab-like material, if at all pyramid-like, may cause a wedging action under stress. It has been proved, however, in over 20,000 tests in America that there is no difference between "sharp" sand and sand of a spherical shape; of course the same may not apply in the case of the large aggregate. A test of concrete made of marbles, such as we used in our schoolboy days, with another using cube-like material, might throw some light in this direction and while unpractical would give valuable theoretical information.

Large aggregates should have large sand while smaller aggregates should have small sand. Even very fine sand, if of first quality, will give a concrete as strong as one with coarse sand if properly proportioned, *i.e.*, less of it used, which will be the case if the correct proportions are found by a trial mix in which one must aim at producing the *heaviest* concrete using those materials.

Having now decided two things—(*a*) that any concretes made up for comparative test values of different aggregates should all contain the same percentage of cement, and (*b*) that some large aggregates do not require so much sand as others, we (in the University Laboratory, Cork) proceeded to make up what we were pleased to call "Corrected Concretes" and also 1 : 2 : 4 concretes for comparisons of cement content and strength. We asked some of the stone and gravel merchants for materials and a cement company for cement, all of which were willingly supplied.

We made up over 700 specimens and started to test at one month, when we discovered great variations, far greater than were expected. The cement had been tested by taking from one bag in four and it came out well, but upon testing the remainder of the bags individually we found no two bags alike. Certainly some were approximately the same in strength, but between the best and worst the following differences were shown :—

	7 days paste.	28 days paste.	7 days mortar.	28 days mortar.
Cement, Bag A	360	640	175	285
,, ,, B	470	630	240	380

Average of three in each case.

As a result of this we had to discard the whole of those 700 specimens.

TABLE I.

No. of Mix.	Large Aggregate and per cent. Voids.	Small Aggregate and per cent. Voids.	Loose Volumes. Large Aggregate.	Loose Volumes. Small.	Loose Volumes. Cement.	Finished Volumes.	Weight per cu. ft. Wet.	Cement in Finished Volumes of Concrete. By Ratio.	Cement in Finished Volumes of Concrete. By per cent.	—
	GRAVELS.						lb.			
1	Gravel as from river (33 per cent.)	None	6	—	·1	6·0	118	1 to 6·0	16·70	*Gravel Concretes* (excepting Nos. 1 and 8.)—Average per cent. cement = 18·85; average per cent. voids = 38½; average weight per cu. ft. = 143½ lb.
2	Gravel, ¾"–⅛" (38 per cent.)	Sand from gravel, ⅛"–$\frac{1}{78}$" (40 per cent.)	4	2	1	5·6	140	1 ,, 5·6	17·90	
3	Gravel, ⅛"–⅜" (42½ per cent.)	Ditto	4	2	1	5·25	143	1 ,, 5·25	19·10	
7	Gravel, ¾"–⅛" (43 per cent.)	Sand from gravel, ⅛"–$\frac{1}{20}$" (44 per cent.)	4	2	1	5·10	144	1 ,, 5·10	19·60	
8	Gravel, ¾"–⅛", less ⅛"–⅜" material (35½ per cent.)	Sand from gravel, ⅛"–$\frac{1}{78}$" (40 per cent.)	4	2 parts 2–1 mortar		4·96	142	1 ,, 4·96	20·20	
11	Washed gravel, ¾"–⅛" (34¾ per cent.)	Sand from gravel carefully washed, ⅛"–$\frac{1}{78}$" (42 per cent.)	4	2	1	5·26	144	1 ,, 5·26	19·00	
12	Ditto	Special sand quite clean, ⅛"–$\frac{1}{78}$" (35 per cent.)	4	2	1	5·38	146½	1 ,, 5·38	18·60	
	STONES.									
4	Crushed limestone, size as No. 2 (45½ per cent.)	Sand as for No. 2 ...	4	2	1	4·92	143	1 ,, 4·92	20·40	*Stone Concretes* (excepting Nos. 9 and 10.)—Average per cent. cement. = 20·50; average per cent. voids = 46½; average weight per cu. ft. = 146½ lb.
5	Crushed limestone, size as No. 3 (48¾ per cent.)	Ditto	4	2	1	4·90	144	1 ,, 4·90	20·50	
6	Crushed limestone, size as No. 7 (48 per cent.)	Sand as for No. 7 ...	4	2	1	4·80	149	1 ,, 4·80	20·85	
9	Crushed limestone, size as No. 8. (45 per cent.)	Sand as for No. 8 ...	4	2 parts 2–1 mortar		4·4	145	1 ,, 4·4	22·70	
13	Washed crushed limestone, size as No. 11 (45 per cent.)	Sand as for No. 11 ...	4	2	1	4·83	148½	1 ,, 4·83	20·70	
14	Ditto	Sand as for No. 12 ...	4	2	1	5·00	149½	1 ,, 5·0	20·00	
10	Crushed whinstone, ¾"–⅛" (46 per cent.)	Fine sand, $\frac{1}{20}$"–$\frac{1}{78}$" (48 per cent.)	4	2	1	4·33	144	1 ,, 4·33	23·20	

TABLE II.

6" Cubes.

Values given are average of three cubes in each case.

Materials.	1 : 2 : 4 Concretes.				Corrected Concretes.				
	Per cent. Cement.	Weight lb. per cu. ft.	Strength lbs. sq. in.		Per cent. Cement.	Weight lb. per cu. ft.	Strength lbs. sq. in.		Proportion.
			1 month.	3 months.			1 month.	3 months.	
GRAVELS:									
Sandstone gravel and fine sand ...	21·6	143½	2,400	3,360	20·8	146	2,575	3,575	1 : 1·43 : 4·5
Ditto and coarse sand	20·45	146	2,640	3,255	20·4	145½	2,292	2,970	1 : 1·43 : 4·3
Limestone gravel and fine sand ...	21·85	142½	2,320	3,645	20·90	145	2,890	4,020	1 : 1·43 : 4·3
Ditto and coarse sand	21·35	144	2,675	3,165	21·0	146	3,060	3,970	1 : 1·6 : 4·15
STONES:									
Crushed sandstone and fine sand ...	23·9	144	2,380	3,185	20·8	146½	2,750	3,355	1 : 1·4 : 4·6
Ditto and coarse sand	21·5	146½	2,910	3,718	21·75	146	2,730	3,650	1 : 1·8 : 4·4
Hand broken limestone and fine sand...	23·35	147½	2,450	3,110	21·0	148½	2,710	3,660	1 : 1·72 : 4·75
Ditto and coarse sand	22·25	149	2,535	3,103	21·0	148½	2,490	3,213	1 : 1·67 : 4·5

Cubes in moulds 48 hours, in water five days in Laboratory air until broken.
Of fine sand two thirds passed $\frac{1}{50}$" sieve, all passed $\frac{1}{32}$" sieve.
Coarse sand was Leighton Buzzard $\frac{1}{10}$ to $\frac{1}{20}$ about.
Water used averaged about 10 per cent (see Table 6).

TABLE III.

3·16" Cubes (10 sq. in. per face).

Values given are average of three cubes in each case.

Materials.	1 : 2 : 4 Concretes.				Corrected Concretes.				
	Per cent. Cement.	Weight lb. per cu. ft.	Strength lbs. sq. in.		Per cent. Cement.	Weight lbs. per cu. ft.	Strength lbs. cu. in.		Proportion.
			1 month.	3 months.			1 month.	3 months.	
KIND:									
Sandstone gravel and fine sand ...	21·6	143½	2,615	3,070	20·8	146	3,100	3,785	1 : 1·43 : 4·5
Ditto and coarse sand	20·45	146	2,880	3,645	20·4	145½	2,675	3,680	1 : 1·43 : 4·3
Limestone gravel and fine sand ...	21·85	142½	3,060	3,480	20·90	145	3,520	3,885	1 : 1·43 : 4·3
Ditto and coarse sand	21·35	144	2,995	3,710	21·0	146	3,405	3,860	1 : 1·6 : 4·15
Crushed sandstone and fine sand ...	23·9	144	2,816	3,026	20·8	146½	2,880	3,220	1 : 1·4 : 4·6
Ditto and coarse sand	21·5	146½	2,970	4,080	21·75	146	3,030	3,865	1 : 1·8 : 4·4
Hand broken limestone and fine sand ...	23·35	147½	3,445	3,370	21·0	148½	3,070	3,685	1 · 1·72 : 4·75
Ditto and coarse sand	22·25	149	3,280	3,650	21·0	148½	3,060	3,185	1 : 1·67 : 4·5

(N.B.—These cubes are too small because there is a tendency to place more of the finer parts of the concrete in them in order to get it into the moulds easier. The moulds were not made for concrete but for paste and mortar tests of cement.)

In order to partly repair the damage we immediately started the making of over 400 more specimens, and the results of one and three months' tests are given in Tables 2 and 3.

PERCENTAGE OF CEMENT USED IN CORRECTED CONCRETES.

Having made up "corrected" concretes in the 700 specimen series we were able to decide upon the percentage of cement to use in this, the second, series, and decided upon 21 per cent. where the cement was assumed to weigh 100 lbs. per cubic ft., which we found to be roughly the case, since a bag holds (when the cement has settled in it) about 2¼ cubic ft.

The average percentage of cement in 1 : 2 : 4 concretes is about 20 to 21.

ORDER OF MAKING SPECIMENS.

The 1 : 2 : 4 concrete of each material was made up first and immediately afterwards the "corrected" concrete was made, thus avoiding any possibility of a change in the cement's value, small though it might be after a few days.

METHOD OF PROPORTIONING.

The weights per cubic ft. of all materials were first found by getting the average of three tests, all loosely filled into the measure without any shaking or ramming, then in proportioning so many pounds of the required material was taken (corresponding to so many cubic ft. or parts of a cubic ft.), thus avoiding any errors of judgment in filling measures in using by volume.

The materials for the 1 : 2 : 4 concretes were, of course, easily weighed, but the "corrected" concrete materials had to be proportioned to get maximum weight per cubic ft. This work, however, is quite simple. We know that in order to make 1 cubic ft. of concrete we must have ·21 cubic ft. of cement=21 lbs. We also know that by trial and error we can arrive at the correct ratio of sand to large material, *but only by mixing the cement and water with them;* in other words, *no proper concrete can be correctly made except by an actual test of the materials to be used.*

TABLE VI.

PERCENTAGES OF WATER USED IN THE CONCRETES.

Materials.	1 : 2 : 4 Concretes.	"Corrected" Concretes.
	Per cent.	Per cent.
Sandstone gravel and fine sand	9¼	9¼
Limestone gravel and fine sand	9¾	9¾
Crushed sandstone and fine sand	11¼	10
Broken limestone and fine sand	10	9¾
Sandstone gravel and coarse sand	9¼	9¾
Limestone gravel and coarse sand	9¾	9¾
Crushed sandstone and coarse sand	11¼	11
Broken limestone and coarse sand	9¾	9¾

TABLE VII.

TEST OF 10-IN. CUBES OF MORTAR, AGE 28 DAYS, MIXED 1 CEMENT TO 3 SAND FOR STANDARD SAND, OTHERS ON PER CENT. CEMENT PRINCIPAL.

—	Weight in oz.	Strength at 28 days comp.	
		Individual in tons.	Average lb. sq. in.
Fine sand mortar, Cube A ...	—	21·0	4,850
„ „ „ Cube B ...	40·5	22·3	
Standard sand mortar, Cube C ...	42	26·0	5,620
„ „ „ Cube D ...	42	24·1	
Coarse sand mortar, Cube E ...	42·5	Held 30·4T. for ¾ min.	6,815
„ „ „ Cube F ...	42·5	Held 30·4T. for ¾ min. but unbroken, so removed and placed in larger machine giving 28·5T.	

All made on per cent. cement principal—*i.e.*, each cube had same quantity of cement in it.

The averages of three cubes in each case are given in Tables II. and III. Table VI. gives the percentages of water used in terms of the total weight of all the dry materials. Table VII. shows the effect of size of sand grains on the strength of mortar.

SPECIFICATION.

A correct specification for concrete equal to average 1 : 2 : 4 concrete—*i.e.*, containing 20 per cent. by loose volume of dry cement equal to 14 per cent. wetted :—

The concrete shall be composed of perfectly clean crushed stone or gravel passing the -in. sieve and retained on the -in. sieve (⅛ in. suggested); the particles of gravel shall have a least dimension of not less than one-half the greatest dimension, the stone a least dimension not less than one-third the greatest dimension, and no flakes that can be levered with a knife from the surface of any of the particles. Specific gravity not less than 2·5.

The sand shall be thoroughly washed, and when *dry* shall pass the ⅛-in. sieve and be retained on the 1-76-in. sieve; the particles shall be as nearly spherical as those of the gravel mentioned above. Specific gravity not less than 2·5.

The cement shall *easily* pass the minimum requirements of the British Standard Specifications of August, 1910, when not less than 22 per cent. of water is used for neat cement specimens and not less than 8½ per cent. for mortar specimens.

The proportions for mixing shall be determined on the principle that the minimum amount of sand consistent with easy working of the mass shall be introduced (not more than will give a ratio of 1 sand to 2 stone for stone concrete, or not more than will give a ratio of 1 sand to 2·4 for gravel concretes), and that the resultant thoroughly mixed concrete shall not contain less than 20 per cent. of cement by loose volume or 14 per cent. by wetted (22 per cent. water) volume. The weight per cubic ft. when wet shall not be less than 145 lb.

Samples of the materials proposed to be used shall be deposited with the undersigned (architect or engineer) before any concrete materials arrive on the job, and the proportions to be used shall be proved to be as called for, by a demonstration in the presence of the undersigned, who will then give written authority to use such proportions if found correct.

Such a method of proportioning is easy for the contractor, since he knows, as soon as he has his quantities out, exactly how much cement he requires.

For instance, if a job called for 100 cubic yards of concrete he would require 20 cubic yards = 24 tons.

His quantities of large and small aggregate will be easily obtained as soon as a test has been made.

The architect or engineer will certainly know that his work contains a full and proper quantity of the only material which holds his building together.

CONCLUSIONS.

1. The 1 : 2 : 4 method of proportioning should be considered obsolete, since no two 1 : 2 : 4 concretes contain the same percentage of cement, neither does it allow the majority of materials to produce their best values.

2. An *actual test* of the materials it is proposed to use should be made, introducing the percentage of cement required for the particular purpose the concrete is for and finding the ratio of small to large aggregate accurately by this means

3. Other things equal, the percentage of cement closely governs the strength.

Other things equal, the larger the aggregate the stronger the concrete.

4. Previous tests proved that washing the average aggregate carefully will allow 30-40 per cent. higher strength in a hand mix, but only about 15-25 per cent. in a machine mix. This is always excepting really dirty material.

5. Using a mixer and giving 2-3 minutes for mixing will give a concrete, other things equal, about 50-75 per cent. stronger.

6. For equal working consistency and equal cement gravel concrete is as strong as stone concrete.

7. Gravel passing same screens as stone always has less voids than the stone.

8. Fine sand concrete has smaller weight per cubic ft. than coarse sand concrete.

9. Fine sand plus large aggregate (without cement) gives *smaller* volume than coarse. Fine sand plus large aggregate (with cement) gives *larger* volume than coarse.

10. Fine sand concrete is easier worked than coarse sand concrete for equal amounts of sand.

11. The finer the aggregate the more deleterious material and air it carries with it into the concrete.

12. The finer the sand the less should be used.

13. 30-40 per cent. higher strengths are obtained with 3·16 in. cubes than with 6 in. cubes.

14. Small cubes are more uncertain and inconsistent in the strength values than larger cubes.

15. In the future and in order that tests at various places shall be truly comparative, two things are required—

(a) The percentage of cement in the concrete.

(b) The strength of the cement in mortar tension or mortar compression.

DISCUSSION.

The President, in opening the discussion, said Mr. Johnson had done an extraordinary amount of work on the preparation of concrete, and his paper was the more interesting at the present time as the substance of the investigation dealt with in it influenced very largely the research work which was being carried out under the auspices of the Institute in connection with the Council for Scientific and Industrial Research.

Dr. J. S. Owens, B.A. wished to make it clear that the opinions given in the paper were based upon the assumption that the strength of concrete was determined by the amount of cement; the more cement the stronger the concrete. If that were true, a good deal of the rest followed. If it were not true, then a good deal of it broke down. He did not know whether it was true because concrete consisted of a mixture in which there were little spaces filled with a mixture of sand and cement. These spaces were between the larger aggregates, and if more cement was added these aggregates would be separated still further. If all the particles were completely coated with cement and all the cavities were filled with cement, then it seemed to him that the addition of further cement would not add to the strength of the concrete, unless it happened that the strength of the concrete was less than the strength of the cement, in which case the strength might be increased, but that was not usually the case. From the statement made in the paper that "Any cement beyond that necessary to fill these voids is waste and does not increase the strength," he gathered that that was also the author's opinion. In the case of gravel concretes the particles had a smaller surface per unit volume than broken stone, because the particles were rounded, and was it right to assume that that factor alone would increase the strength? He suggested there was another factor that possibly did increase the strength, and that was a smaller percentage of voids. With these two factors working against each other the same result might be obtained in certain circumstances with gravel as with broken stone. As to the effect of the surface for adhesion, with a large number of particles there was a larger surface for adhesion but the strength was reduced owing to the smashing up of the aggregate. On the other hand, if the particles instead of being spherical in shape were irregular, but of the same size, there was then a larger surface for adhesion also but there would be increased strength. Merely to say that an increase of cement would increase or decrease the strength was not sufficient. This was borne out by the fact that the smaller the particles the weaker the concrete. Another important factor to be taken into account was the moisture content. He believed that moisture in a cube of concrete reduced the strength, and therefore the cubes should have the same moisture content. If they had a different moisture content, differences in strength might be due to the moisture or to the mix, it was impossible to know which.

Professor S. W. Dixon, M.Sc., speaking with regard to the difference in size of the test cubes mentioned in the paper, viz., 3·16 in. and 6 in., and the statement that higher strengths are obtained with the smaller cubes, said he had an idea that the larger specimens generally gave the stronger results, but would not that depend almost entirely on the size of the aggregate. A 6-in. specimen would give a quite different result to a 3-in., because of the difference in the size of the aggregate. Then, again, when looking for tests of strength, surely the quantity of water must be taken account of. With a very wet mix a weaker result was obtained than if the right quantity of water was used. The same care must be taken to get the right quantity of water as to get the right quantity of cement. The most recent experiments in America showed conclusively that the quantity of water added was very important when aiming at getting consistent results in the laboratory.

Mr. D. B. Butler, F.C.S., said the author seemed to be comparing the values of gravel and broken stone aggregate, and suggested that gravel was the more efficient, because it adjusted itself and flowed more easily than broken stone. Very likely the strength of concrete depended largely on the shape of the stone used, and rounded gravel might give way under stress, whereas angular stones would more or less bite on one another. Another point with regard to gravel and broken stone aggregates generally was the condition of the face of the broken stone; whether it was smooth or whether it was rough, and so gave a hold to the matrix or mortar to adhere to. That was a point well worth looking into. The difference in cement from different bags but supposed to be from the same consignment was often met with. These differences would not occur if it were seen to that the cement in all the bags came from the same bin. The method of making corrected concrete given in the paper seemed to depend entirely on the personal equation, because the expression "working consistency" was used. Surely no two men in different places would arrive at the same consistency, and it all depended on the operator's ideas of "working consistency." The same criticism might be levelled at the general specification for concrete, because it was stated that the minimum amount of sand consistent with easy working should be used. What was the easy working of the mass? That surely depended upon the ideas of the man who was mixing it. Dr. Owens' suggestion with regard to the strength of concrete when wet or dry, that before testing concrete the amount of moisture given off should be determined, was based on tests that he had made with limestone. Limestone, however, was a non-hydraulic material, and it could easily be understood that if the test piece was damp that would afford more or less lubrication for the particles and would crush more easily. Cement, on the other hand, being an hydraulic material hardened better when damp than when dry, and the question of the moisture did not apply so much to cement as to non-hydraulic materials.

Mr. M. E. Yeatman, M.A., agreed with the author that the present system of proportions was not quite right. They had gone generally on the idea that the sand should be half the stone and that the proportion of the cement to that should be varied. The author's figures seem to show that the proportion of cement to get the best results should not be much less than 1 to 1½ instead of 1 to 2, and that the proportion of stone could be considerably increased with regard to the sand.

Dr. Oscar Faber expressed the view that the paper was exactly what the Institute wanted. He was not quite in agreement with the author as to his chief results. He still thought that the way to specify concrete was exactly the way in which concrete was specified now. It should not be left to the contractor to determine the amount of sand to ballast, as was clearly implied in the specimen specification. The engineer should determine the sand and stone he wanted to use, and he should make experiments as to what proportions he desired and write his specification accordingly. Working some of the average results in Tables II. and III. it would be seen that the increase of strength for the corrected concrete was very small, and against this had to be set the disadvantages the so-called corrected concrete carried with it. Corrected concrete contained very much less sand and correspondingly more stone, and this made it very difficult in reinforced concrete work to ensure that there would be no air pockets where the stone would not pass, as between two bars, and this difficulty was specially liable to occur where the bars were rather close together. If, therefore, air pockets were formed for this reason corrosion would soon follow. For this reason, if the increase of strength of corrected concrete was only about 10 per cent., as shown by the figures in the tables he had mentioned, he would rather have the concrete with the larger amount of sand and sacrifice the extra strength. The author referred to washing dirty material. If the material was not dirty no increase in strength was obtained by washing. It was only by virtue of it being dirty that an increase of strength could be obtained by washing. With regard to the size of the cube, Taylor and Thompson's figures showed that the larger cubes gave the stronger results, and he was in entire agreement with Professor Dixon that it depended upon the size of the aggregate in relation to the size of the cube. Professor Owens had raised the point as to whether the cement content beyond a certain point increased the strength, and if so, why? He (Dr. Faber) thought it did. His experience was that if the amount of cement in concrete was increased the strength was increased even after the so-called theoretical considerations had been complied with, and the explanation was this: With a concrete with certain size particles of stone, so much sand and so much cement might be used which would exactly fill the interstices and stick all the surfaces together. The addition of further cement had the effect of causing the particles to go farther apart and some of the cement went between. The reason why such a concrete would be stronger was this. It was agreed that concrete failed in compression, but even in a compression failure the failure was really due to tension. With a cube or a frame failure always took place either by sliding on one or several planes, and there was no doubt that on these planes tension existed and was the real cause of the failure. He suggested that by taking a plane through a cube of concrete such as he had mentioned, there was practically no adhesion, or at least a very small adhesion, between the face of the stone and the mortar, and what was really responsible for the strength of the tension was the amount of mortar, and on a plane such as he indicated by the sketch on the board, the amount of mortar was very much less, and that was the explanation of the cube with the larger amount of cement standing a higher compressive stress. Professor Owens also mentioned the effect of moisture in cubes. It certainly was the fact that moisture in cubes had a considerable influence on the strength, but there was a point in connection with that which should not be overlooked, and that was that if they took a dry cube and tested it and then took a fellow cube and immersed it in water and tested it shortly afterwards, it would show a great reduction in strength. If, however, the cube were left for a short time in water and then tested there was not the same reduction in strength, and the reason was, he believed, that when a cube, initially dry, was plunged into water the outside got wet long before the inside. The outside expanded quite appreciably and there were quite big internal stresses set up by the expansion of the outside before the inside expanded, and as the water gradually penetrated through the cube and the moisture content became uniform, that effect disappeared. Careful experiments that had been made upon that point in Germany, he was sorry to say—but they were good results for all that—resulted in curves being drawn showing how a dry specimen which increased in strength up to a certain point was then dipped in water and gave a continuous curve as the water content became uniform throughout. When the specimen was first dipped in water the strength dropped for a time and then gradually increased.

Mr. Ewart S. Andrews, B.Sc., said it was very difficult to get the perspective of such a paper by a cursory glance at it. So far as he could understand the paper, however, it was that if on comparing two concretes of the 1 : 2 : 4 mixture it was found that the strengths were different, the aggregate must not be blamed if the real reason was that the amount of cement was less in the weaker one than in the stronger. That, he believed, was the principal claim and it was a very important point and, as far as he could make out from a cursory glance at the paper, the author had proved that most, if not all, of the difference in strength between concretes, apparently the same mixture must be attributed to the difference in the amount of the cement. So far, Mr. Johnson had done very valuable work, and it seemed quite possible that it might be desirable in all laboratory experiments to standardize the specimens in some way. He took it, however, that the author would rather they went further and have the mixtures specified in terms of his corrected values, and it was there that he saw some considerable difficulty. In the first place, it seemed to him that the method of determining the corrected proportions was a difficult if not a hazardous one, and even when that was accomplished there appeared to be practical difficulties in the mixing. The present system was really of very great value and ease in practice, and it occurred to him that the same result as that aimed at by the author might be obtained by attacking the problem from another point of view. If the real purpose was to know exactly how much cement was being used it appeared to him possible to prepare curves from experiments such as the author had carried out, showing the percentage of cement per yard of finished concrete for various mixtures. With that information it would be possible to determine exactly how much cement was required for a certain mixture. As to the difference in strength of different size cubes, it was necessary to be very careful in speaking of the compressive strength of concrete or of any material of that kind which, as Mr. Faber said, really failed by tension. We must be very careful to ensure that there was a standard method of applying the load. It was well known that by embedding the specimen in various materials totally different results could be obtained. Some authorities said that lead should be discarded because it did not give the right strength, but it was quite possible, in his opinion, that the experiments with lead did give the right result, or at any rate, a more constant strength. In this connection he would like to know whether in the case of the 3-16th-in. cube and the 6-in. cube the platen was of the same size. The amount by which the platen overlapped the specimen was an important matter. The platen should overlap the specimen as little as possible because of the drag effect which the size of the platen had in preventing the transverse spread of the concrete.

Mr. C. J. Jackman asked the author to supplement the information he had given with regard to corrected concrete by stating the percentage of interstices in the sand.

THE LECTURER'S REPLY.

Mr. Johnson, in replying, maintained that cement governed the strength, other things being equal. The more cement was diluted the less would be its strength, and on that point Dr. Faber had effectively answered the suggestion of Professor Owens. He had made many tests and believed he was right in saying that by allowing concrete to dry out again a greater strength was obtained than before, because it appeared that the cement was not sufficiently hydrated in the first place. Despite Professor Dixon's views on the strength of the large cube, his experience had been that the small cube gave the greater strength. The footnote to Table III. would give some idea of what the effect of size would be. Mr. Butler's suggestion that rounded aggregate was weaker than broken stone referred, he presumed, to reinforced concrete. Smoothness of surface might decrease the strength, but not to any great extent. With regard to the specification he conceded that no two men would agree as to a working consistency. It was not contended that the tests he referred to showed the maximum differences; they were used to manifest the advantages of using corrected concrete as compared with 1 : 2 : 4 concrete in giving increased strength, and they must be limited to that. For out-door work the inclusion ot some dirty material was an advantage in securing an impervious concrete, as for instance, in wharves and tanks. As to the second immersion of concrete decreasing the strength, that pointed to the necessity for a dense concrete so that the water could not penetrate so readily.

MEMORANDA.

Concrete Institute: Annual Meeting Postponed.—The eighth annual general meeting of the Concrete Institute, which was to have taken place last month, has been postponed until the autumn. Due notice of the meeting will be given when the programme for next session is issued to members.

Chefoo Harbour Improvements.—Mr. C. Rickard, Engineer-in-Chief to the Chefoo Harbour Improvement Commission, has made the following report on the work done from July 1st to December 31st:—*The Breakwater.*—Stone dumping has been continued on the first 1,800 ft. of the foundation, about 11,000 tons having been deposited in the half-year. A length of 900 ft. is practically ready for the placing of the masonry blocks, and 600 ft. has the heavy stone protection on the slopes. The first caisson has been launched and completed, and was successfully sunk in its position on the prepared foundation at the south head of the breakwater in September, since when some 150 cu. yds. of concrete and 100 cu. yds. of sand filling have been deposited in it.

Good progress has been made during the last six months with the under-water work. Some 250,000 cu. yds. of good, hard sand have been dredged from the north-west part of the bay and deposited in the mound. The construction of the caisson for one end of the quay wall has been commenced on the slipway at the Bluff, and 30 cu. yds. of reinforced concrete have been deposited (in forming caisson); 133 blocks for the quay wall, containing 1,900 cu. yds. of masonry, have been made at the west beach.

The jetty for loading large masonry blocks has been constructed, and the trolley lines leading from the blockyard to the same have been laid and put into use. Some 1,300 tons of cement have been received on the works, also over 60 tons of reinforcing steel.

CORRESPONDENCE.

Under this heading we invite correspondence.

To the Editor of CONCRETE AND CONSTRUCTIONAL ENGINEERING.

DEAR SIR,—In the very excellent paper read before the Concrete Institute by Mr. W. Cleaver, which is reported in your May issue, the ability of reinforced concrete structure to withstand shock is referred to.

Mr. Cleaver attributes this to two causes—namely, the extra *mass* of the reinforced concrete and to its *monolith* nature. To increase the former he advocates "the wisdom of designing beams with single reinforcement in every possible instance" (page 273).

Some ambiguity exists in the minds of many engineers as to the means of resisting shock by a structure. The action seems to me to be twofold. First, there is the transference of the momentum of the ship or other object *through* the structure to earth, and manifestly the actual movement of the centre of gravity of the structure will be inversely proportional to the mass. The stress on the points of attachment of the structure to earth (the piles in a detached wharf) will be proportional to this movement, which in most cases will be an angular one. It will be clear, however, that the number of attachments to earth is much more important than the actual mass connected to those attachments.

Assuming, however, the number of suitable attachments to earth to be adequate, the need for bringing this large *mass* into operation becomes evident Should all the beams of the structure be only in compression due to the shock the increased mass of each beam would, of course, be advantageous. A little consideration, however, will shew that this cannot be. Many beams will be subject to direct tension (top as well as bottom), and to bring the maximum portion of the mass of the structure into operation, therefore, it is eminently desirable to have some top reinforcement, so that suitably situated beams may *pull* at other parts of the structure and thereby increase the mass resisting or taking up the momentum of impact.

When the primary movement of the structure mass is overcome by the earth attachments there is the swing back effect of the strain energy stored in the attachments which sets up vibration, the secondary action above referred to. In fact, as the momentum is transferred from one part of the structure mass to another this vibration or "shiver" is set up. These secondary actions are, in fact, going on all the time the mass of the structure as a whole is having the initial momentum transferred to it, and to counteract these vibrational stresses (introducing tension as well as compression) some steel is desirable in the top as well as bottom of the beam.

The greater efficiency of reinforced concrete to transfer these stresses from member to member over the timber or steel structures by reason of the "play" at the connections of the latter is, of course, well known and recognised by Mr. Cleaver when speaking of the advantage of the monolith nature of the reinforced concrete structure.

Let me say, in conclusion, how much I appreciate Mr. Cleaver's paper; at the same time, however, let me express the hope that engineers reading it will not overlook the fact (probably very well recognised by Mr. Cleaver) that it is much more important to have a *large part of the mass of the structure* assist in taking up the impact or shock than to have one or two beams, near the point of impact, of large mass. This can only be efficiently done (in my judgment) by introducing some reinforcement in the tops of beams, so that the top as well as the bottom can take up the tensional stresses introduced.

I am, sir,
Yours faithfully,
HARRY JACKSON, A.M.Inst.C.E., etc.

We are compelled to hold over until our next issue Mr. Cleaver's reply to the above letter. —ED.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

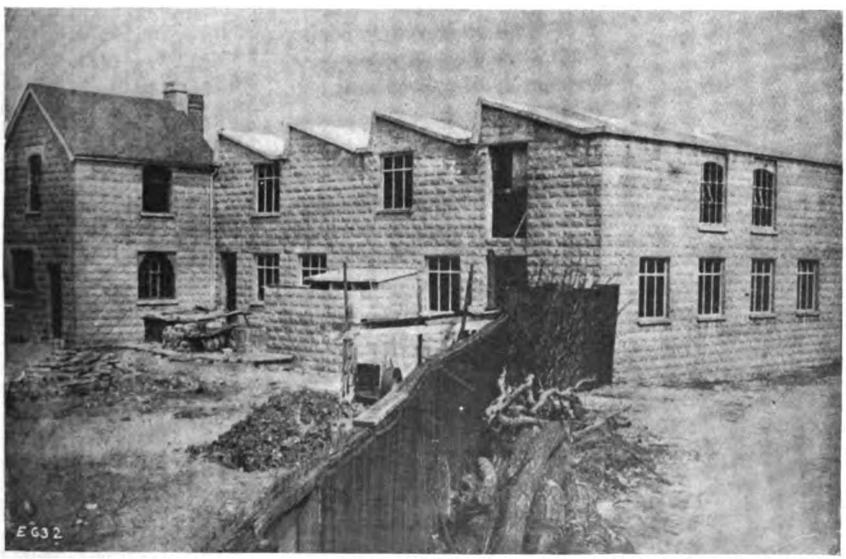
CONCRETE BLOCKS USED FOR A TOY FACTORY EXTENSION AT CHESHUNT.

OUR illustration shows the extension to a toy factory. The extension is built entirely of concrete, the walls being constructed of concrete blocks, the size of which is 18 in. by 9 in. by 4½ in. The blocks are made of crushed clinker and faced with a sand and cement facing. The blocks for the outside walls are rock faced, while the quoins or corner blocks are made with a raised plain panel. The blocks for the internal walls were the same size, but were plain faced.

The window sills were reinforced with steel rods, while the heads, which had raised plain panels to match the corners, were also reinforced.

The ground floor is of the ordinary concrete floor type, and the first floor is of reinforced concrete supported by concrete columns and girders or beams.

The metal reinforcement used was the Expanded Metal Co.'s steel reinforcing. The roof is also of concrete, and it will be seen is on the northern light principle, the



A TOY FACTORY EXTENSION AT CHESHUNT.

roof being supported by means of short concrete columns, which rest upon the main girders or beams. These girders also form the valley gutters for the roof. Crushed clinker was the aggregate used for floors and roof.

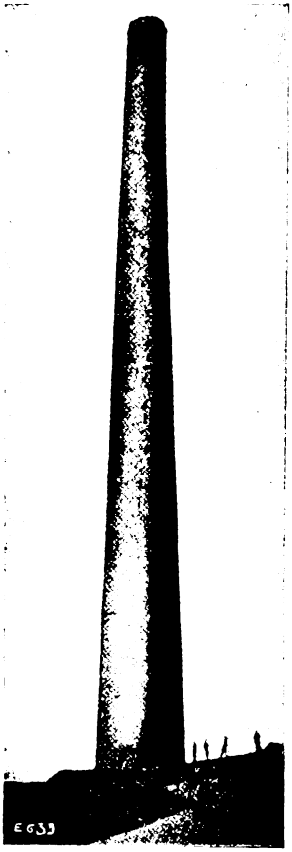
The whole of the work was carried out under the personal supervision of Mr.

H E Hughes, the owner of the factory. The blocks were made upon a patent pressure block machine supplied by Messrs. Sam Deards, of Harlow. The moulds for the window sills and heads were also supplied by the same firm.

A CONCRETE CHIMNEY IN JAPAN, JUST COMPLETED.

Designed to Resist Earthquake Shocks.

A DESCRIPTION is given in *Engineering News-Record* of a reinforced concrete chimney recently completed in Japan, and it is stated it is the highest chimney in the world. The chimney is for a smelter plant at Saganoseki, Japan. It is 570 ft. high, 42 ft. 8 in. outside diameter at the bottom and 26 ft. 3 in. inside diameter at the top, with a thickness of 29½ in. at the bottom and 7 in. at the top. It was designed and built by the Weber Chimney Co., of Chicago, for the Oriental Compressol Co., of Japan, which has the general contract for the entire plant. The design includes provision for earthquake stresses, and was checked and approved at the Imperial University of Tokyo. The foundation is a huge block of monolithic concrete in the form of a truncated cone 17 ft. high, 95 ft. diameter on the base and 42 ft. at the top. The centre portion of the top is concave, with a bottom thickness of 7 ft. This foundation contains 2,711 cu. yd. of concrete and required thirty days' work, day and night, for its construction. The pressure on the base is about 6,000 lb. per sq. ft., including allowance for wind pressure. The steel reinforcement in the foundation and chimney amounts to 530 tons and consists of plain round and square bars. In the lower portion of the chimney there are pairs of rings of ⅜-in. square bars spaced 6 in. c. to c. vertically; at the upper portion there are single ⅝-in. rings spaced 7½ in. c. to c. One 5-ft. course at the base of the chimney contains as much concrete as would make a 6-ft. chimney 120 ft. high.



A REINFORCED CONCRETE CHIMNEY IN JAPAN.

The lightning-rod protection is quite extensive. At the top is a copper circle with seven platinum points extending 4 ft. above the edge of the chimney. From this circle seven cables lead down the chimney. At a height of 400 ft. from the base is another copper circle, or circuit, with four platinum points, and from it four rods lead down to the base.

For the chimney the concrete mix is 1 : 2½ : 4, using 1-in. stone. For the foundation the mix is 1 : 3 : 5, with 2-in. stone. The chimney was built in courses 5 ft. high. Two sets of movable forms were used, which allowed for leaving the forms in place 24 hours after the concrete was poured.

A 1-yd. Smith mixer was used, and a steam hoist for an elevator bucket in a wood tower built up inside the chimney. The Japanese authorities at first insisted that a complete outside scaffolding must be built, in accordance with local practice, but they were finally convinced that the other method was practicable. This effected an enormous saving in timber for the construction. All material was delivered by an aerial wire tramway 5,000 ft. long.

SMOKE FLUE BAFFLED.

The chimney is on a hill about 430 ft. above sea level, the ground having a steep slope to the water. The smelter is on the water front, as all transportation is by water, there being no railway. The distance is 2,500 ft., and a reinforced concrete smoke flue extends from the smelter to the chimney. The latter is of elliptical section, 30 ft. larger diameter, with a wall 8 in.

thick. It is built on a zigzag line, so as to form a series of baffles to check the flow of gas and cause the dust to settle. A manhole and interior stairway provide access for collecting and removing the dust. The lower part of this flume is built in a trench cut to the required shape. At the base of the chimney is an opening 20 ft. wide and 31½ ft. high, from which a horizontal conduit 20 ft. long is built integrally with the chimney. The smoke flue is connected to this. The bottom of the opening is level with the top of the foundation.

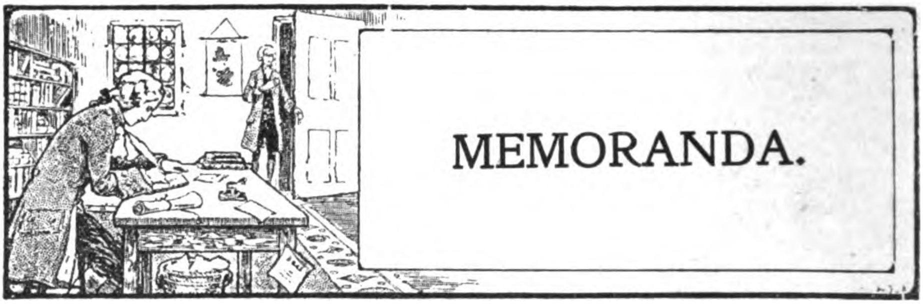
PUBLICATIONS RECEIVED.

The Boy in Industry.—The Special Intelligence Branch of the Ministry of Munitions have sent us for notice an interesting pamphlet dealing with the boy in industry.

Dr. Addison, M.P., the Minister of Munitions, states that the number of boys between the ages of fourteen and eighteen engaged in various occupations in this country is approximately 1,250,000, and that "their young shoulders are gallantly helping to support the burden of war." But while the war has heightened the value of the boy in the labour market it has intensified the problem of his welfare, and the Ministry of Munitions has issued a pamphlet on the subject which Dr. Addison commends to the attention of parents, employers, social workers, and teachers, in the hope that the problem may be brought nearer solution.

"The Boy in Industry" (H.M. Stationery Office, Kingsway, London, W.C.2; 3d. net) puts the case of the factory lad clearly and without concealment of unpleasing facts. The ordinary boy of fourteen to eighteen years, states the author, is "unstable, wilful, elusive; the age is a critical one in his career, and he is receptive to influences both good and bad—chiefly bad." To-day various contributory causes make his position more precarious; the father's control is absent and high wages are paid for his labour. The boy knows nothing of the part he is to play, either in the world or in his work, and finding himself regarded as a man he thinks that the sooner he apes man's follies the better.

Various methods have been devised to stay this national waste, but the social and recreative agencies at work are insufficient. "A more highly developed system of engagement and control" from inside the industrial system is essential. This could be accomplished, the author insists, by the appointment in the factories of a sympathetic supervisor who would watch the personal interests of the boys. This officer would engage all the lads, would keep in touch with them at work and at play, and would encourage them in a wholesome outlook on life. Those concerned with the position of boys in industry would do well to read this booklet and to obtain the scheme for boy supervision in the munition factories from the Welfare Department, Ministry of Munitions, 6, Whitehall Gardens, London, S.W.1.



Memoranda and News Items are presented under this heading with occasional editorial comment. Authentic news will be welcome.—ED.

Concrete Roads—Inquiry into their Claims.—The council of the Roads Improvement Association, of which Prince Arthur of Connaught is president, at a meeting held in London last month, resolved to act upon a recommendation that investigations should be made forthwith into the claims of concrete roads.

The council of the association is in possession of much interesting data from America and elsewhere concerning the economy and durability of concrete roads with reinforced concrete foundations. Instructions have now been given by the association for a report to be prepared and presented by Mr. H. Percy Boulnois, M.Inst.C.E., formerly City Engineer of Liverpool, and Deputy Chief Engineering Inspector to the Local Government Board.

Concrete Shipways.—Concrete ways 990 ft. long will be built in America to handle one of the new battle cruisers recently authorised by Congress. For the foundation, supporting crib, blocks, and launching ways over 12,000 cu. yd. of concrete and 3,000 wooden piles will be required, while 3,000 tons of structural steel will be placed in the 870 ft. craneways. There will be one 50-ton and three 7½-ton electric cranes, all of 120 ft. span, the big crane running 121 ft. above mean low water. The construction of this shipway is being carried out by the Aberthaw Construction Co. It is expected the ways will be ready by September 1st.—*Engineering News Record.*

Canadian Reinforced Concrete Barges.—Concrete barges and other vessels are being made in Canada by building up and riveting the steel frame in the usual way, and then completely covering with concrete. Portland cement and crushed quartz or other suitable rock are used for a concrete of high grade, the mixture being applied by compressed air. Each section is reinforced independently by networks of light steel bars and wire mesh. Being perfectly enclosed, the frame is protected against rust.—*Science Siftings.*

Demands of a Housing Conference.—At the South Wales Housing Conference at Cardiff last month it was decided that a demand be made on the Government for a loan of £5,000,000 to local authorities in Wales and Monmouthshire for the erection of working-class dwellings. The conference also asked for the removal of all insanitary dwellings, obligatory town planning, and the establishment of Local Government and Agricultural Boards for Wales under a separate Minister.

Enemy Machine-Gun Pits.—Under the new conditions the German defence has taken new forms. As the enemy has no longer one definite strategic point to which to cling, there is on our immediate front no definite elaborately constructed trench system. In place of such a system are innumerable minor scraps of trenches and machine-gun positions all over the open country.

The new German type of machine-gun position, the "Mebu," as it seems to be called (M.E.B.U., which appears to stand for *Maschinen Eisen Betun Unterstand*), built of reinforced concrete, as its name implies, is a very carefully designed and elaborate structure. It is, of course, entirely subterranean, generally a group of three pits for a like number of guns, connecting in a chamber below, from which concrete steps go up a concrete-lined shaft to the actual positions above. The roof of each pit is circular, protected with a lid or covering of steel and concrete, with a narrow observation slit in front, and the orifice through which the gun fires is only a few inches above ground level.

For the defence of open country and bare slopes these "Mebus" are the enemy's favourite device.—*The Times.*

Concrete Tile in Alkali Country.—In our issue of December, 1915 (p. 628, vol. x.), we gave a short abstract from a report issued by the Bureau of Standards, U.S.A. (Technologic Paper 44) dealing with some investigations that had been undertaken to test the causes of the disintegration of concrete when exposed to water strongly charged with alkali salts. At the time this report was issued the test pieces had all been under exposure for one year. A further report has now been published (Technologic Paper 95), in which the results of the tests are summarised as follows:—

Concrete that is to be placed in alkali soil should be made of selected and tested material, so proportioned as to produce a dense concrete. As small an amount of mixing water should be used as will allow the mass to be placed properly. If these precautions are taken the resistance to alkali will be reduced. The following conclusions were drawn as to the use of concrete drain tile exposed to soils or waters containing alkali salts in quantities of 0·1 per cent. or greater: (1) The use of cement tile in soils containing alkali salts in large quantities is experimental. (2) Porous tile, because of the use of lean mixtures or relatively dry consistencies, are subject to disintegration. (3) Some dense tile are under certain conditions subject to surface disintegration. (4) Disintegration is manifested by physical disruption caused by the expansion resulting from crystallisation of salts in the pores and by softening resulting from chemical action of the solution with the constituents of the cement. (5) While the results obtained will not permit a definite statement as to relative effect of the various constituents of the salts, indications are that the greater the quantity of sulphate of magnesium present and the greater the total concentration of salts, the greater will be the disintegrating effect. Rich tile made by the process commonly used, which allows removal of forms immediately after casting, are subject to disintegration when exposed to soils or waters containing 0·1 per cent. or more alkali salts similar in composition to those encountered in this investigation. (7) Hand-tamped tile of plaster consistency are not equal in quality to machine-made tile of the same mixture and do not resist alkali action as well. (8) Steam-cured tile show no greater resistance to alkali action than tile that are cured by systematic sprinkling with water. (9) Tile made with sand-cement have less resistance to alkali action than tile made with Portland cement in the same proportion. (10) Neither tar coating nor cement-grout coating is effective in preventing the absorption of alkali salts from the soil. (11) No advantage is found in introducing ferrous sulphate into the cement mixture.

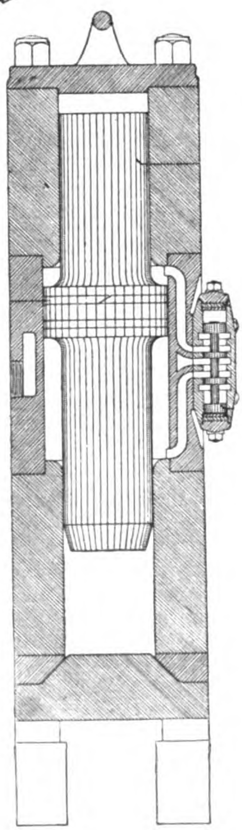
What Traffic Can a Road Carry?—There is no agreement among engineers as to the number of vehicles per day for which pavements of different types are economically suited, but an indication of the range is given by the following limits tentatively adopted by the State Highway Department of Michigan: 9-ft. gravel roads, up to 200; 16-ft. gravel and macadam roads, 200 to 500; 16-ft. macadam roads and bituminous surfacing, 500 to 1,000; 16-ft. concrete roads, 500 to 2,000.—*Engineering News Record.*

Sinking Concrete Cylinders Under a Philippine Bridge.—The road and bridge system of Tayabas Province, P. I., was badly damaged by a typhoon a little over a year ago. The reconstruction of the Dumacaa bridge—one of the larger structures wrecked—has several noteworthy features, which are described by Mr. A. T. Sylvester, district engineer, in the *Quarterly Bulletin* of the Bureau of Public Works.

The main span of the Dumacaa bridge is a 100-ft. steel through bowstring truss. There is also a 20-ft. reinforced concrete span. The floor surface is concrete. The east abutment was on rock and was undisturbed, but the pier and west abutment, founded on sand and gravel, were undermined.

The reconstruction plans called for a new pier and a new abutment—each carried on two concrete cylinders. The original superstructure was put back in place, but

The British Steel Piling Co



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26 ft. west of its former position, on the old centre-line, and about 6 ft. higher than the old elevation. The east abutment was carried up to the required height.

Two sets of forms were made for the reinforced concrete cylinders—which were precast—one 13 ft. long and the other 10 ft., 2 by 4-in. and 2 by 6-in. lumber being used. The outside form had a batter of 1 : 120 to reduce friction, which necessitated splitting all the staves. The outside form was built in two pieces, the inside one in four to facilitate removal. The cutting edge, shod with a small angle iron, had an inside bevel of 60° from the edge of the angle to the full 8-in. thickness of the cylinder. First the inside form was erected, then the reinforcing steel and the outside form, following which the concrete was poured.

The cylinders were allowed to set for twenty-one days, being kept thoroughly wet down during that period. The two pier cylinders were rolled into the river and dragged into position by a hoisting engine, being spotted by two 5-ton hand differential hoists. Rock was encountered at once, and the entire excavation in these cylinders was in rock, which was loosened by chisels, loaded by divers (with helmet only) into buckets and hoisted out.

Excavation in the abutment cylinders was easier. Two divers—using a half of a cocoanut shell and their hands—were able to load eleven buckets of sand per shift.

For building up the cylinders as they were sunk, one set of original forms was cut in half to reduce weight, and four holes were left near the top of the section last cast. In these holes ¾-in. bolts were inserted to support the forms, no guide piles or falsework being used.

The abutment cylinders were sunk 19½ ft. below low water and were filled with concrete. Two or three days later the pier cylinders reached their final depth of 15 ft. In each instance a seal of concrete was first run into the bottom of the cylinder with a tremie made of a piece of 6-in. galvanised iron pipe, handled by block-and-tackle. A diver levelled off the concrete thus deposited, and twenty-four hours later the cylinder was unwatered and the remaining concrete was placed in the dry.

Reinforced Concrete Wheat Elevators for New South Wales.—The State Government of New South Wales has decided to erect some large wheat elevators, and one of the largest of these is to be erected on a site at Glebe Island, Sydney. Reinforced concrete and steel construction are specified throughout. The storage house will contain 60 cylindrical bins and 45 interspace bins. The former will be 21 ft. 11 in. diameter with walls 7 ins. thick and 108 ft. high. The outside dimensions of the storage house will be 225 ft. 7 ins. by 135 ft. 7 ins. A somewhat smaller elevator, similar in design to the one at Glebe Island, will be erected at Newcastle, and a number of country elevators are also included in the scheme. The scheme is designed by the John F. Metcalf Co., Ltd.

Unit Concrete Stairway Construction.—The method of casting unit stair concrete steps, which greatly facilitated the construction of concrete stairways for subways in Boston, is described by W. B. Conant, in *Concrete,* of U.S.A. The old method of setting up a timber form for each flight of stairs was found expensive, because a considerable amount of lumber was destroyed in removing the forms. A unit system of casting each step was worked out, which proved to be from 33 to 50 per cent. cheaper.

The plan of casting is as follows :—A cypress form of sufficient length to carry two 8-ft. lengths is used to give the face of riser and tread—*i.e.*, the stair is cast in an inverted position. The base plate, 7 in. wide by ⅜ in. thick, to which a corrugated "safety tread" is attached, is laid face down on the form. Reinforcement consisting of ¼-in. deformed bars, are placed in position; lateral rods bent to conform with the elbow of the unit are spaced at about 2-ft. 6-in. intervals in the length and wired to the longitudinal rods, the reinforcing being cast ¼ in. from the outer surface.

End bulkheads are set in position, and over these is placed the form for the back and the under side of the unit. This is screwed to the bulkheads.

Then the form is filled with a mixture consisting of one part Newburyport sand, one part cement, one part stone dust, ¼ in. diameter and finer, and ½ lb. lampblack, the materials being measured by volume. Standard stairs are of 7-in. riser and 11-in. tread, with tread 1½ in. thick and riser 1¼ in. thick.

As the concrete sets, the form is carefully trowelled off to a finished surface, it being necessary to get an absolutely uniform thickness.

The unit is allowed about twenty-four hours to set; then the front form is removed and the riser finished. After one more day the unit is turned over and the tread finished. Each stair is allowed to cure at least one week.

Preliminary to erecting, a flight of concrete stringers is cast against either wall, and for a wide stairway another stringer in the middle, each 8 in. to 12 in. wide. The practice is to snap a chalk line on either wall for a nosing line, and to set each unit to this, beginning with the bottom stair. Units are laid in a 1 : 1 : 1 mortar, and where conditions make it necessary the spaces under the stairs are grouted with a similar mix through holes 1½ in. in diameter cast in the treads by means of pipe sections. Otherwise, if the space beneath the stairs is accessible, the space is concreted from below.

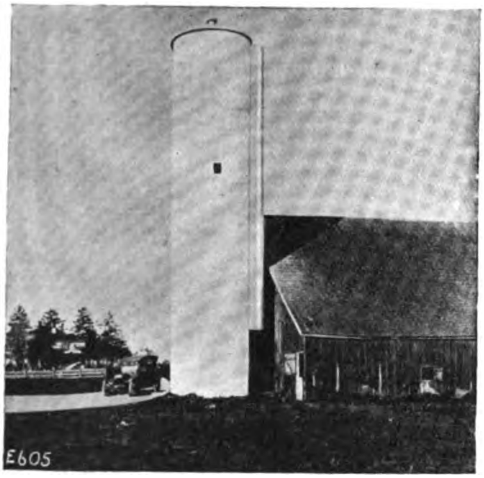
Canadian Concrete Road.—The Imperial Trade Correspondent at Toronto reports that a concrete highway has now been completed, with the exception of a few short gaps, between Toronto and Hamilton, a distance of about forty miles. This is the first important highway of this nature to be constructed in Ontario.

Reinforced Concrete Pulp Mill in Russia.—H.M. Consul at Helsingfors reports that a timber company is erecting a large pulp mill at Karihaara, at the mouth of the Kemi River. The buildings are to be constructed of brick and reinforced concrete.

Tasmania.—A Royal Commission has been appointed to inquire into the harbour improvement works being carried out on the Tamar River. Mr. A. C. Mackenzie, chief engineer of the Melbourne Harbour Trust, is expert adviser to the Commission.

ERRATUM.

Concrete Road Construction in Australia.—In dealing with some examples of concrete road construction in Australia in a recent issue (December, 1916) we omitted by an oversight to state that the particulars contained in this article were abstracted from the *Commonwealth Engineer.*



A CONCRETE SILO AT CHICAGO.

CONCRETE THE MONEY SAVER.

CONCRETE AS A SUBSTITUTE FOR TIMBER

(*Conclusion*)

FOR FARM AND ESTATE WORK.

HAVING referred to one of the principal uses for which timber has always been required, *i.e.*, fencing, and to which concrete has been adopted to replace it, we need not refer to this in connection with farm and estate work. Some illustrations of concrete fencing were given in a previous issue. In *Fig.* 1 a view of a rick stand is shown which entirely disposes of the use of wood. These are made of concrete and are cast in a mould, and can be made upon the wet or the " semi-dry " methods.

Stabling, etc.—Many estate owners have adopted concrete for cowbyres. The advantage of concrete for this class of work is that it is absorbent, free from joints and cracks, even in the surface, and is easily cleansed. Its strength and durability are important features, but its chief merits are, that it is both fire and vermin proof.

An interesting example of a concrete cow stable and creamery may be seen in *Figs* 2 and 3 and 4. These were erected on a farm in U.S.A. at Bethsham Woods, Middletown.

The cow stable measures 34 ft. by 50 ft., and is plastered on the inside with white Portland cement. The sanitary creamery measures 16 ft. by 20 ft. Both buildings have hollow walls and fire-resisting floor construction.

Feeding troughs, etc., for pigs and cattle have been produced in concrete, and the advantages mentioned in reference to cowstalls also apply to these. Concrete has been used for feeding floors, mangers, feeding troughs in cowhouses, horse stalls, loose boxes, etc., etc. Watering troughs and even chicken houses have been made of this useful material. It would require too much space to go into all details in this issue, but we are always willing to assist in every possible way anyone who is desirous of making these or any other articles.

Silos.—Wooden silos have been much used in the past in this country, but it has been found by practice and experimenting that concrete silos are much more practical, as the smoothness of the concrete allows the silage to settle after being packed. It is said that even the slightest roughness is liable to catch the cornstalks and prevent their settling evenly. This, as is well known to farmers, forms air spaces, and the silage becomes mouldy and has to be thrown away. Concrete silos should be built with prepared or planed boards for the inside so as to make sure of getting it as smooth as possible. There are several different forms of building silos with concrete, and the three which have proved very good have been monolithic (or solid walls) concrete silos, the hollow wall monolithic concrete silos, and the concrete block silos.

Quite recently six reinforced concrete silos have been erecetd in East Anglia, and from the report in February's issue of the "Journal of the Board of Agriculture" they have proved very successful.

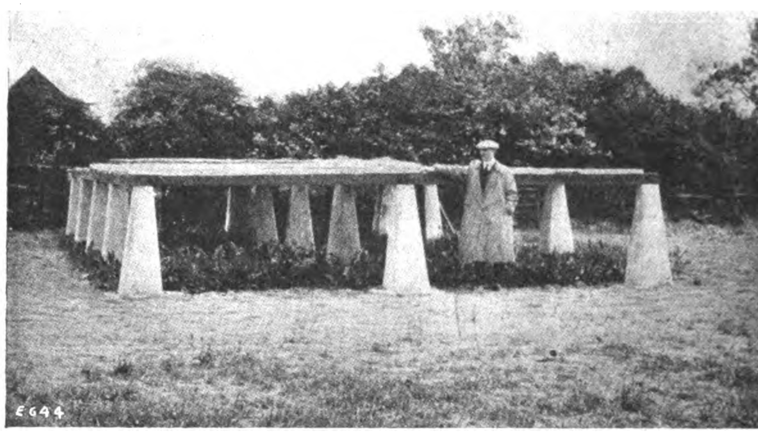


FIG. 1. A CONCRETE RICK STAND.

FIG. 2. A CONCRETE CREAMERY.

FIG. 3. A CONCRETE COW STABLE. EXTERIOR VIEW.

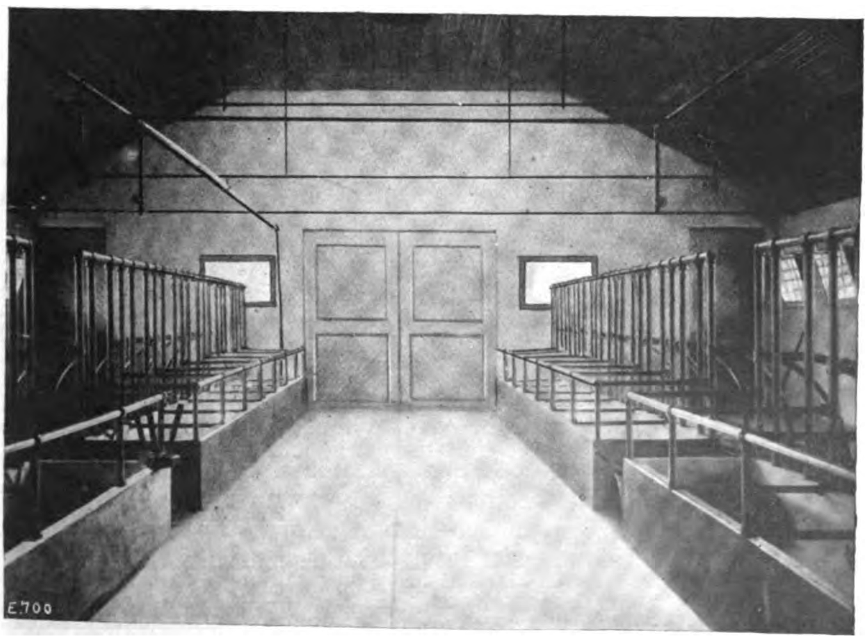


FIG. 4. A CONCRETE COW STABLE. INTERIOR VIEW.

The usual shape for concrete silos is cylindrical, and if solid walls are used the thickness usually adopted is 12 in. The one erected at Beccles had an internal diameter of 25 ft. and the total height was 36 ft. The walls were 12 in. in thickness. It was first filled in 1915, after having only been built a few months. It is claimed that this silo will hold 370 tons of silage. A former milk recorder of the East Anglian Milk Recording Society has had the opportunity of examining and inspecting the silage

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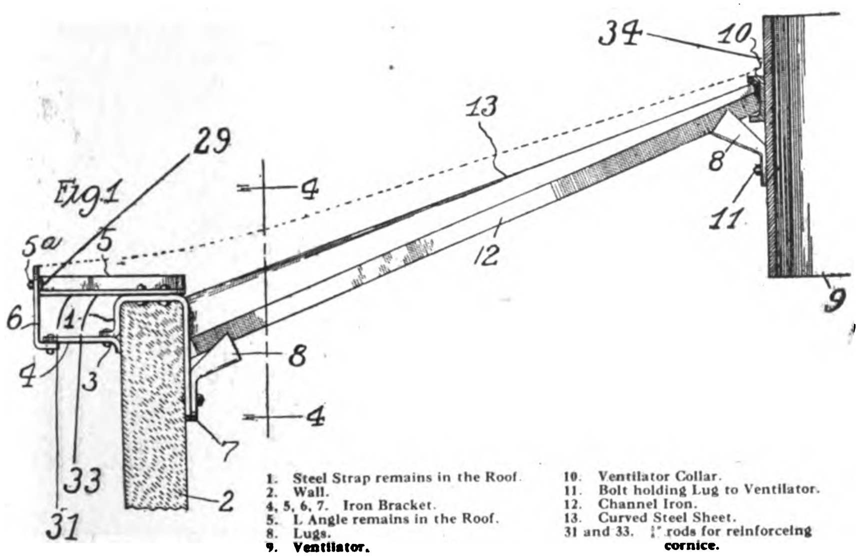
FIG. 5. A CONCRETE SILO IN EAST ANGLIA.

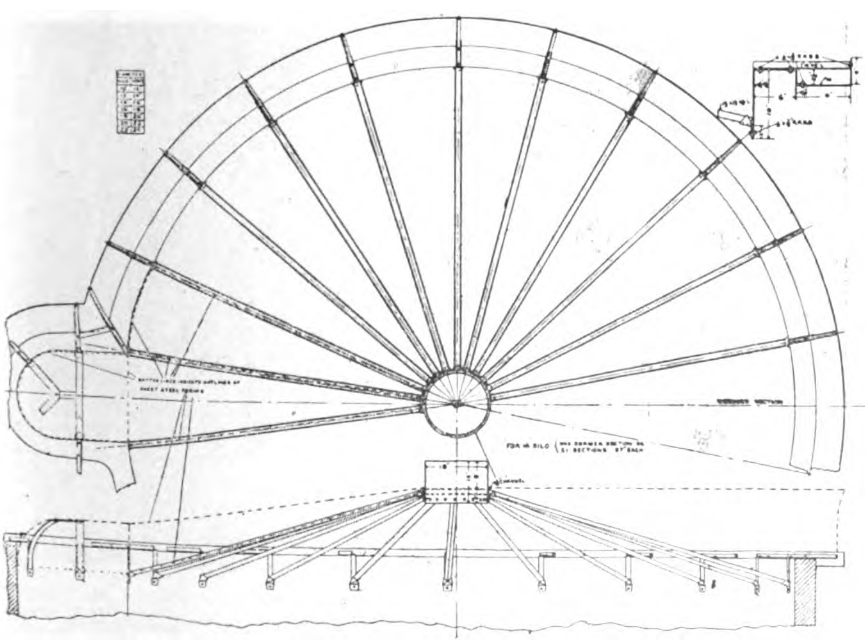
from both wooden and concrete silos, and considers that there is less damaged material around the walls of the concrete silos than around the outsides of the wooden silos. This is accounted for by reason of the one being air-tight and the other not being air-tight.

It is interesting to note the observations from U.S.A. on this subject. The use of concrete silos has been very largely adopted there, and the advantages put forward are as follows:—The acids formed by fermentations in the silage rot out wood and eat away metal silos, but acids have no effect on concrete. Every farmer knows the

CONCRETE FOR FARM AND ESTATE WORK.



1. Steel Strap remains in the Roof.
2. Wall.
4, 5, 6, 7. Iron Bracket.
5. L Angle remains in the Roof.
8. Lugs.
9. Ventilator.
10. Ventilator Collar.
11. Bolt holding Lug to Ventilator.
12. Channel Iron.
13. Curved Steel Sheet.
31 and 33. ¼" rods for reinforceing cornice.



Figs. 6 & 7. Assembly Drawings of Roof Form.
A CONCRETE SILO IN CHICAGO.

annoyance and danger of rats. Nothing built of wood is rat-proof, but a silo built entirely of concrete is rat-proof. A concrete silo cannot be blown down, and if pro-

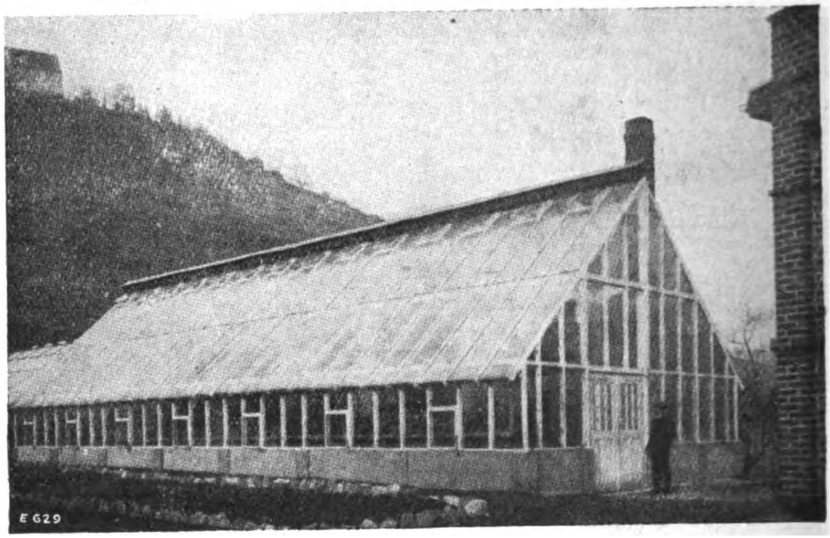


Fig. 8. Exterior View.

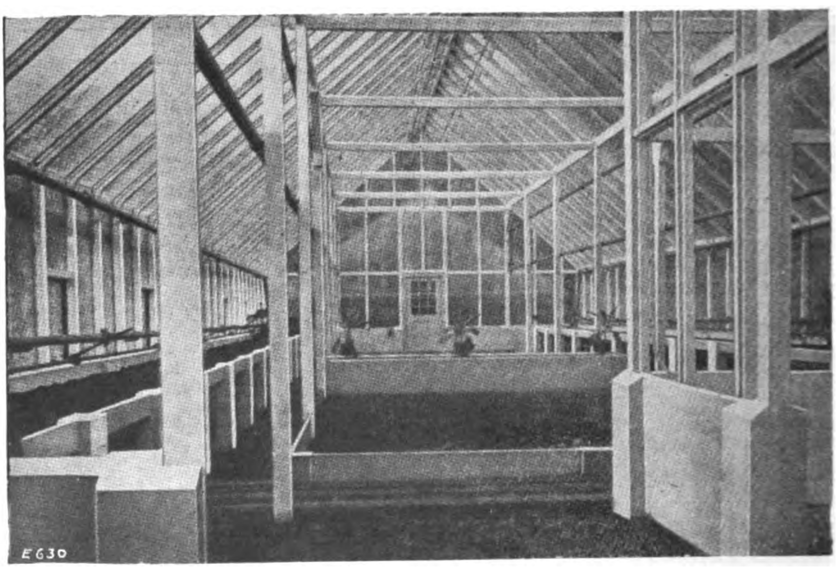


Fig. 9. Interior View.
A Reinforced Concrete Greenhouse.

perly constructed will last for ever. It cannot leak from expansion or contraction. No rods are necessary to pull the sides together in summer (as is the case with wooden ones) when they dry out, or to allow for swelling when the silo is filled in the autumn.

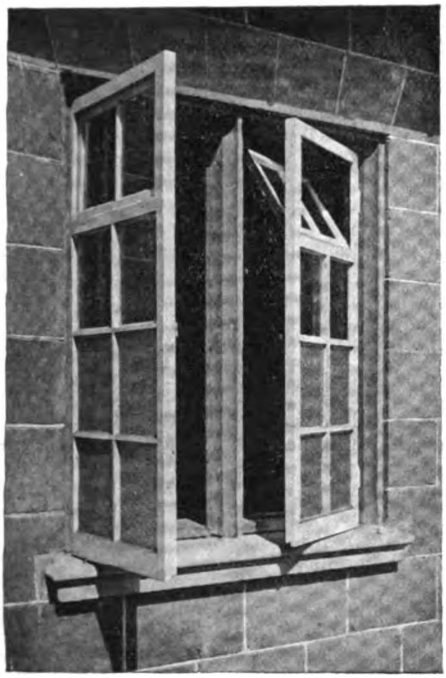


FIG. 10. A CONCRETE WINDOW FRAME. (*On the Marriott System.*)

Fig. 5 shows a concrete silo as erected in East Anglia.

The accompanying drawings, *Figs.* 6 and 7, and the photographic illustration at the beginning of this article, show the roof form and completed concrete silo of the monolithic type, as developed at Chicago, Ill.

In this silo the moulds were made of durable 16-gauge steel in segments sufficiently light to permit of easy handling. They were 3 ft. high, and each, when set in place, was clamped to the mould below it, thus making it practically impossible to build out of plumb. It may be stated that these moulds provide for a 6-in. wall perfectly uniform from bottom to top up to 20 ft. in diameter. The moulds can be placed one on top of another to permit of 6 ft. of wall per day being poured at a time.

Greenhouse Construction.—Reinforced concrete construction has been used upon the Continent most economically and advantageously in the construction of greenhouses and hot-houses. In *Figs.* 8 and 9 we give external and internal views of a reinforced concrete greenhouse. The framework is entirely of reinforced concrete, the doors being of iron and wood. The maintenance cost is practically nil. The external walls consist of double or single reinforced concrete slabs.

Cottage Fittings.—Concrete has been used for many articles in connection with building construction. In *Fig.* 10 we give an illustration of a concrete casement frame. The sashes are of wood. These frames are constructed on the Marriott system of reinforced concrete by Messrs. John Ellis and Son, of Leicester.

Articles such as sinks, mantel-shelves, chimney pieces, etc., etc., can all be made of concrete.

CONCRETE MOSAIC TILES.

In our issue of March, on page 177, we gave some illustrations of concrete mosaic tiles; but, owing to lack of space, we have had to hold over the description of same until this issue.

We cannot leave the subject of concrete flooring tiles without dealing at some length with concrete mosaic tiles, which are of more variety, especially in colour, and look altogether a better article than the ordinary flooring tile. They can be made to any shape, size or thickness, and with as many different colours on the surface of the tile as may be wished for.

These tiles are not made in a machine as described for the ordinary flooring tiles, but are made on a press which may be worked by hand or by hyrdaulic pressure or by mechanical means. So long as sufficient pressure is obtained the make of the press is immaterial. Some makes of concrete mosaic tiles are rough, or are made to represent Terrazzo flooring, which is laid *in situ*. The usual size for mosaic tiles is 8 in. by 8 in. by 1 in. Illustrations of mosaic tiles are given in *Figs.* 23 to 28, and some of the different parts for making these tiles are shown in *Figs.* 29, 30, 31, 32 and 33.

Fig. 29 shows the plate which forms the face of the tiles, and which is known as the "matrix." *Fig.* 30 illustrates the part which is known as the "stencil." *Figs.* 31, 32 and 33 illustrate the sieves, and it must be noticed that some parts of the sieves are

" blind." This will be explained later on. *Fig.* 34 shows the die plate which forms the underneath side of tiles, but which is the top while being pressed. In making the tiles, first take the three-coloured tile as shown in *Fig.* 26.

After the colour has been mixed thoroughly with the cement, the mixture should be sprinkled with a little water just sufficient to keep it from " dusting." If a handful is dropped this watering will prevent the dust from flying about. This is a very important feature. The top mixture of ordinary concrete, gauged semi-dry, should be composed of 2½ of clean, sharp sand, granite, or other suitable aggregate, to 1 of cement. For purposes of illustration we will assume that the tile (*Fig.* 26) is a three-coloured tile, being red, green, and white. The colours are indicated on the drawing.

Everything being ready for making, the mould box is placed in position on the table of the press. The " matrix " (*Fig.* 29) is placed face upwards in the bottom of the mould. Next the " stencil " or guide for the colours (*Fig.* 30) is placed upon the matrix, and the mould is then ready for the colours. The sieve which has the white colour in is placed upon the top of the mould box, the mould box having pins in it so that the sieve may fit on it accurately each time.

The part of the tile which is to be coloured red is left open in the meshwork of the sieve, while the parts which are green and white are blinded, or the meshwork covered, so that no red colour can escape other than through the right part. The colour is released from the sieve by means of the colour scraper, as illustrated in *Fig.* 7. The stencil guides the colour down on to the " matrix," the divisions keeping the colour to its own particular shape. The green colour is next applied, and after that the white in exactly the same way as the red was done. The stencil is now taken from the mould with care, and the ordinary concrete is filled in on top of the colours, but this must not be done with a shovel or else the colours may become disarranged and intermixed and the whole design spoilt. So another sieve is used with a coarser mesh and the concrete is sieved into the mould box. Next the die plate is placed on top of the concrete and the mould is moved under the press. The pressure is then brought to bear upon the tile, and when it is pressed to the required thickness, the pressure is released and the mould box is then moved from under the press. The tile is taken from the mould, it still being upon the matrix face down. The die plate is removed from the top of the tile and a pallet is placed upon the tile which is now turned over and left lying upon the pallet. The matrix is then removed from the face of the tile which is now exposed. If the press is a thoroughly good one the tile should stand handling with care upon its edge without a pallet. After the tile has been made three or four hours it should be sprayed with a very fine syringe which should have a rotating nozzle. After the tiles have been made 36 hours they should be ready to stack on edge. When first watering the tiles, care must be taken only to use a very fine spray or else the colours will run one into the other, and thus spoil the design of the tile. This completes the mosaic tile making, but a tile with any number of colours can be made by the same principle.

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CONCRETE AND CONSTRUCTIONAL ENGINEERING

JULY 1917. VOL. XII. No. 7.

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ISSUED MONTHLY

CONTENTS.

SPECIAL ARTICLE.

CONCRETE RAILWAY SLEEPERS: An Illustrated Review of the Experiments made with Concrete Railway Sleepers in England and the Colonies, America and in Continental Countries.

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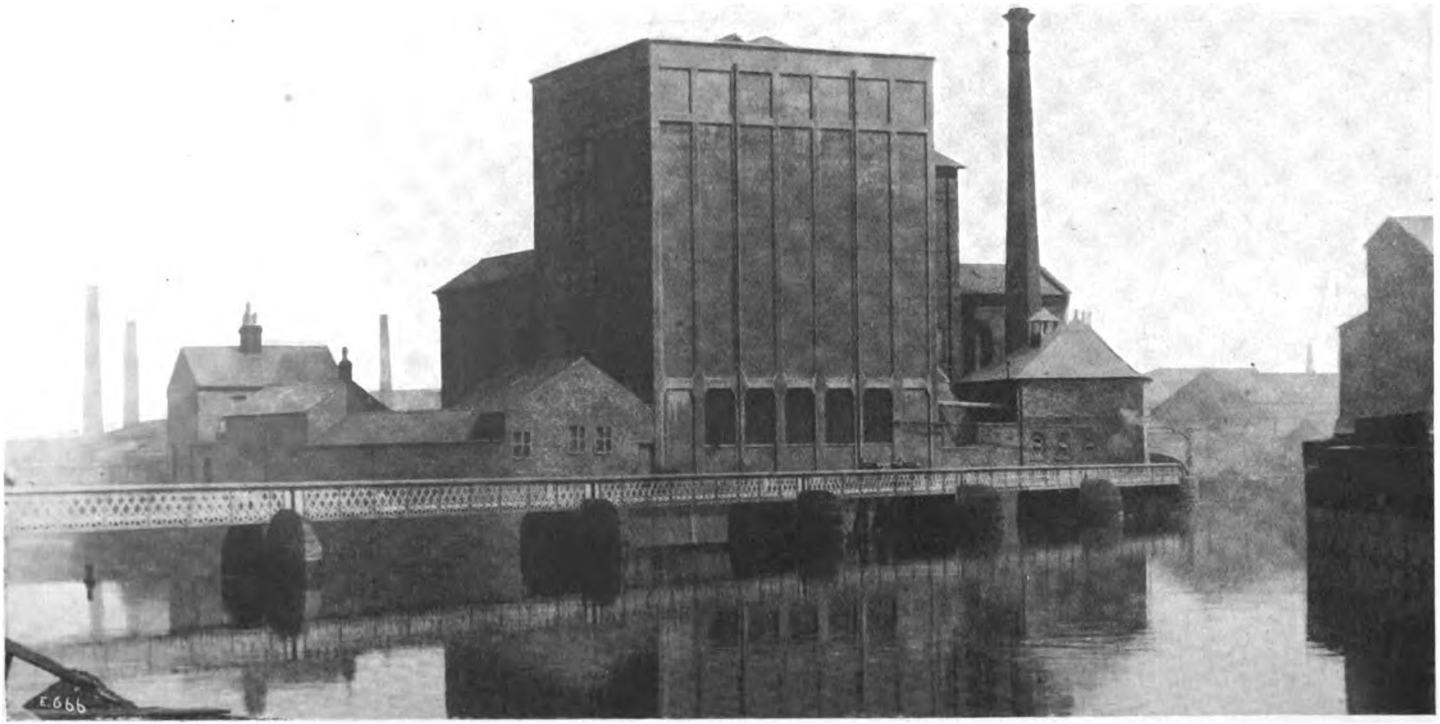


General View.
Reinforced Concrete Grain Silo and Mill Extension, Leicester.
(*For description see page 355.*)

CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume XII. No. 7. LONDON, JULY, 1917.

EDITORIAL NOTES.

CONCRETE AS A WAR ECONOMY.

DURING the current year we have from time to time pointed out the very great advantages of using concrete in its various forms as a substitute for timber, especially in respect of the innumerable minor uses such as poles, props, etc. As published in our previous issue, on page 321, a considerable number of questions have been asked in the House of Commons on the subject. A Cabinet instruction has been issued as to the necessity of all public Departments observing the most rigid economy in the use of timber, and several Departments are actively encouraging the use of concrete, notably certain sections of the Ministry of Munitions.

It is, however, essential that the economy of timber should become more popular, and that concrete should become a popular substitute. We are still far off from this, and a considerable amount of propaganda work seems to be essential until this very necessary economy is achieved.

There have recently been some changes in the administration of the Timber Department of the Government. It is no longer under the control of the War Office, and an eminent railway engineer in the person of Mr. Ball, M.Inst.C.E. (of the London, Brighton and South Coast Railway), has been appointed to take charge of this organisation. It is to be hoped that this new Department will realise that timber economy is not merely a question of economical timber distribution, but primarily a matter of reducing the timber requirements in every department of public and private life and finding and encouraging the use of simple and cheap substitutes.

Just as the medical man who can prevent disease is a far more valuable factor in the community than the one who undertakes its cure, so in a matter of war economy the engineer who will reduce the nation's requirements in timber will be a far greater man than the one whose mere concern it is to effect an economical distribution of this commodity.

We wish the new Timber Department every success, and we need hardly say that any propaganda that this journal can undertake to assist it in effecting a reduction in the use of timber will be readily given in the public interest.

THE CONCRETE INSTITUTE.

The first session of the Concrete Institute under the presidency of Mr. Wentworth-Sheilds has just come to an end, and although the Institute's annual meeting has been postponed until the autumn, we desire to take the opportunity of congratulating the Institute on its recent work. In these days of stress and anxiety it has been a most pleasing and commendable feature of the Institute's work that the character of the papers and meetings has not only been up to the average, but, in certain respects, well above previous records. The past series of papers and meetings has been of great utility and interest, whilst the work done by the various committees on the science side is also well worthy of congratulation.

In one direction do we think that the Concrete Institute has perhaps not quite come up to what the public expected of it in these days: it does not appear to have taken any very active part in solving such problems as those of timber economy, the provision of temporary structures, and similar matters in which concrete should be playing a far greater part than it does at present, and in which the pioneer society concerned in the subject may have been looked upon to take a lead.

On the other hand, the greater attention which the Institute is now paying to questions of research should be an invaluable factor in the post-war building operations that must follow the present collapse of practically all municipal and private building enterprise, so that in this direction the efforts of the Institute should have a far-reaching effect in the future.

CONCRETE RAILWAY SLEEPERS.

Concrete railway sleepers have been used, we believe, with considerable success for sidings and wherever the traffic is not very heavy or continuous, but the question of using them on long stretches of main lines subjected to a continuous heavy traffic is one on which there is much difference of opinion, and the problem offers many difficulties to the engineer. On the other hand, a very keen interest has been evinced in the possibilities of concrete for this purpose and much experimental work has been done on an extensive scale in the United States, and, to a smaller extent, in this country, in some of our Colonies, and on many of the Continental railways.

It has occurred to us that it would be a great aid to railway engineers if there could be presented in a concise yet comprehensive form, a review of the many experiments that have been made, with a view to finding the design of sleeper which would answer the varying conditions that exist on different lines in different countries. We therefore have pleasure in drawing the special attention of our readers to the article which appears on page 362 of this issue.

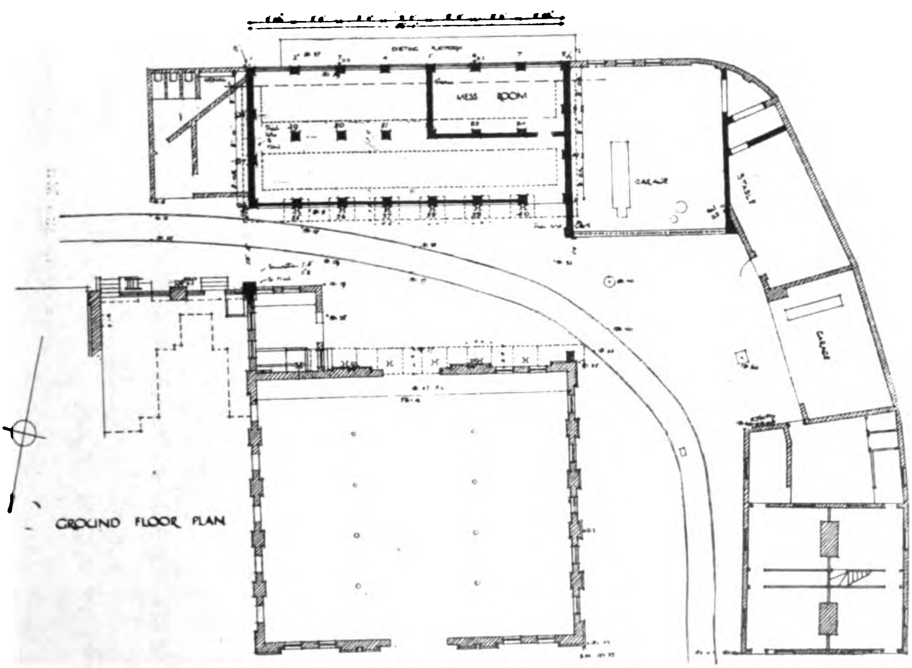
It has been the object of the writer of this review to present actual facts together with any special advantages claimed for particular sleepers without in any way criticising the merits of the many designs described and illustrated. We feel that the publication of this matter meets a long-felt want and we trust it will form a useful means of reference to all those engaged in solving the difficult problem of the most effective concrete sleeper for the varying traffic conditions which exist.

The shortage and high price of timber make it all the more urgent at the present time to find an efficient substitute for work of this description.

REINFORCED CONCRETE GRAIN SILO AND MILL EXTENSION, LEICESTER.

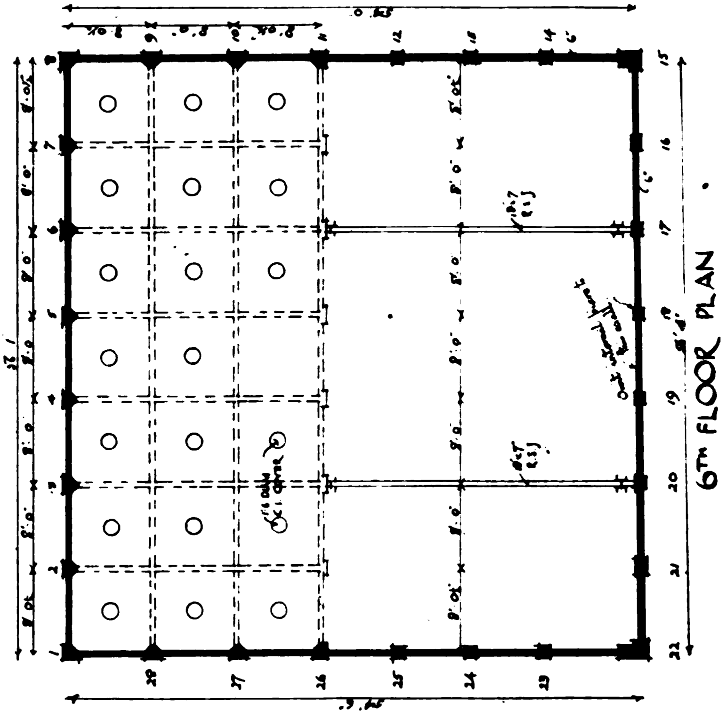
The following is another example of the application of reinforced concrete for silo buildings and similar structures.—ED.

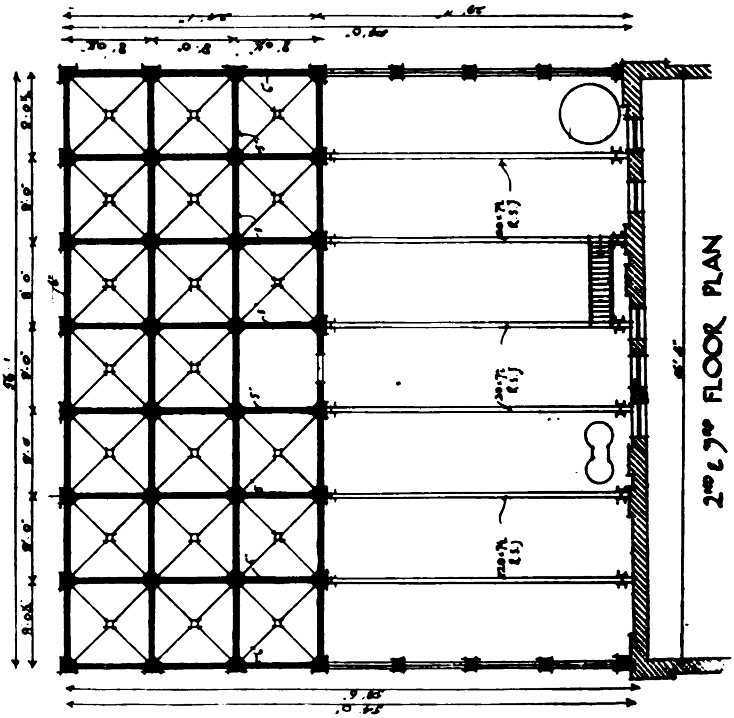
THE Silo and Mill Extension at Leicester shown by the accompanying drawings have a storage capacity of about 9,500 quarters, in addition to space for discharging and mixing machinery. The dimensions of the block are 56 ft. by 55 ft. on plan by 96 ft. from foundations to roof, the southern half being devoted to bins and the remainder to the mill extension.



Ground Floor Plan.
GRAIN SILO AND MILL EXTENSION, LEICESTER.

The somewhat restricted area of the site added interest to the problem of weight distribution, the north wall of the block being carried on an old building and the south wall on a river retaining wall. The intervening space on the ground floor is partly occupied by an indispensable siding.

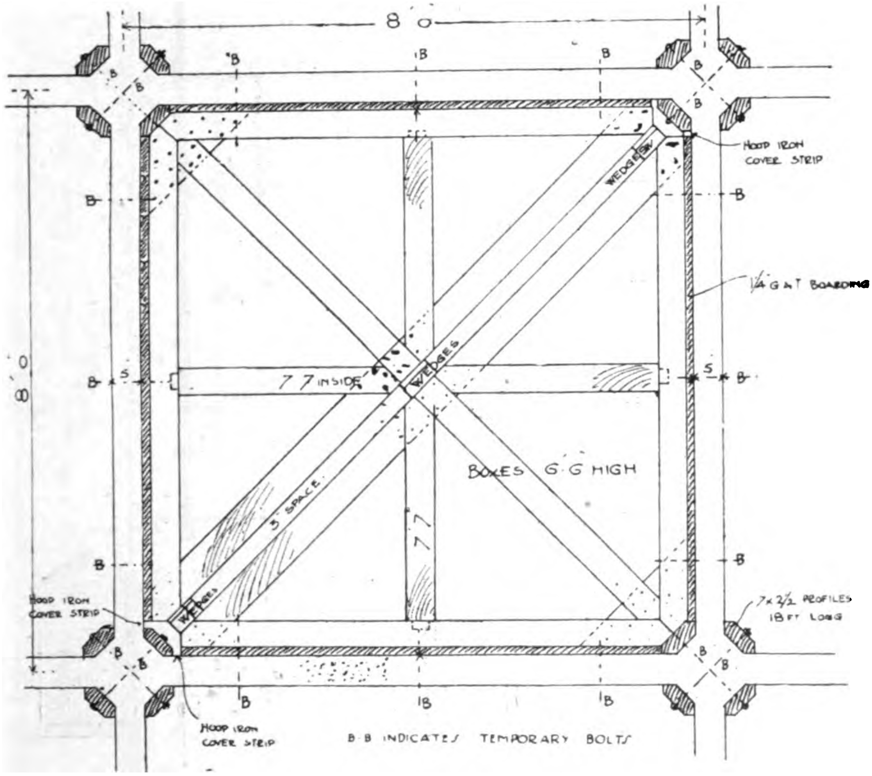




GRAIN SILO AND MILL EXTENSION, LEICESTER.

Fortunately a good "bottom" was secured at a moderate depth, the alluvial gravels at 12 ft. overlying the hard red Keuper Marl at 16 ft., forming a secure basis for the superincumbent weight.

The Silo.—The silo, with a capacity of about 6,000 quarters, consists of twenty-one bins (one occupied by elevators), each 7 ft. 7 in. square and 50 ft. deep, the bottoms tapering at an angle of 45 degrees to a 6-in. cast iron outlet controlled by a gate. Grain mixing machinery, pneumatic plant for discharging wheat from barge or truck, and a mess-room occupy the space below the bins. The incoming wheat is lifted by elevators to the top of the building, is auto-

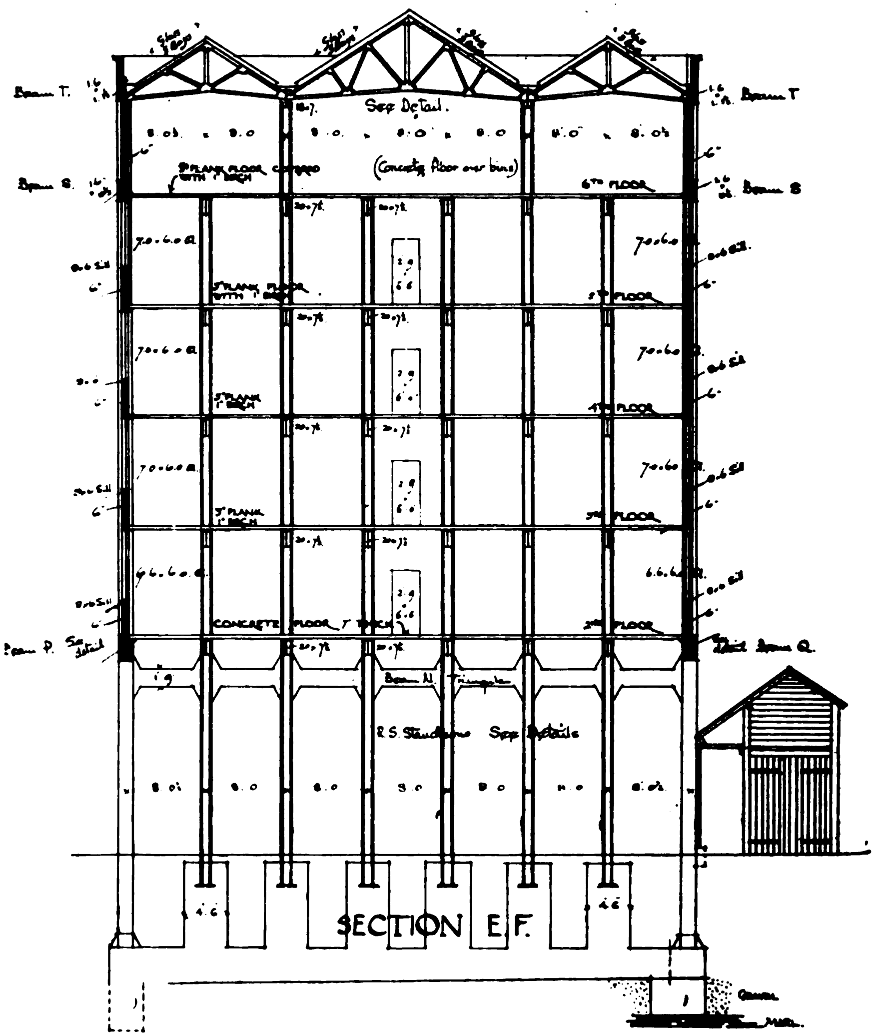


Portable Box Shuttering to Bins.
GRAIN SILO AND MILL EXTENSION, LEICESTER.

matically weighed, and is then distributed by shoots connected to a horizontal conveyor to the various bins. The thickness of the bin walls, based on Professor Airy's formula, is 5 in. doubly reinforced, the external walls for protective purposes being made 1 in. thicker.

Half-inch horizontals spaced from 6-in. to 11-in. centres, and ½-in. verticals, 12-in. centres, form the reinforcement to the internal walls of the bins, hoop-iron clips being freely employed to ensure correct horizontal spacing.

The shuttering shown in the accompanying sketch was of the portable type. It consisted of strongly framed boxes diagonally halved and 6 ft. 6 in. high, thus allowing the bins to be completed in eight lifts. An overlap of 6 in. was given to secure alignment. The outside walls were shuttered externally in the usual way. By this means a comparatively smooth interior, essential to a grain silo, was obtained. The exterior was brushed over with a thick cement grout. The walls remain dry and the wheat keeps in excellent condition under this protective coat.

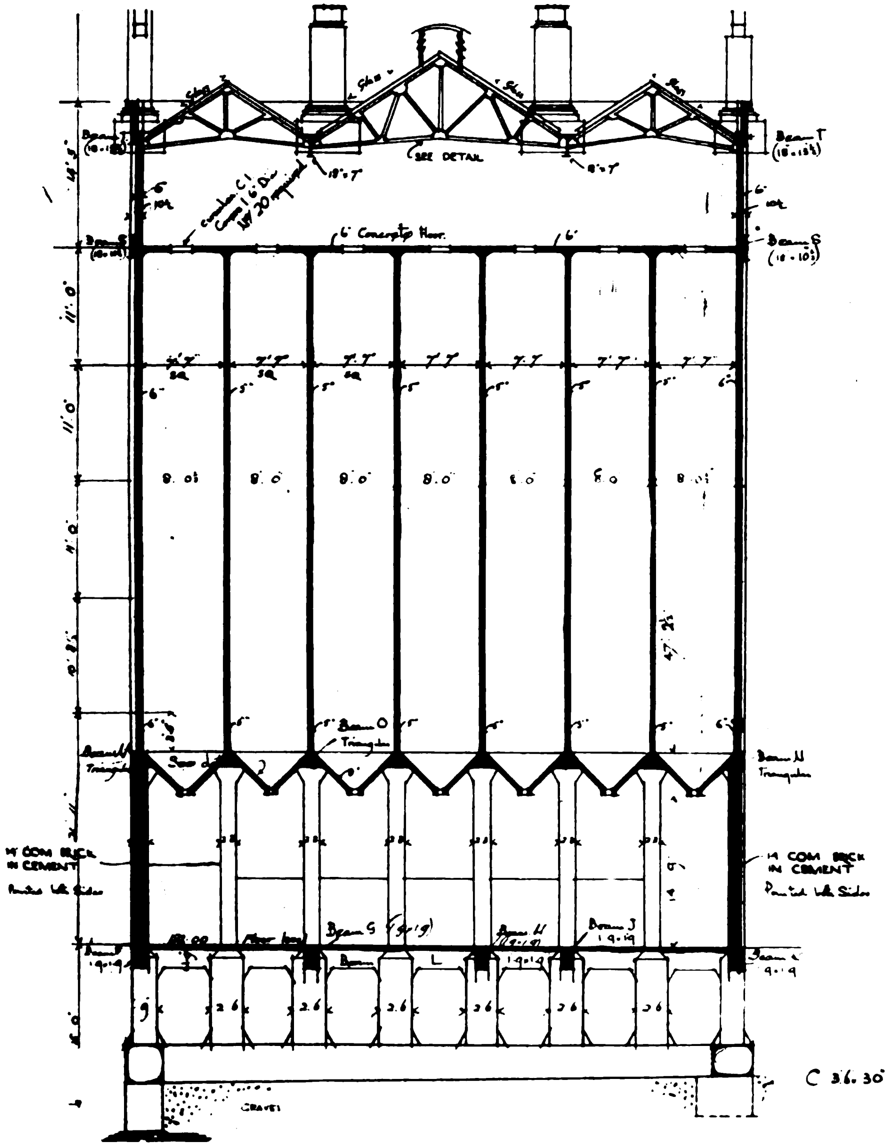


Section.
GRAIN SILO AND MILL EXTENSION, LEICESTER.

The Mill Extension.—The northern portion of the block consists of six floors, one floor only and the external walls being in reinforced concrete. The remaining floors were required in wood, and this led to the adoption of a framed steel construction for their support, the weight being carried independently of both the silos and the existing mill.

The floor coverings are formed with 3-in. planks, 8 ft. span, covered with 1-in. sawn birch boarding laid diagonally. Birch was adopted because of its excellent wearing qualities.

A light slated steel roof enclosed within a parapet wall surmounts the

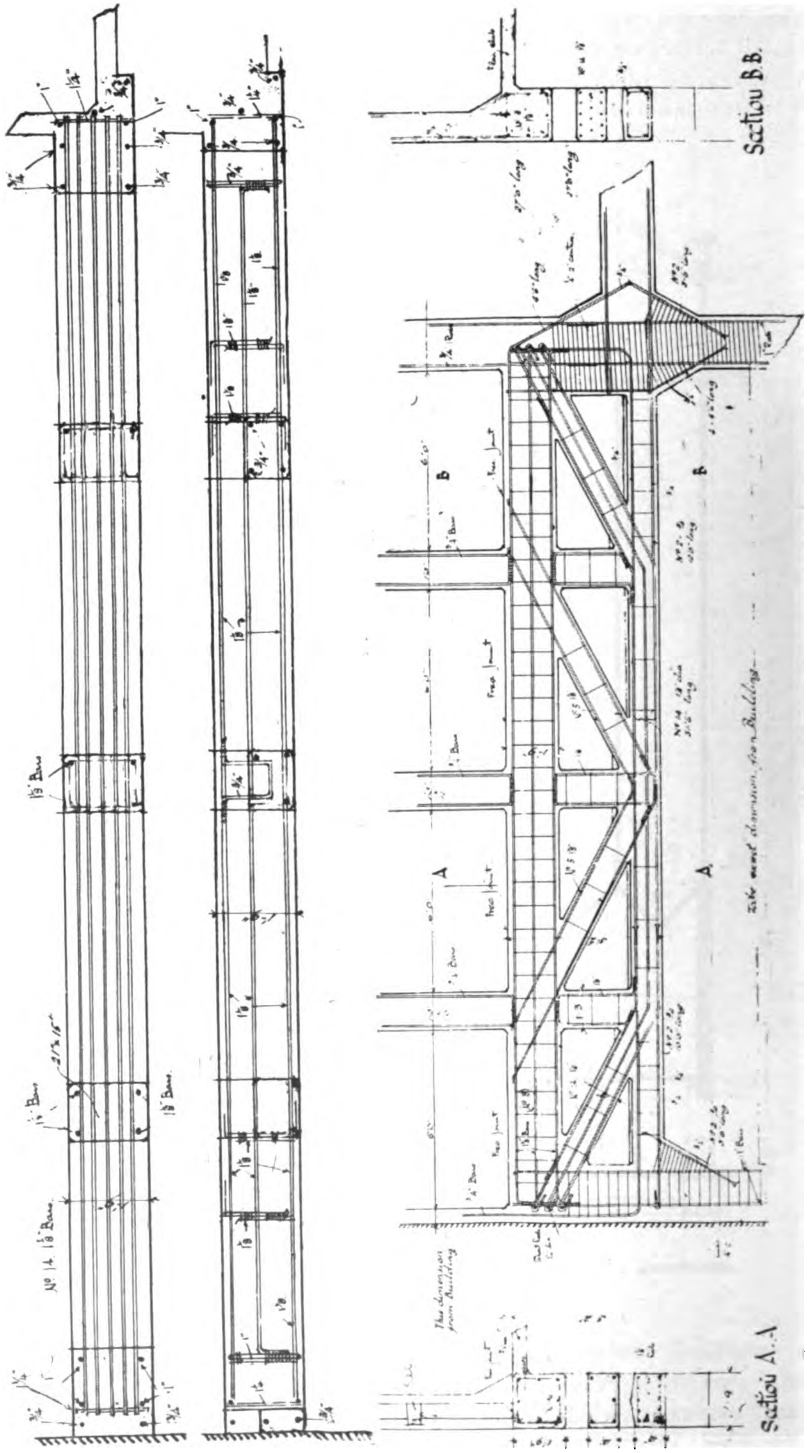


Section.

GRAIN SILO AND MILL EXTENSION, LEICESTER.

whole structure; the gutters are substantially made in cast iron and afford walking space for access to the roof.

Steel casements, each having a portion to open on a vertical axis to avoid dust troubles, give a well-lighted interior. The sills and copings are of



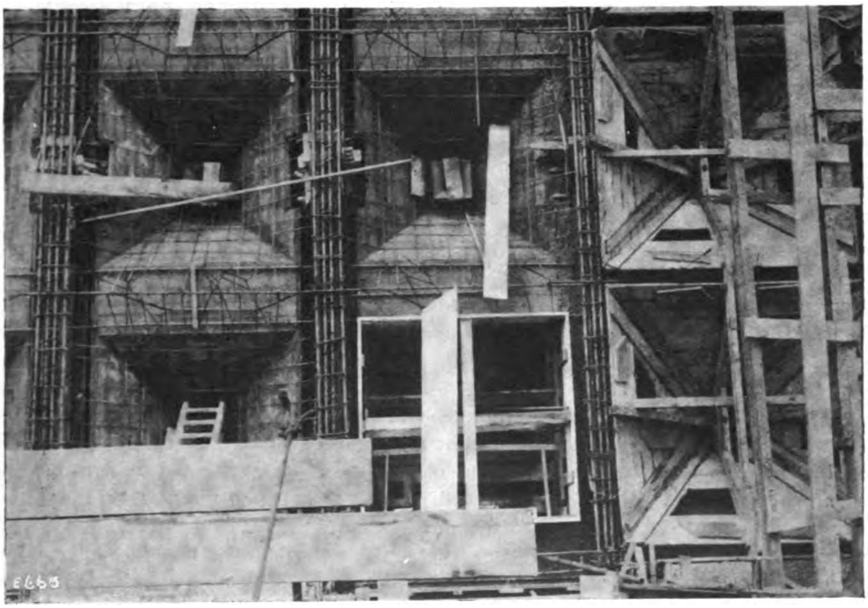
Details of Beams carrying Pillars.
GRAIN SILO AND MILL EXTENSION, LEICESTER.

indurated concrete. A cast iron spiral sack shoot and a continuous band passenger lift form important accessories to the mill.

Materials.—The cement accorded with the B.S. revised specification; Leicestershire granite varying from ¾ in. to ¼ in. formed the aggregate, and the sand was obtained from Leighton Buzzard.

The concrete throughout (with minor exceptions) was mixed in the proportion of 1 : 2 : 4, the equivalent of a cubic foot of cement (which was added by weight) having been considered as 90 lbs.

All the reinforcement consisted of round bars of mild steel, in accordance with the British Standard Specification No. 15. Special attention was paid to hooking and the connections at intersections.



Reinforcement to Hoppers.
GRAIN SILO AND MILL EXTENSION, LEICESTER.

Plant.—A satisfactory mixer of the continuous type, a barrow hoist electrically driven, rod benders, and a small crane for handling the "boxes" complete the inventory of the contractor's plant.

Calculations and Tests.—All calculations, drawings, and quantities were made and prepared by the engineers on the basis of the L.C.C. regulations for reinforced concrete and steel construction.

The bulk of the steel bars were tested at the makers', and frequent tests of the cement, steel, and concrete were made by the Cement Users' Testing Association.

The work was carried out under the direct superintendence of the engineers by Messrs. Wm. Moss and Sons, Ltd., of Loughborough, whose tender amounted to £6,124. Mr. R. Maples acted as foreman of works. The engineers were Messrs. Everard, Son, and Pick, of Leicester.

CONCRETE RAILWAY SLEEPERS.

A Review of Many Experiments on railways in England, America, India and the Continent, together with drawings and photographs.

INTRODUCTION.

The question of using concrete railway sleepers, or ties as they are described in America, in the place of creosoted timber has for a very long time been the subject of much consideration and frequent trials by railway engineers and experts in this and other countries. Within recent years many of the pioneering difficulties have, it is claimed, been diminished or successfully combated. Negative issues have been closed and here good has been done, for it is only through the discovery of failure that success is ultimately achieved. Still, the advent of concrete sleepers for all permanent ways, and especially for those main line tracks over which heavy and continuous traffic is running, is not a matter for to-day's adoption, and certainly it is a point about which engineers will take no risks.

We think, however, before these notes are concluded the reader may fairly assume that their coming into general use is but an affair of time, further development, and possibly perfecting beyond doubt some of the numerous examples which have been and are being made. With this in mind we feel that it will be of special interest to place on record all the information to hand on a matter of such importance. Another reason for doing so is the fact that the very high price of timber has greatly increased the cost of a railway sleeper, and, again, apart from the question of price, it is doubtful if timber in anything like normal quantities will, for a period, be obtainable.

Concrete, reinforced and otherwise, is now taking the place of wood in such a marked degree that, presently, to find our railway sleepers made of this material would surprise no one.

Suppose that a reinforced concrete sleeper was somewhat higher in cost than the one of timber, although this at present may not be the case, this difference would probably soon disappear if the satisfactory concrete sleeper be found, because its life would be far longer, and, as a consequence, the cost of relaying the timber sleeper at a much earlier period would be saved.

In America the number of trials and examples of concrete ties proves how elaborate and painstaking have been the efforts of the engineers and others who have conducted them, and this fully shows the great interest which has been aroused. Still, as we have already indicated, the perfectly ideal sleeper has yet to be found.

It is not our intention in this review to criticise in any way the merits or otherwise of any particular sleeper. We simply give the information which has been carefully collected, together with the claims in some instances put forward. This, with the addition of the drawings and photographs, will at least afford serious study and reflection to those interested, and we trust will aid in solving some of the problems which of necessity embarrass a subject of this character.

A trial of concrete sleepers in America was made in 1905—just a hundred being used; these were down for four years. Prior to this date and certainly onwards, trials, more or less extensive, have been conducted on several American lines, English railways, and on lines in India, the Continent, and elsewhere.

Gabellini of Rome.—It was about 1906 that the *Italian Railroad Administration* took the matter seriously in hand and placed an order with the firm of Gabellini, of Rome, for 300,000 concrete sleepers. Many of these, which, in time, were put off from the main tracks, have been repaired and utilised in the secondary tracks in the stations. The same firm made 3,000 others for the States Arsenal at Spezia, where, we believe, they have proved excellent. The trains here, although very heavy, move but slowly, so that the sleepers receive a gradual compression, not hammer shocks as on the main lines with trains running at high speed. Messrs. Gabellini, in concluding an interesting letter, from which the facts just stated were taken, say: "There is certainly a field in which cement sleepers are preferable to iron or wooden ones, because they last much longer. The attachment of the rail on the sleepers is the principal co-efficient for broadening the limits of the application field for cement sleepers." It will be seen subsequently that this difficulty is stated to have been overcome.

The French Railroads in Indo-China have been using concrete sleepers for many years, and to a very large extent. The designs adopted for this particular work, and which were first placed in service November, 1901, consist of two blocks of concrete, each 3 ft. long, placed symmetrically under each rail, so that the centre of each section will coincide. These two blocks of concrete make one tie and are rigidly connected by being moulded on the ends of a pair of 3-in. channels, weighing 3 lb. per lineal ft. The channels are placed back to back and held 2 in. apart by cast iron spacers. The concrete blocks have a thickness of 7 in., with a 9-in. face, and show practically the same cross section as a timber tie that has been slabbed from a log about 11 in. in diameter. Hardwood blocks about 18 in. long, designed to cushion shocks, distribute pressure, support derailed trucks, and serve as spiking blocks, are secured to the top of the concrete blocks, these hardwood blocks being centred transversely to the line of the rail.

The Chicago and Alton Railway, in October, 1905, have likewise used this same design of tie. In 1911 1,700 of these ties were placed in the tracks of the Pere Marquette Railroad at Bay City, Michigan. The tie referred to is known as the Percival.

The North Western Railway of India and also the Assam Railways.—Reinforced concrete sleepers made on what is termed the Jagger system, and to which reference will be made when describing a trial on one of the English railways, have been tried on both these lines, on the Assam somewhat extensively—and this to some degree also applies on the line

Madrid to Caceres and Portugal.—They were installed in January, 1909, between the stations of Madrid and Villeaverde. After eighteen months' use the engineer appears to have been quite satisfied with them, but we have no later information as to their condition.

AMERICAN EXAMPLES.

Lake Shore and Michigan Southern Railway.—In the *Engineering News* of October 17th, 1905, there is an article entitled "Concrete Ties on the Lake Shore and Michigan Southern Railway." This particularly describes the 3,000 concrete ties used by this railroad as being the most extensive test of this material for this purpose. According to the assistant general engineer, Mr. Samuel Rockwell, the results of their experience with concrete ties have proved the merits of this material. Mr. Rockwell says in his statement that he has been experimenting for three or four years with a patent tie which consists of a piece of rail turned upside down and embedded in concrete, the bottom being shaped somewhat similar to an ordinary wooden tie. The only failures met with were those where they had been laid singly with seven or eight wooden ties between them. He states further, however, that he does not know the direct cause of these failures, whether by reason of the severe shock or its extreme rigidity over the wooden ties. The steel rail used in this particular tie weighed 65 lb., the flange of the rail forming the seat for the track and attachment for the fasteners. It is proposed to use a rail section which will weigh about 80 lb. These ties, as made, weigh 400 lb. (concrete 235 lb., steel 154 lb.), and in some of them the concrete proportions are one part cement to four parts of gravel, while others have one part of cement, one part fine washed limestone, and three parts ½-in. washed limestone.

The Pennsylvania Lines.—The Pennsylvania Lines, near Toledo, Ohio, have used some of these ties, and there are various trials of about 4,200 in use to-day as follows:—

Lake Shore and Michigan Southern	2,943
Pennsylvania Lines...	450
Lakeside and Marblehead Railway	550
Sandusky City Waterworks Track	120
Ann Arbor Railroad	77
Lake Erie and Western	24
Wabash	25
Chicago and North-Western	15

Galveston, Houston and Henderson Railway.—In November, 1906, issue of CONCRETE, page 23, there is an article entitled "Concrete Ties for Railroad Use," which particularly describes the experiments of the Galveston, Houston and Henderson Railway. The ties were placed in the main line track at 43d Street, Galveston, which point is subjected to an enormous amount of heavy switching, together with regular service. After they had been laid a year a careful inspection showed them to be in perfect condition. A derailment occurred over these ties and no material damage was done. Three had their rails broken and their centre shattered, but the utility of the tracks was not impaired. The cars derailed at this point were loaded with steel rails, so that the test given was severe.

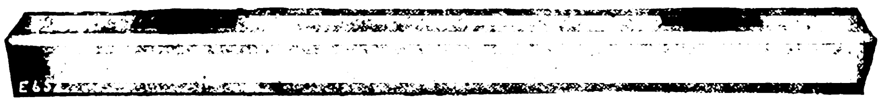
The Florida East Coast Railway.—This company placed on a section of their track near St. Augustine several concrete ties, and the general manager of the company, Mr. Carter, reports that they are satisfactory.

The U.S. Steel-Concrete Tie Company of Milwaukee.—Here is presented one of the most recent developments in steel concrete ties. They claim to have solved what has been a perplexing problem retarding their adoption, namely, satisfactory and simple rail fastenings. This company have some concrete ties in the main line of the

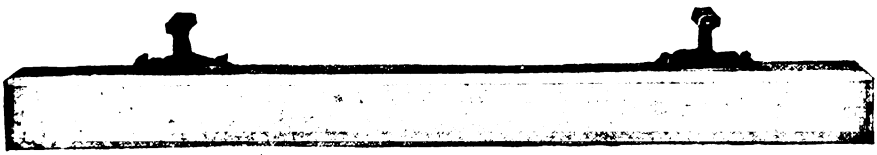
Chicago, Milwaukee and St. Paul Railway, located on a 6 degree curve just north of Milwaukee, Wisconsin. These ties have been in place since December last, and, according to their road foreman, have received no attention whatever, the fastenings proving themselves to be all that can be desired.

This particular tie is composed of a 5-in. I-beam encased in concrete, to which is bolted a cast iron plate, which, in turn, supports the rail, being separated therefrom by the regulation insulation. The plate has two slotted holes, in which is fitted a link, and the fastening consists of a clip dropping over this link and resting on the flange of the rail, being securely held in this position by a heavy split-pin. There is absolutely no concrete carrying any direct load from the rail. The wheel loads are transmitted through the rail and the plate to the I-beam section, where, in turn, the entire load is distributed throughout the total section of the concrete. While these ties have only been in service six or seven months, they are said to be substantiating all the claims which have been made for them.

THE U.S. STEEL TIE WITH TIE RAIL FASTENINGS BEFORE THE CONCRETE IS MOULDED AROUND IT.



THE U.S. STEEL-CONCRETE RAILROAD TIE READY FOR USE.



THE STEEL-CONCRETE TIE SHOWING INSULATIONS UNDER RIGHT RAIL.

The Riegler type of reinforced concrete tie, tried on the main line track of the Pennsylvania railroad, has been reported upon by the Committee of the American Electric Railway Association as follows:—

"All ties are still in good condition and giving satisfactory service with no apparent depreciation after six and a half years." This tie has a concrete body with a curved steel blade on each side, being connected with the top and bottom by transverse rivetted straps. Rails raised on a flat steel tie, blades secured by through bolts and clips. Bolt heads lying in pockets in the bottom of the tie. Two bent steel rods are embedded in the concrete.

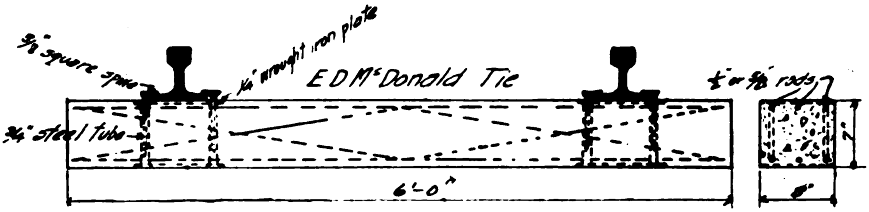
The depth is 7 in., width $9\frac{3}{8}$ in., and flap of 12 in. over the curved sides. The width and form of section are claimed to give such a large bearing that the fifteen ties used under one rail length are as efficient as the eighteen wood ties per rail used elsewhere in the track, and the curved sides are believed to prevent any tendency of the ties to slew in the ballast. The weight is about 800 to 850 lb.; but according to the inventor this causes little inconvenience in handling when proper tools are used, at the present time adding to the stability of the track. No data as to the cost of these ties is given. The annual cost per mile of track, with uniform supporting area of 80 sq. ft. per rail length, is given as follows in a statement prepared by the inventor:—Concrete ties, 16 per rail, $875 per mile per year; untreated oak ties, or inferior treated ties, 20 per rail, $1,196 and $1,286 respectively.

The life of the concrete tie is estimated at 20 or 15 years for roads of medium and heavy traffic, as against nine or six years for wood ties under same conditions.

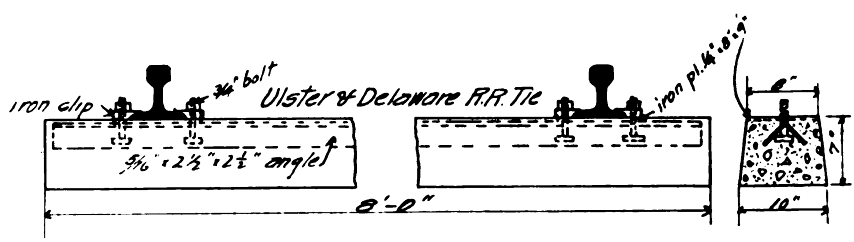
A further report on the Riegler concrete steel tie is given in 1910. Fifteen ties in use carrying a 44-ft. rail length of track on the westbound main passenger track of the Pittsburg and Fort Wayne and Chicago Railroad west of Emsworth, Pennsylvania. This track carried through suburban trains together with freight trains daily. Ties were laid in May, 1908, and at the inspection in September, 1909, they were found to be in excellent condition. The bolts were tight, with the exception of one, the nut on which could not be tightened on account of the bolt turning in the tie. Section foreman stated he had not found it necessary to tighten the bolts for a period of five months previous to inspection. The ties require about the same amount of surfacing as the wooden tie in the same track, but they hold in line better. Insulation is thoroughly satisfactory, and they have experienced no trouble with the track circuit used in connection with the automatic signals. The engineers of maintenance of way consider the tie as being too heavy and too costly.

Some types of concrete ties which have been tried with fairly satisfactory results are shown below:

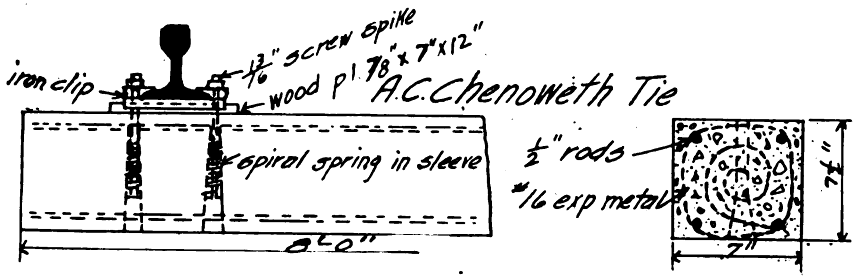
The McDonald Tie.—Seven thousand have been installed by the Los Angeles Street Railway Company in Los Angeles, Cal., and two years' service, it is said, has shown them to stand up quite well under a traffic of 2,800 street cars daily. The steel tubing fasteners for the rail spikes are reported to work very effectively.



The Ulster and Delaware Railroad Trial.—About 100 ties of the angle iron reinforcement type have been used for about one year on this railroad. The fastening by means of a bolt through the angle iron reinforcement is said to hold very well; the square head of the bolt being unable to turn after tightened up in between the legs of the angle.

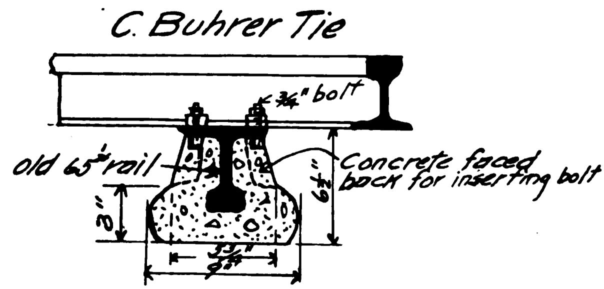


The Chenoweth Ties.—A number of these have been tried in the Scully Yard on the Pittsburg Division of the Pennsylvania Railroad, also on the Philadelphia Rapid Transit Street Railway car tracks, and at the Dyckman Street Station of the New York City Subway. This tie is made in a special machine mould, in which a reinforced roll is first made and then squared by pressure. The fastenings device for holding the rails consists of a small shell of galvanised steel coiled into a hollow frustrum of a cone, into which is inserted a spiral spring of such a pitch as to take the threads of a 13/16-in. lag screw. The shell and spring are inserted from under side of the tie into holes cast for them.

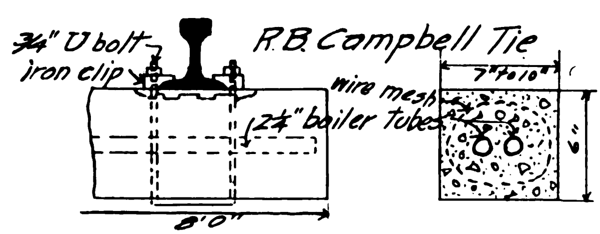


The Buhrer Tie.—Has been installed as follows:—

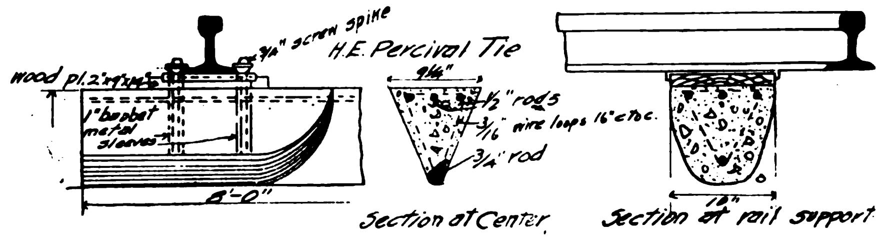
Railroad.	No.
Lake Shore and Michigan Southern	2,943
Pennsylvania Lines	450
Lakeside and Marblehead Railway	550
Sandusky City Waterworks Track	120
Ann Arbor Railway	77



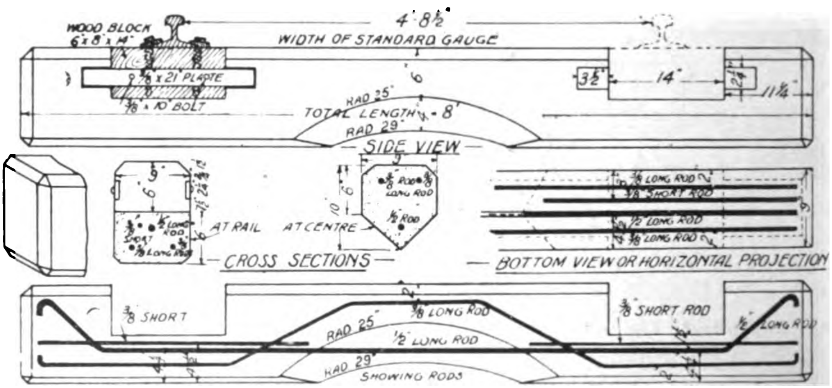
The Campbell Tie.—Is reinforced with 2¼-in. scrap boiler tubes and an oval wrapping of wire netting (chicken-wire). The rail flange is given a bearing on the tie on top of an embedded plate, consisting of a grooved and shouldered tie plate 8½ in. square laid upside down. The fastening consists of a ¾-in. U bolt, with a spread of 8¾ in., placed diagonally and held on top with two nuts screwed over clip washers which bear on the flange edges. These have been tried on the Elgin, Joliet and Eastern Railway.



The Percival Tie.—Previously referred to. A few of which have been used on the Galveston, Houston and Henderson R.R. in Texas. It has a rather triangular cross section and is reinforced with four longitudinal rods wrapped 16 in. centre to centre with 3/16-in. wire loops. The fastening of the rail is effected by driving screw spikes into a sleeve or socket of babbitt metal embedded in the concrete. The head of the spike is bevelled on the under side to fit over the rail flange.



A Trial at Eagle Pass, Texas.—A tie in which Mr. F. E. Shearer, of San Antonio, Texas, is interested, has a wooden inset, and is stated to be simple in construction. They have been used in the Galveston, Harrisburg and San Antonio yards at Eagle Pass, Texas, for a year, during which time it is asserted not a tamping bar has been placed on them, and they have not deviated out of line, so that the results are deemed to be satisfactory. The traffic is said to have been heavy, and a point is made that when wooden ties were used here they had to be changed every year.

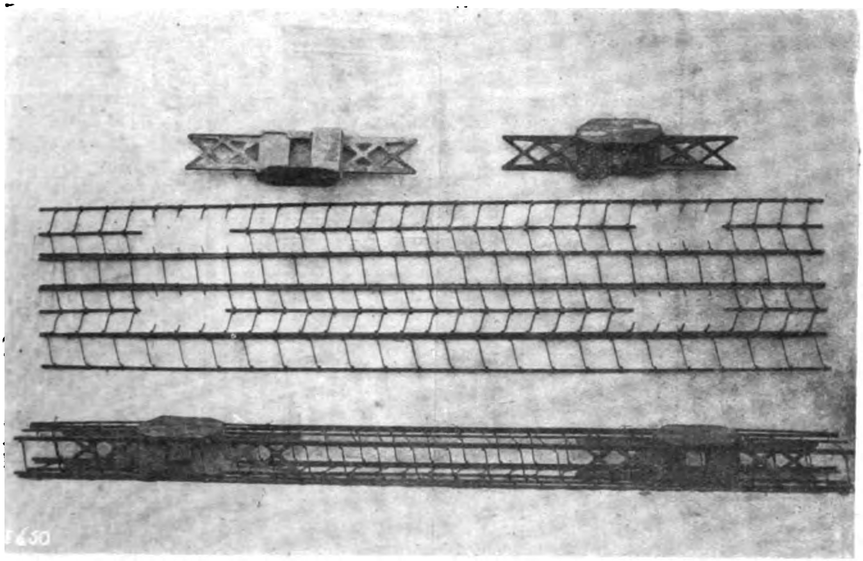


SIDE VIEW

The Weber Concrete Tie is the invention of H. L. Weber, of Mound Avenue, South Pasadena, Cal. A feature of this is the manner in which the rail fastening is dealt with. There are two malleable anchors with two boxed recesses in each, one anchor being placed under each rail. In these boxed recesses wood blocks are driven firmly, and it is into these that are fixed the usual spikes to make the rail connection. The wood, when necessary, can be replaced. The reinforcement in two of the ties at Bucyrus, Ohio, consist of three ½-in. by 1½ in. Kahn bars—two in top of the tie and one in the bottom. The other two ties were reinforced with one sheet of rib metal, bent into the form of a basket. These have been in service nearly seven years. Last year (1916) 50 Weber ties were made for the Atchison, Topeka and Santa Fe Railroad Co., which, so far as the steel reinforcement and anchor arms are concerned, were constructed to the following specification :—

Steel Reinforcement.—Steel for reinforcing consists of the "Kahn" two two-rib studs, one on each side, and two three-rib studs, one on top and one on bottom, assembled to form a box-shaped reinforcement, 4½ in. by 6¼ in. by 7 ft. 10 in. long. The studs are made of the highest grade of open hearth steel, with an estimated strength of from 50,000 to 70,000 pounds per sq. in., and an elastic limit of at least half the amount, with an elongation of at least 20 per cent. A bar or rib shall bend cold through an angle of 180° and close down upon itself without cracking. There are ten ribs in each tie, five on top and five on bottom, with sectional area of ·09 sq. in. each.

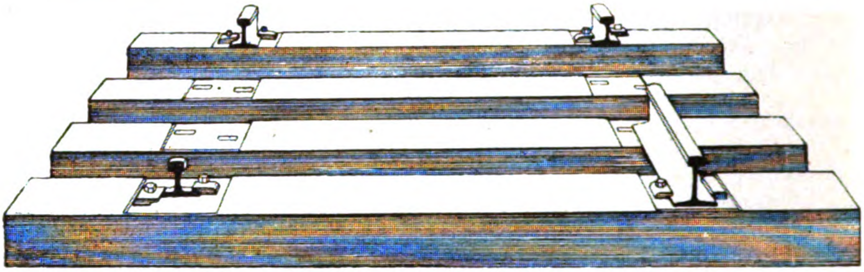
Anchor Arms.—There are two malleable iron anchor arms, one on each end of the tie, weighing 15 lb. each. In each arm there are two white oak inset blocks, 1⅛ in. by 3 in. by 5½., for spiking into. The anchors are placed 4 ft. 11 in. on centres. The spiking range in width is 9½ in.



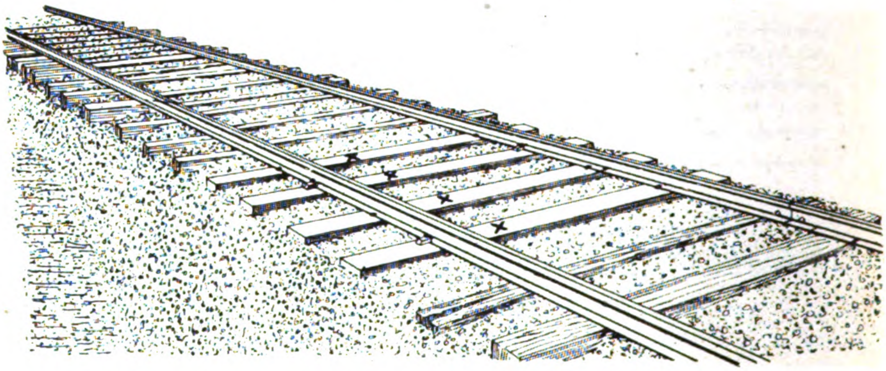
SHOWING THE REINFORCEMENT.

THE TIE PREPARED FOR THE SANTA FE RAILROAD, LOS ANGELES, CALIFORNIA.

Steel.—The proportion of steel in the beam of the tie is ·45 sq. in. to 48 sq. in. of concrete, or practically 1 per cent. in both the bottom and top sections, exclusive of the anchor arms.



THE TIE AT BUCYRUS, OHIO.



THE TIE (those marked with an x) IN THE TRACK AT BUCYRUS, OHIO, 1909, AND THE PACIFIC ELECTRIC RAILWAY, LOS ANGELES, CALIFORNIA, 1912.

The Wolf Tie.—Riverside Rialto and Pacific Railway.—This is one of the experiments which have been carried out on the above named railway. In an article by J. H. G. Wolf, published in the *Engineering News* of March 15th, 1917, all the details and claims are set out. It will be noticed that these ties are of hollow form, the object being to obtain lightness and resilience. The method of rail attachment used is such that the attaching medium is entirely free of the tie construction itself. A screw spike passes through an opening in the rail seat into a loosely

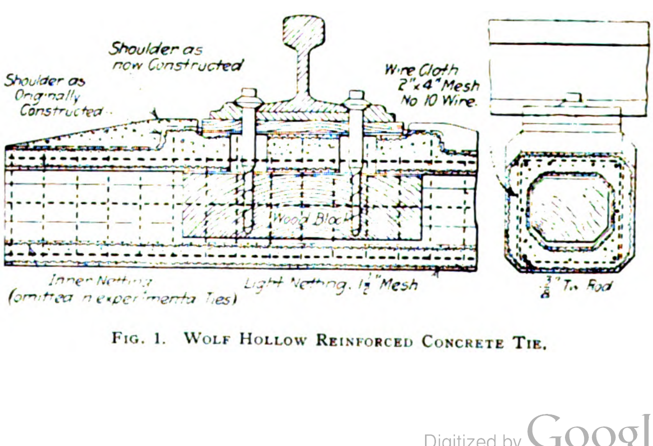


FIG. 1. WOLF HOLLOW REINFORCED CONCRETE TIE.

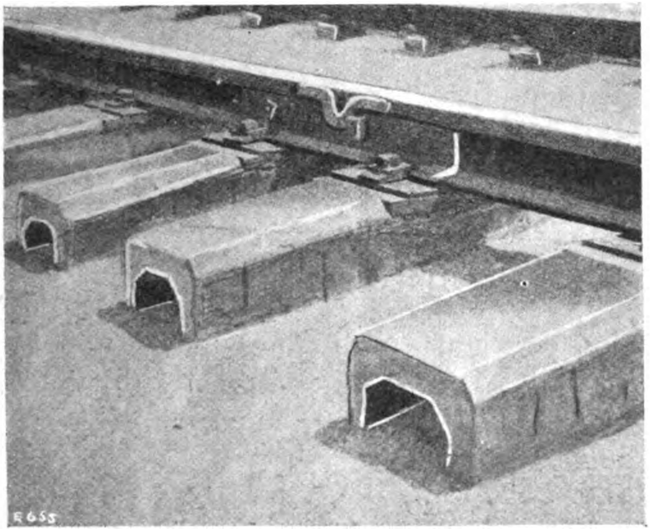


FIG. 2. THE REINFORCED CONCRETE TIES IN PLACE.

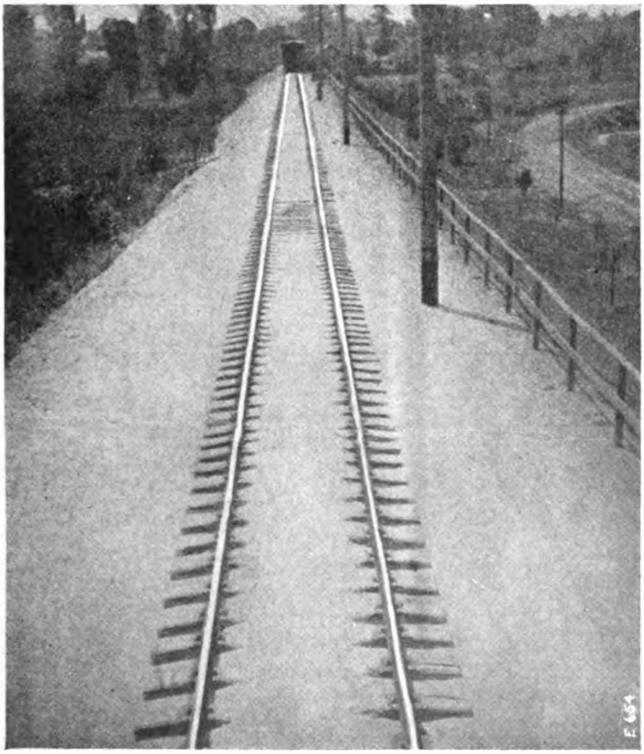


FIG. 3. VIEW OF TRACK WITH WOLF TIES.

inserted block of wood, some 18 in. long, within the tie. The thrust on curves and from swaying train equipment is thus taken on the upper surface by the cushion block against the raised shoulder, and on the interior by the upward thrust of the block against the concrete surface.

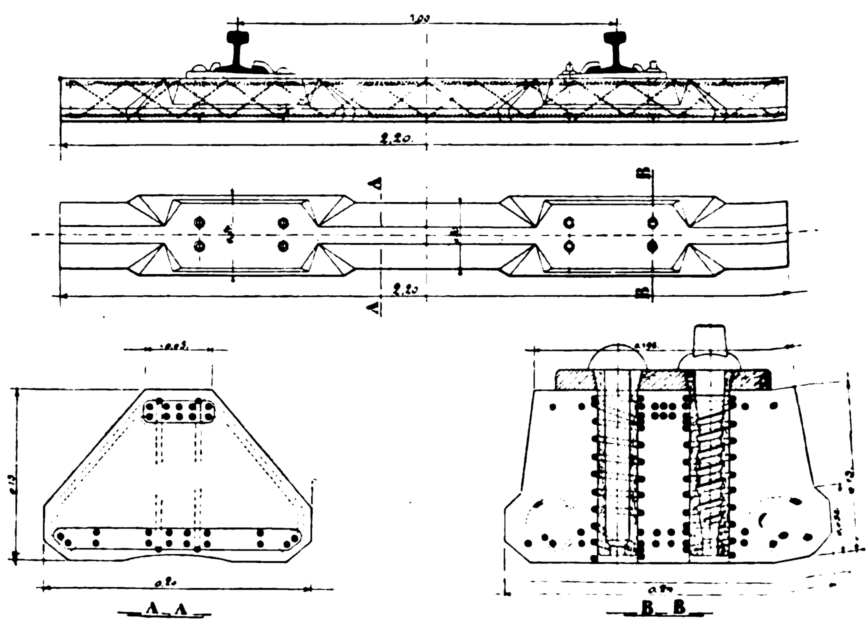
About 120 ties were cast in August and September, 1913, and some 60 of these, seen in *Fig.* 2, were placed in the track in October, 1913. They have been there ever since, except for a few removals for minor failures. The ties are 7 in. by 8 in. in cross section, and 8½ ft. long. They have 1½ in. walls, increased to 2 in. under the rail seats, except that a few have straight 2-in. walls throughout. The average concrete is a 1 : 2 : 3 mix.

The stretch of 200 lineal ft. of track comprised in the experiment is on the Riverside, Rialto and Pacific R.R., at Riverside, Cal., which line carries an interurban high-speed electric service in addition to an intermittent but heavy-weight steam railway service. Trains with 87-ton locomotives, hauling 20 steel cars loaded to capacity with cement (and weighing up to 70 tons each) pass over this track at high speed to overcome a 20 per cent. grade to Riverside. The ties are at the foot of this grade.

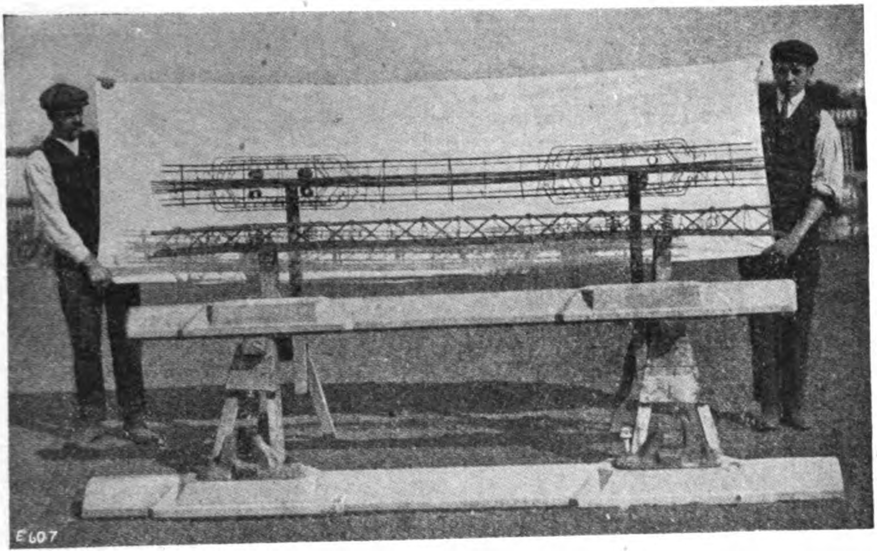
A few of the ties have split on the ends of the upper surface, owing possibly to expansion stresses. The concrete under the rail seat of one or two ties is said to have given way; all others are reported to have stood up well during the three years' service. The ties weigh 320 lbs., can be handled by two men, and it is claimed there is less tendency to bury themselves in the ballast than is the case with one of solid concrete.

TRIALS ON ENGLISH RAILWAYS.

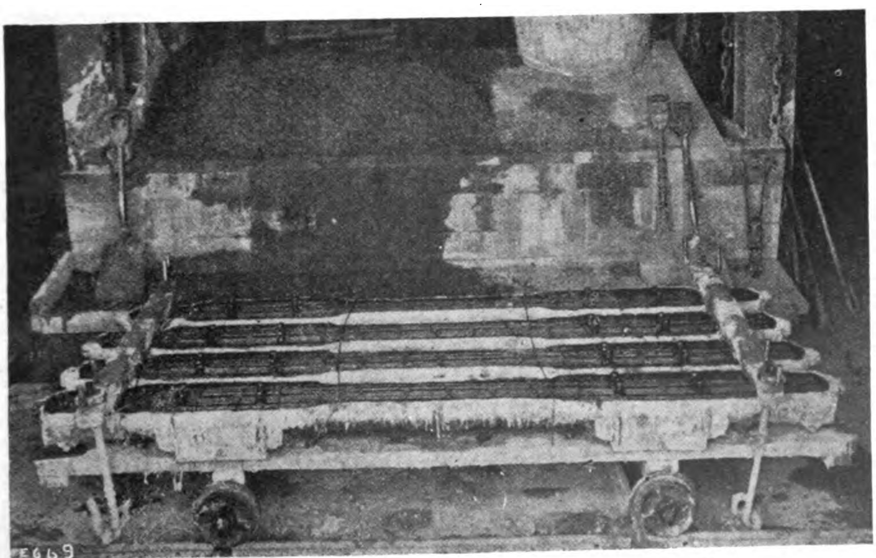
The South-Eastern and Chatham.—In December, 1909, the British Improved Construction Co., of 47, Victoria Street, Westminster, supplied the above-named company with some reinforced concrete sleepers made on the Jagger, vibrating and oscillating process. They consisted of 24 intermediate sleepers—*i.e.*, those to be used



DESIGN OF SLEEPERS ON SOUTH-EASTERN AND CHATHAM RAILWAY AND METHOD OF FASTENING between joints of rails—and 78 joint sleepers to support joints of rails. The design of the joint sleeper was the same as the intermediate, but had a greater bearing area on the ballast. The approximate over-rail dimensions of the sleeper are 8 ft. 11 in.

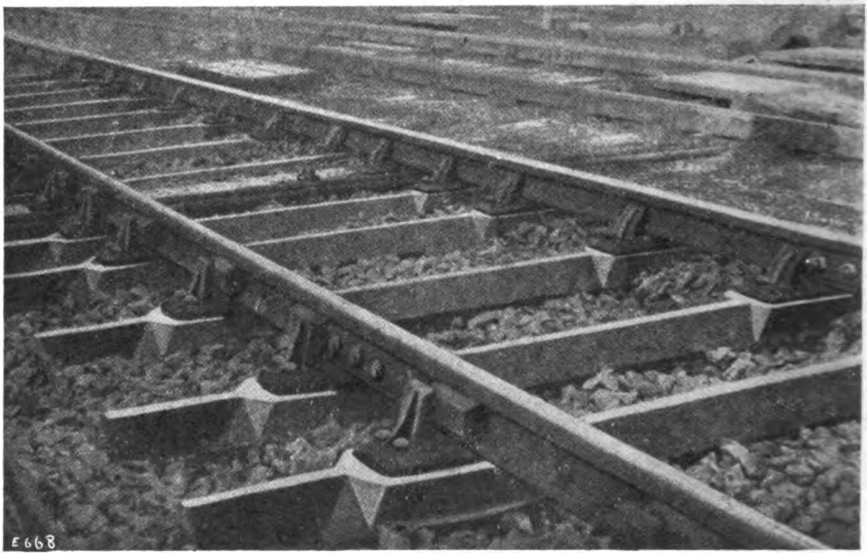


VIEW SHOWING REINFORCEMENT OF SLEEPERS ON SOUTH-EASTERN AND CHATHAM RAILWAY.



MAKING REINFORCED-CONCRETE SLEEPERS AS USED ON SOUTH-EASTERN RAILWAY.

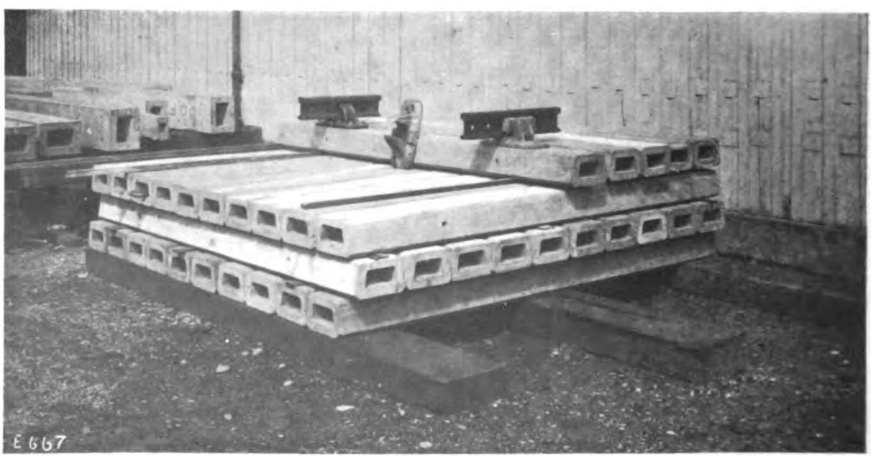
by 12½ in. by 5 in., the latter being the part which supports the chair. They were laid on the main London to Dover track, near Knockholt Station, through which trains run at high speed. Twenty-four of the intermediate and two of the joint sleepers were put in one section of the main down-line track, and 76 of the joint sleepers on the up line. The ballast is broken stone (Kentish rag.) In March, 1912, after over three years' wear, they were reported to be in sound condition. More recent investigations, however, have shown that this desired result has not altogether been maintained, and attrition of the concrete at the base, combined with some



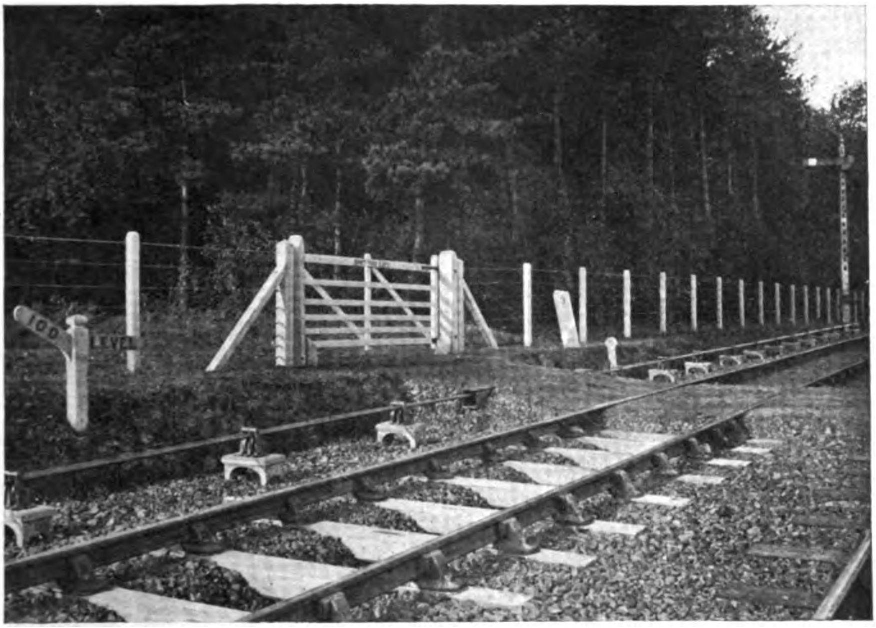
REINFORCED CONCRETE SLEEPERS AT KNOCKHOLT (STATION), SOUTH-EASTERN AND CHATHAM RAILWAY.

fractures, has caused the removal of 16 of the smaller sleepers after four years' service. The joint sleepers are still in the track, and the fastenings are stated to be satisfactory. It is possible that some of the defects can be remedied, and the trial must be regarded as a valuable contribution to the list of experiments.

The Midland and Great Northern Railways Joint Stock Committee.—Some twelve months since a trial of the Marriott system of reinforced concrete



THE MARRIOTT SLEEPER STACKED, SHOWING THE ATTACHMENT



VIEW OF MARRIOTT SLEEPER ON THE TRACK OF THE MIDLAND & GREAT NORTHERN JOINT STOCK RAILWAY.

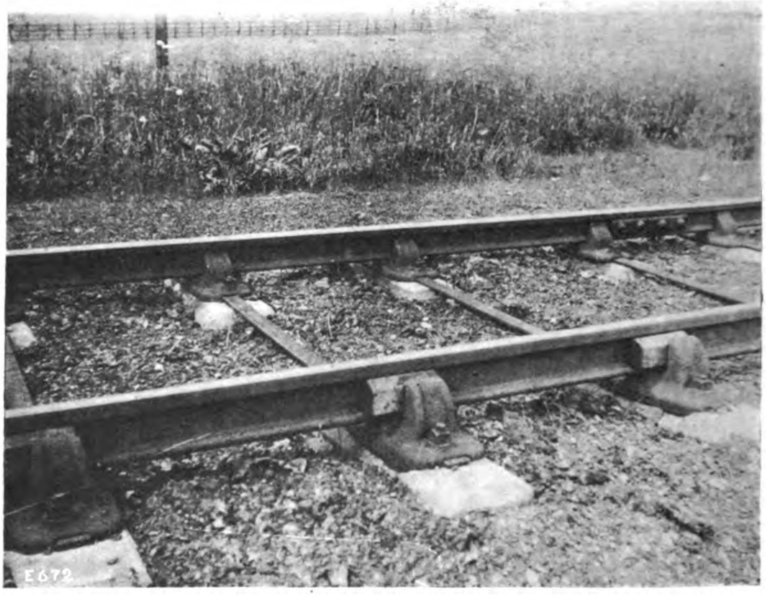
sleepers was instituted on this line at Melton Constable. The sleepers, as will be seen, are hollow, and about 100 have been made. Two stretches are placed on the main line, and it is stated they have to bear heavy shunting traffic.

Great Central Railway.—The Yokeblock sleeper of the Permanent Way Improvement Co., Ltd., 95, Colmore Row, Birmingham, on trial on the Great Central Railway at Neasden, Middlesex, consists of two blocks of concrete supporting the chairs under each rail, the blocks themselves being held at the correct gauge distinct from each other by means of light steel or wrought-iron tie-bars, of 2¼ in. by ⅜ in. section. The concrete blocks with which experiments have been made hitherto have been reinforced with a bent sheet of expanded metal, but such reinforcement they say is not essential. Compression tests of concrete blocks made in 1912 clearly prove that the resistance of concrete to crushing far exceeds the maximum compression and sheer strain that would be put upon it by the rolling load on such short concrete blocks; further, that resistance is found to increase 75 to 100 per cent. with age. Concrete has also the advantage of an indefinitely increased life.

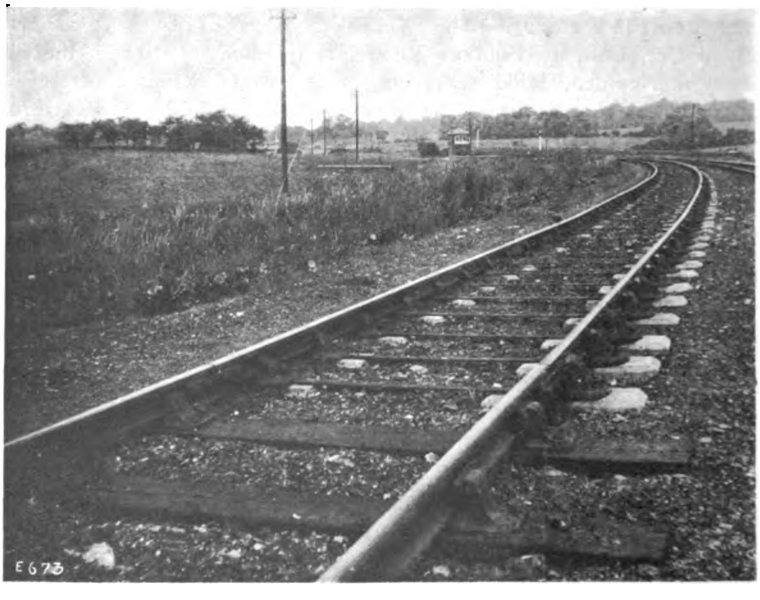
The tests at Neasden are on certain shunting tracks which carry a heavy traffic. The rails employed are of bull-head section, weighing 86 lb. per yard, and are carried on cast-iron chairs in the ordinary way. Ash ballast is used. The heaviest G.C.R. locomotives are worked over these lines, with axle-loads reaching a maximum of 20 tons.

Sixty-seven concrete block sleepers were laid nearly two years since on a curve of 19 chains radius, with a super elevation of 3 in. No special attention in the way of packing and lining other than that which ordinary through sleeper roads would require has been found necessary, and it is claimed the results are so far satisfactory.

The Yokeblock system also comprises the use of a timber block, but as this review is devoted to showing what has been accomplished in the tests of concrete sleepers, we have dealt exclusively with the blocks made of this material. Another important consideration is the fact that it is now becoming imperative as far as possible to find a substitute for wood.



VIEW OF THE YOKEBLOCK CONCRETE SLEEPER AT NEASDEN BY J. ALLEN.



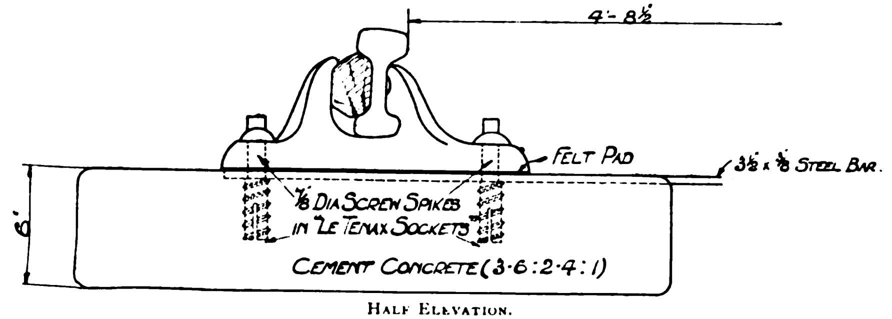
VIEW OF THE YOKEBLOCK CONCRETE SLEEPER AT NEASDEN BY J. ALLEN.

Concrete Compression Tests.

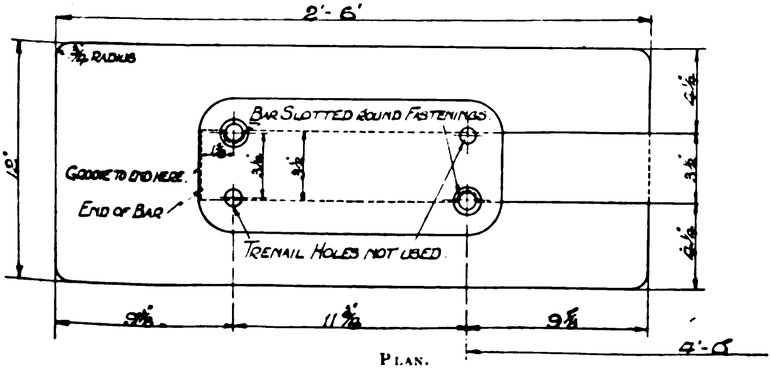
Following are the results of compression tests carried out by Mr. H. J. Harding at the laboratory of Messrs. G. and T. Earle, Wilmington Cement Works, March 14th, 1912, on 6-in. cube blocks of concrete, made from washed and graded gravel and sand. The gravel and sand were taken from the pits of the North London Ballast and Sand Co., Angel Road, Edmonton, London, N. :—

	Nature of Aggregate	Grading of Aggregate (mesh)	Parts by measure	Per cent. of water used	Maximum crushing stress in tons per sq. ft. after following periods			
					1 mth.	3 mths.	6 mths.	12 mths.
A	Washed gravel (stones only) Washed sand Cement	2" down to 3/16" 3/16" down	6 2 1	8.3	229	263	337	359
B	Washed gravel Washed Sand Cement	3/4" down to 3/16" 3/16" down	3/4" 4¼ — 3/16" 1½ — 1½ 1	7.1	240	314	332	425
C	Washed gravel Washed gravel (stones only) Washed sand Cement	3/4" down to 3/16" 3/16" down to 1/16 1/16" down	3.6 1.2 1.2 1	7.1	252	364	416	459
D	Washed gravel Washed sand Cement	1/2" down to 3/16" 3/16" down	4½ 1½ 1	7.1	208	318	348	402

The Great Eastern Railway.—We are informed that arrangements are being made by this company to lay a test length of Yokeblock sleepers the same as those referred to in the notice of the Great Central Railway on a passenger route near Stratford, Essex, which carries a heavy mixed traffic running at speeds up to



HALF ELEVATION.



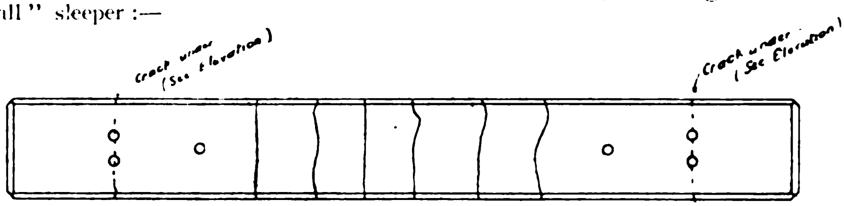
PLAN.

30 m.p.h. The section of the line is both curved and steeply graded. The experiment is also to be made of using wider tie-bars, $3\frac{1}{2}$ in. by $\frac{3}{8}$ in., instead of $2\frac{1}{4}$ in. by $\frac{3}{8}$ in., to alternate sleepers; no ties to the other sleepers (see drawing p. 377). If this is found suitable, the economy in iron or steel bars thereby effected is obvious.

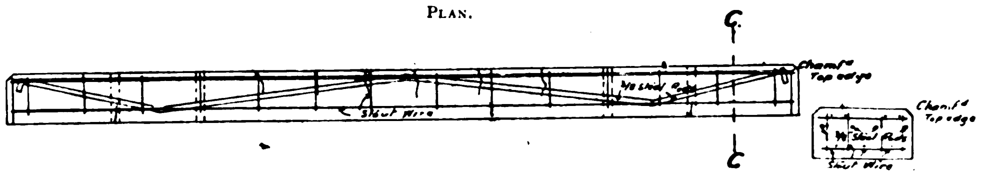
The London and South Western Railway.—A trial of the "Hall" reinforced concrete sleeper was made on this railway some years back at Eastleigh. In the experiment 12 of them were put down on the up goods line, but the results were not satisfactory, and all were removed at the end of about three months.

It was found that after a frost the sleepers had cracked in many places, as shown by the lines on the attached drawing; in some cases the cracks were right through the treenail holes. The formation was gravel and the sleepers were well packed and bedded.

Further experiments with concrete sleepers of a different type are in contemplation and will probably soon be made. The following drawing describes the "Hall" sleeper :—



PLAN.



ELEVATION. SECTION.

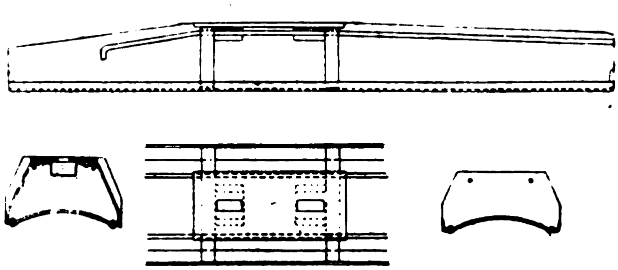
London and North Western Railway.—This company has made trials of three different types of the reinforced concrete sleepers, but in no case has the result been sufficiently good to warrant a more extended use of them for main line traffic. Sleepers made by the British Improved Construction Company were laid down in the main line under heavy traffic in 1911, but had to be taken out after about fifteen months' service. Some of these were still useable, have been repaired, and are now in sidings. Some sleepers laid down under lighter traffic are still in use, although some of them show signs of failure.

Auden's Reinforced Concrete Sleeper—only a few of these were tried in 1912, and a small proportion are still in use, though considerably cracked.

Asbeston Reinforced Concrete Sleepers—a small number of these were laid in February, 1914. The fastenings have worked loose, the sleepers cracked, and have had to be taken out.

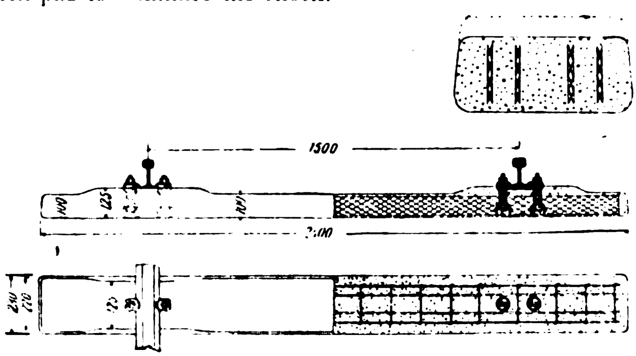
OTHER RAILWAYS.

The Bavarian States Railway.—About eight years since concrete sleepers were laid by way of a trial on a section of the double line between Nürnberg and Bamberg, partly on a bed of broken stone and partly on one of sand. The method of fixing the rail was carried out exactly in the same manner as with steel sleepers. The reinforcement consisted at first of only two square rods, 8 mm. in diameter, in the upper part and angle irons, 20-30-4, in the lower. As a consequence these first laid sleepers soon showed cracks. Round iron rod reinforcement in the proportion of 1 per cent. of the sectional area was therefore added; four square rods, of 8 mm. in the upper, and three square rods of 8 mm. in the lower part, were inserted. In addition the rail-bed plate was improved and wire netting reinforcement used. The under side of the sleeper is hollowed out to increase the friction on the road bed. The angle iron protects the sleeper against damage by the picks during the packing, but they easily break away if the corners get broken.



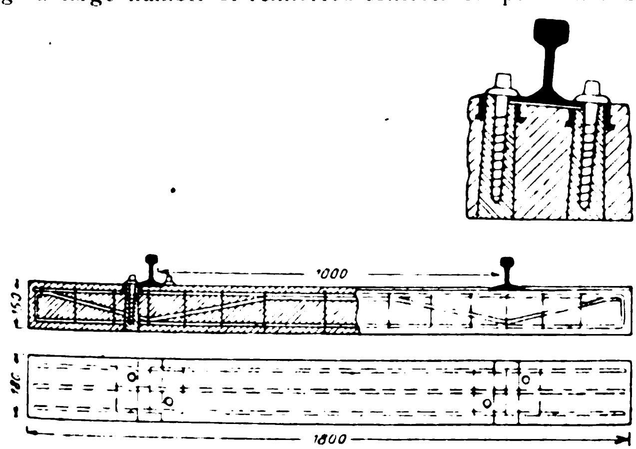
Sleeper on Bavarian States Railway.

The Sardar Sleeper.—This has been tried on the French State Railways, the Paris, Lyons and Mediterranean Railway, and in the French Colonies. It is reinforced with expanded metal, and in the method of fixing the rails the flat side rests upon a felt pad to minimise the shock.



The Sardar Sleeper.

Sleeper for Narrow Gauge Railways.—In addition to those tried for the ordinary gauge a large number of reinforced concrete sleepers have been used for



Sleeper for Narrow Gauge Railway.

branch and narrow gauge lines. An example of this type is shown p. 379. It was one in use on the section between Voiron and Saint Beron. The length is 1·80 metres for a metre gauge line. The reinforcement consists of nine round steel rods 8 mm. diameter, equivalent to 1·8 per cent. of the total concrete section. The method of fixing the rails is shown herewith. In order to prevent a splitting of the wooden plug by the screw dogs it is gripped at the top by an iron ring, which also serves excellently as a seat for the head of the screw. The weight of the sleeper is 105 kg., and they have been in experimental use since 1903.

Trials on Railways in Sweden.—Some years since the Maltesholm Cement Factory at Tollarp made some cement sleepers which were laid as a trial on certain railways, and they were also tried on one of the State railways that bought 2,000 of them. We are informed that these sleepers, which have now been installed for several years, have generally done good service. To this, however, there is one exception—viz., that a cement sleeper at the joint of the rail has, in these experiments, not been found so good as those of wood. In dealing with this matter it is suggested that a timber sleeper might be placed at the joints or a cement one of greater strength. We understand that a Berlin firm have tested a great many examples of concrete sleepers, and considered those made at the above-named factory as being the best.

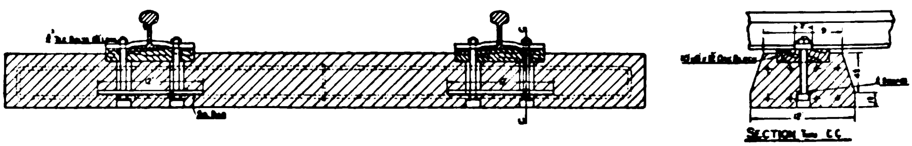
Until very recently trials of these sleepers were being arranged in

Russia.—The idea being that railways and tramways in Petrograd should be provided with concrete sleepers, and also a plan was under consideration for using a large quantity of them in the construction of a new South Russian railway.

It is nearly six years since concrete sleepers were first used on the Christiansstad-Eslöv lines, where we hear they are deemed satisfactory.

A Trial of Reinforced Concrete Sleepers at Swanscombe, Kent.—About eight years since the Associated Portland Cement Co. laid a track of thirty yards on one of their works at Swanscombe, near Northfleet, Kent, as shown in drawing.

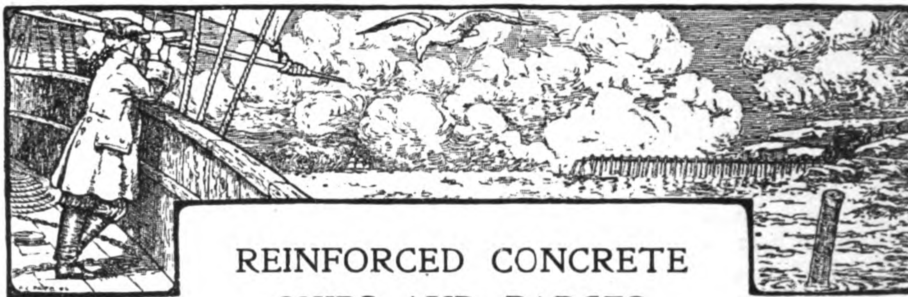
The site selected was a wharf road where they have withstood constant use and severe treatment at times. Frequent inspection of this piece of track has shown good condition generally.



THE SLEEPER AS IN PRESENT USE AT SWANSCOMBE—SECTIONAL ELEVATION.

PORTLAND CEMENT PAINT AS A PROTECTION TO STEEL.

In view of possible experiments that may be made in the construction of reinforced concrete sleepers, it will not be out of place to give the following information respecting certain trials that were made in 1909 by F. E. Giesecke and reported in the American journal, *Cement Age*, in the December of that year. The object of these experiments was to ascertain the best protective coating for a steel reinforcement. It is generally conceded that steel embedded in concrete will not rust so long as the concrete is free from voids. In the trials that were carried out a number of steel rods were painted, some with red lead, others with boiled linseed oil, some with neat Portland cement, and a few were not treated in any way. The painted rods were allowed to dry in the shade for one week, and then all were embedded 5 in. deep in concrete. After a time the specimens were tested in an Olsen machine by pulling the steel rods out of the concrete, and, although the adhesion of the uncoated rods was perfectly satisfactory, it was found to be still better in the case of the rods painted with cement. During the experiments the best results were obtained when the cement setting was maintained repeatedly for several days, either by rain, dew, or by an artificial spray of water. In the first two or three days the coating can be rubbed off easily, but after that it adheres firmly to the steel. The adhesion is increased about 35 per cent. by a coating of neat cement. To determine the cost of applying a coating of cement to structural steel, 1 lb. of Portland cement was mixed with ¾ lb. of water. This quantity was found sufficient to cover 70 sq. ft. one coat, and, consequently, the expense, other than labour, was very trifling. In our next issue we shall give further particulars and details of these trials.



REINFORCED CONCRETE
SHIPS AND BARGES.

The question of Reinforced Concrete for Shipbuilding is receiving considerable attention at the present time, not only in this country but in many of the other European countries, not only owing to the shortage and high price of timber, but because, comparatively, they can be built in a short period of time. It is somewhat difficult to obtain really reliable and up-to-date technical data on the subject, but we hope in a later number to give our readers some more detailed information, apart from the particulars here presented.—ED.

Norway.—We learn from the Norwegian papers that Mr. Nic. Fougner, engineer and shipbuilder, at Moss, has been granted permission by the Government of Norway to build two reinforced concrete ships for traffic in the North Sea, one to be of 1,000 tons dead weight and the other 600 tons. These two vessels are more or less in the nature of an experiment as far as the Norwegian Government is concerned, but should they prove satisfactory, the experiment should go a long way towards assisting in solving the present difficult problem of shortage of tonnage, for the engineer states that he can turn out such ships complete in about four or five months.

It has been stipulated that the ships shall be built 20 per cent. stronger than specified by Mr. Fougner, and also that abundant life-saving material is to be provided.

The 600-ton vessel will be 145 ft. long and it will be provided with a double bottom and five watertight compartments. It will be worked by 250-h.p. motor engines with crude oil, and the speed is reckoned at from nine to ten miles. The accompanying sketch (*Fig.* 1) shows that the vessel is like an ordinary cargo boat, and it is stated that the cost will work out at about the price of a steel structure.

This first concrete ship is to be ready for delivery about the middle of September. They have the necessary materials in Norway, except the armoured steel bars, of which there is a certain supply in the country, and, in any event, it is easier to procure these than steel plates.

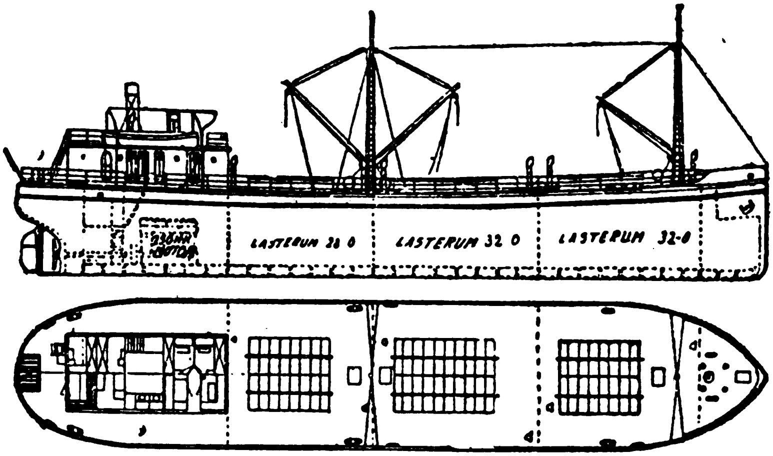


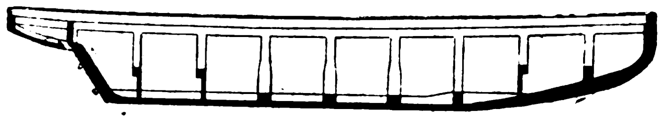
FIG. 1. SKETCH OF NORWEGIAN 600-TON REINFORCED CONCRETE VESSEL TO BE BUILT FOR THE NORWEGIAN GOVERNMENT.

Italy.—In the Italian periodical *Il Cemento* there has recently appeared a short illustrated article on a reinforced concrete barge which has been in use since April, 1912, and is still quite waterproof. By the courtesy of *Il Cemento* we are able to reproduce the accompanying particulars and illustrations. *Fig.* 2 gives a longitudinal and a transverse section and a plan showing half the inside and half the outside of the hull, and *Fig.* 3 shows the vessel when finished.

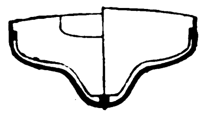
The shape of the vessel conforms to the ordinary rules of shipbuilding, and all its lines are double curves. This made it difficult to apply the usual network of metallic reinforcement, and it was therefore replaced by bars placed very close together and tied by oblique and crossed hoops. The calculation of the dimensions of the different parts was confined to the more important sections, the remainder being merely an extension of the other parts, modified so as to give the necessary contour to the vessel. The same sizes of bars were used throughout, for the sake of simplicity.

The calculations were based on three conditions: (1) With the boat lying free on the bank, but filled with water so as to test its impermeability, (2) with the boat hanging from derricks or from a crane for convenience in launching or transport, and (3) with the boat sailing in a strong current of water. The tensile strains on the concrete were kept within the limits imposed by standard Austrian practice for reinforced concrete.

The barge was constructed by first assembling the reinforcing members and then applying the concrete mixture in such a manner as to obtain as dense and monolithic a mass as possible. Yet whilst every effort was made to secure external impermeability, no special precautions were taken to fill the voids in the interior. At the same time, complete reliance was placed on using a suitable concrete and no waterproofing agent whatever was employed, even paint being excluded. The object of this was to prove the value of concrete for this purpose



Longitudinal Section.



Transverse Section.

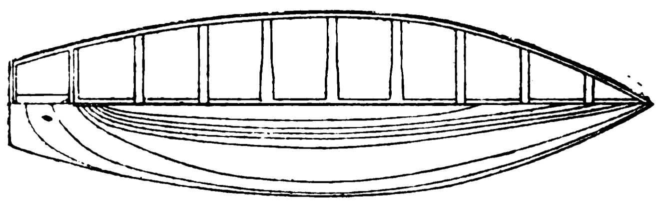


Fig. 2. Plan.
AN ITALIAN REINFORCED CONCRETE BARGE.

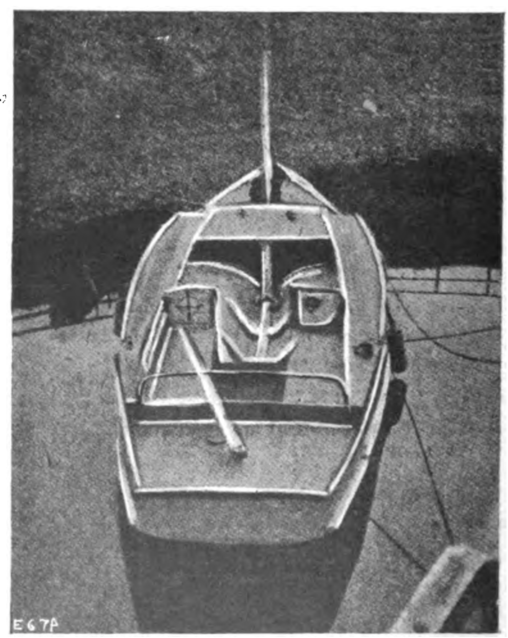


Fig. 3.
AN ITALIAN REINFORCED CONCRETE BARGE.

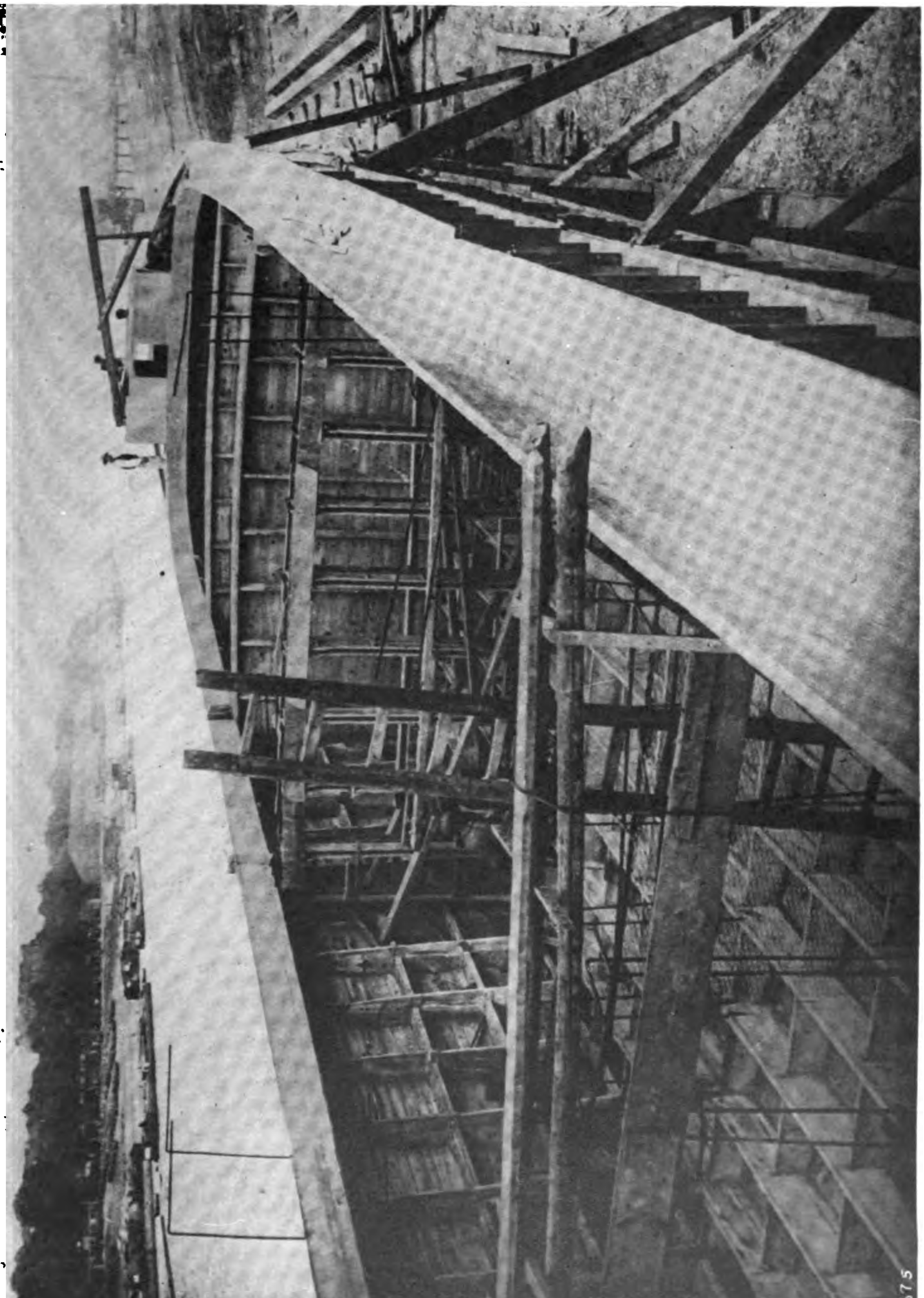


Fig. 4. View showing Interior of a Concrete Ship.
Concrete Shipbuilding on the Paris Canal.

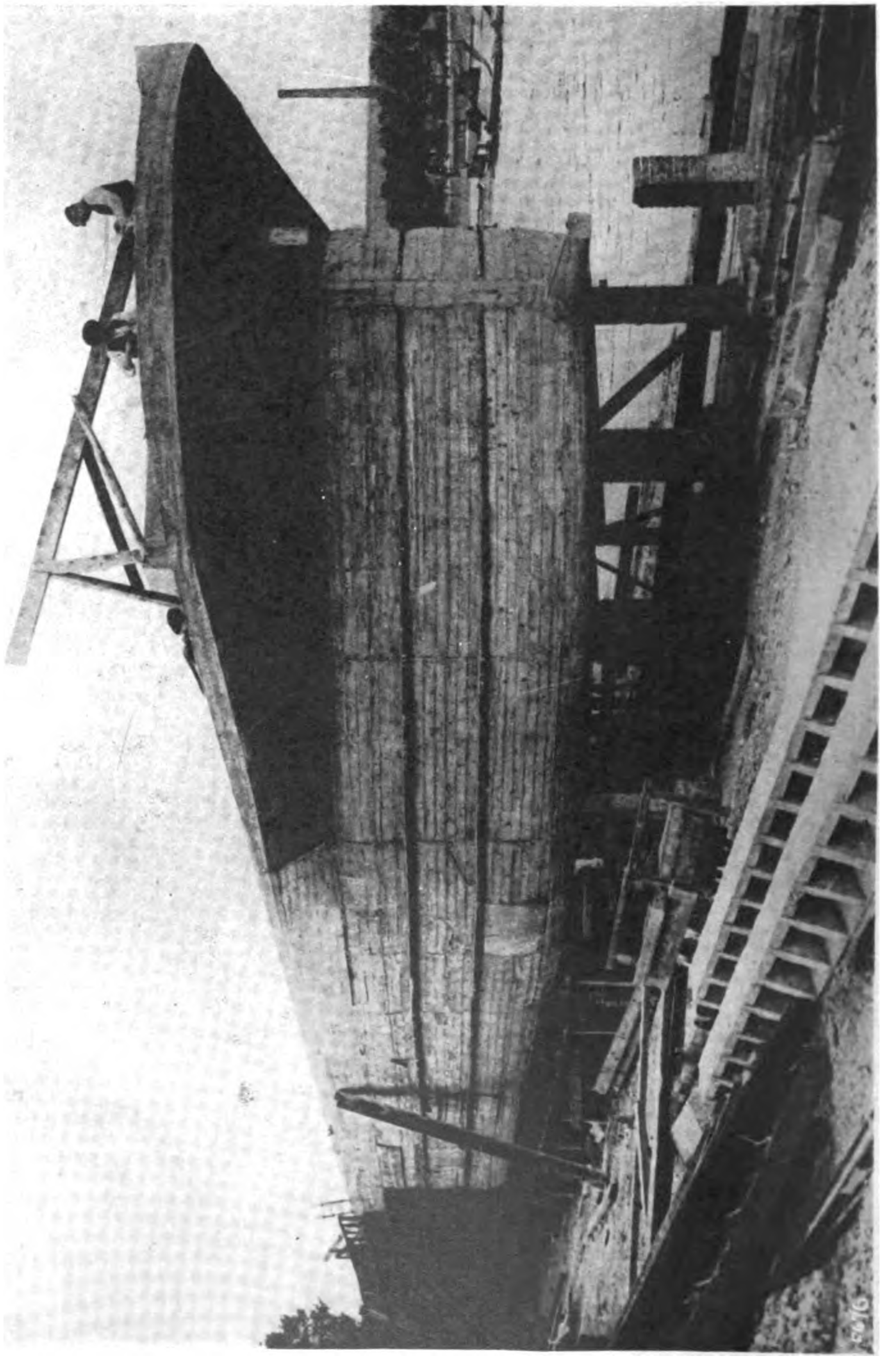


Fig. 5. The stern end of a Concrete Ship.
CONCRETE SHIPBUILDING ON THE PARIS CANAL.

and to keep down the cost by the avoidance of useless additions. At the same time it was considered best to make the construction as simple as possible and to insist on the builder relying on skilled workmanship rather than on the unsatisfactory method of "making good" any defects, which might afterwards be discovered, by the use of waterproofing agents or other correctives.

France.—In a recent issue of our Journal we referred to the concrete shipbuilding at present being carried out in France. We give herewith three illustrations showing a reinforced concrete ship in course of construction on the Paris Ship Canal, and we hope at a later date to give some further details regarding French activities in this direction.

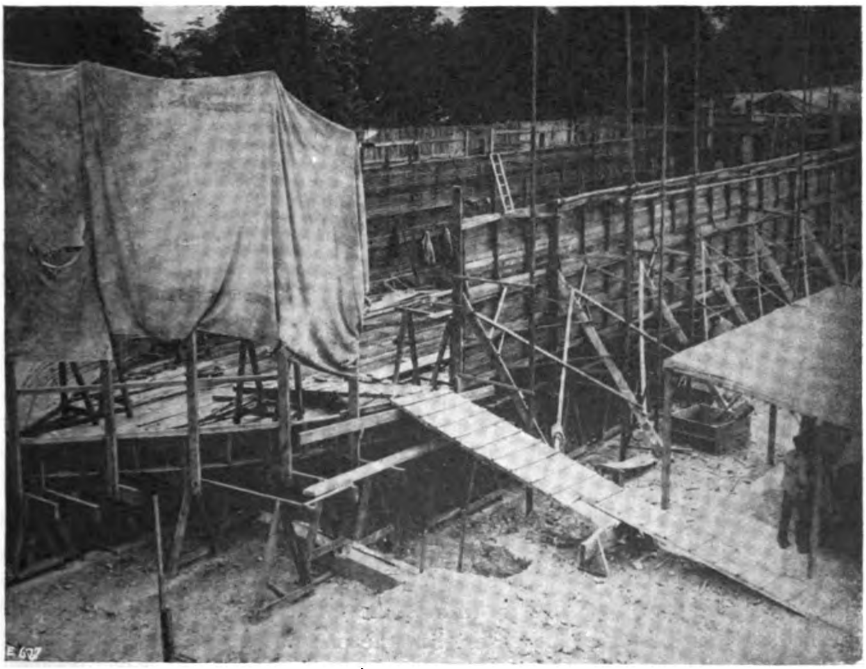
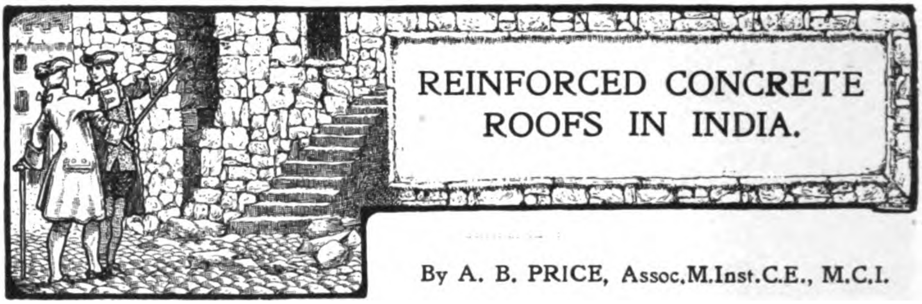


Fig. 6. View showing the Cage in which the Concrete Ship is built.
CONCRETE SHIPBUILDING ON THE PARIS CANAL.

(Figs. 4, 5 and 6 are photographs by Newspaper Illustrations, Ltd.)



The following article has been specially written in response to letters we have received from India complaining of difficulties that have been met in that country in regard to the building of concrete roofs.—ED.

IT is not too much to say that India has not been behind other parts of the Empire in adopting reinforced construction in various forms. Among others, Major (now Colonel) Stokes Roberts, R.E., in the opening years of this century took a keen interest in the subject and produced some clear evidence not only of the possibility of building in this material in India, but of building advantageously as to cost, durability and upkeep.

As in all pioneer work, the older methods and materials of construction stood in the way of progress. This was specially so in Government work, for it is commonly agreed that the climate of India contributes effectively to the "laissez-faire" mood officials frequently show towards any matters necessitating some extra thought or work on their part. Hence it took many years of incessant application to get reinforced concrete to "take on." It is to those pioneers, therefore, a pleasure to find now that it has done so not only in a general way, but among a large number of engineers and others holding responsible positions. Of course, there are still several who are biased in favour of timber, brick, stone, and lime, and no amount of reasoning as to recognised improvement in construction makes any impression. Often such men are prejudiced because they have heard or read of some failure in using concrete, it may be one in fifty or a hundred successes, but the one outweighs the hundred, and the cause of reinforced concrete is undeservedly hampered.

It is the purpose of this article to treat on the subject of "Reinforced Concrete Roofs in India"—a crucial test for such material as this.

At the outset it may be stated that with ordinary care, attention to specified instructions and a moderate infusion of common sense, there is nothing to prevent a reinforced concrete roof being made satisfactorily in any part of India. Some places and seasons are to be preferred, and some workmen are better for the purpose than others, but twenty-seven years' experience of native labour in many parts of the land has convinced the writer that an engineer who can manage natives can get a satisfactory result. Of course there are many little ways and methods which only experience teaches, and these go a long way to facilitate and cheapen work. It is therefore advisable for those requiring reinforced concrete work done to consider this point carefully and employ those firms and individuals who have had due experience in this class of construction.

THE MANIPULATION OF CONCRETE.

A few practical notes on the manipulation of concrete may be advantageously considered here.

It is assumed that the materials are suitable for concrete work and that correct proportions are used to give a solid, compact mass in the work. As to the latter, it was not unusual, until recently, to find a hard and fast specification "4:2:1 mixture," without any reference to voids or sometimes even to size of aggregate. It was the writer's practice to define the proportions as 4 to 1, 3 to 1, and so on, leaving the exact proportions of stone and sand to be settled by practical trial, and on the basis of the best result instructions were issued to the Assistant in charge. In this way the vital proportion of cement is secured and the best proportions of stone and sand obtained. Also the size of largest stone permissible in the several members of a structure can be determined, for in some cases crushed stone 2 in. or even more may be profitably and advantageously used, provided the rest of the smaller crushed stuff goes along with this, only eliminating the actual dust, for strength and retaining the usually small quantity of dust, in cases of a watertight mass being required.

Whenever possible machine-mixed concrete should be used and all materials carefully gauged. If hand mixing is the only method of mixing possible, the most muscular men should wield the "powrahs" and the batches or stacks should not exceed 18 in. of gauged materials in height, so that the powrahs can be got in under the mass and lift it from the bottom in turning it over.

Water.—The quantity of water used in mixing can make or mar an otherwise good concrete. It is a very usual fault to find excess of water used in mixing, as it is easier to work up the materials and it requires less turning to make the concrete *appear* to be mixed. The masons spreading the concrete also like the concrete wet—sloppy—as they can finish their work with ease and dispatch, but the result is not concrete of the best quality; however, a comparatively wet mixture for giving a watertight mass is desirable.

It is, however, *after* this process that in hot climates the real danger to the work appears—*i.e.*, in keeping the concrete moist, thereby preventing it drying and baking in the sun, before complete setting has taken place. How many pieces of work have been ruined owing to this want of care! And there is no effective remedy but complete renewal of the part affected, and perhaps the whole. In most cases relays of "bheastis" (watermen) is imperative, and with good organisation success is assured.

Water must be sprinkled or squirted on to the surface of the concrete and also the centering underneath continuously for several hours immediately after laying, gradually lessening attention till about a week old; then only an occasional watering will suffice during the next fortnight at least—the longer the better.

Frequently clay fillets are formed on exposed roof surfaces of concrete to hold up water in beds. This sometimes causes dirty stains on the finished work, but, provided the beds are kept full, this method is very effective.

Steel.—The steel should in every case be placed ready for inspection by a responsible officer before concreting is commenced. To facilitate this inspection it is a good plan to have gauges or templates made and used, giving the position each bar should occupy, so that at a glance one can tell if any bar is omitted.

It is difficult to get men to keep the steel in correct position while filling, so as far as possible templates and other devices for holding the steel in place must be arranged. Once the process is grasped by the leading workman, it is usual to find him repeat it correctly, without constant supervision.

In manipulating the concrete the writer has found the natives of India quite up to the British workman, and the small quantities carried in basins by women and placed in the work can be more thoroughly worked into the moulds than the larger batches taken by navvies and deposited in larger bulk. It has also been found to be easier to arrange for *continuous* working in India than at home. Thus in some ways Indian methods make for better work. At the same time it must be a fixed rule to wet the mixture only when it can immediately be deposited in position.

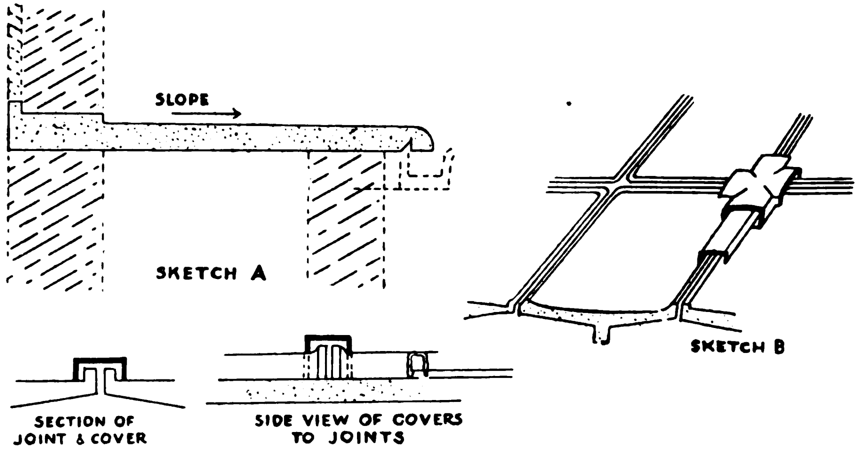


Fig. 1. Sections.
REINFORCED CONCRETE ROOFS IN INDIA.

GENERAL DESIGN AND SPECIFICATION.

In general design and specification reinforced concrete is practically the same in India as elsewhere, except that full allowance must be made for the heat, and consequent quicker setting time for the cement. Slow setting cement should be used, and an ample number of workpeople employed to operate quickly and continuously if possible. Above all, the subsequent watering cannot be too strongly enforced.

Contraction of concrete is greater in hot, as compared with temperate climates, and therefore such large areas of flooring or roofing cannot be taken. Joints in sections must be allowed for, to prevent unseemly, ragged, and detrimentally effective cracks developing later in the work.

SOME EXAMPLES.

Fig. No. 2 shows a test roof cover being made in Bombay. The intention was to find the largest plain slab exposed to the direct rays of the sun which might be relied on without cracking. The construction here is a supporting base formed of H-steel framing, with concrete filled in between them to about 2 in. to 3 in. over top of beams, and covered independently with 1½ in. cover of finer concrete (4 to 1) in sections, the joints ½ in. wide, being afterwards filled with an elastic mastic.

It was ascertained that sections or slabs over 5 ft. length of side tended to crack across the slab, so in this method of construction 5 ft. was taken as a maximum dimension, and the surface usually divided up into approximate square 4 to 5 ft. side (*Fig.* 9).

The joints above referred to are made V-shape, so that the mastic, which is a preparation of bitumen (non-volatile), is continually in touch with the sides of two adjacent slabs, preventing water getting through the joints. The slabs are

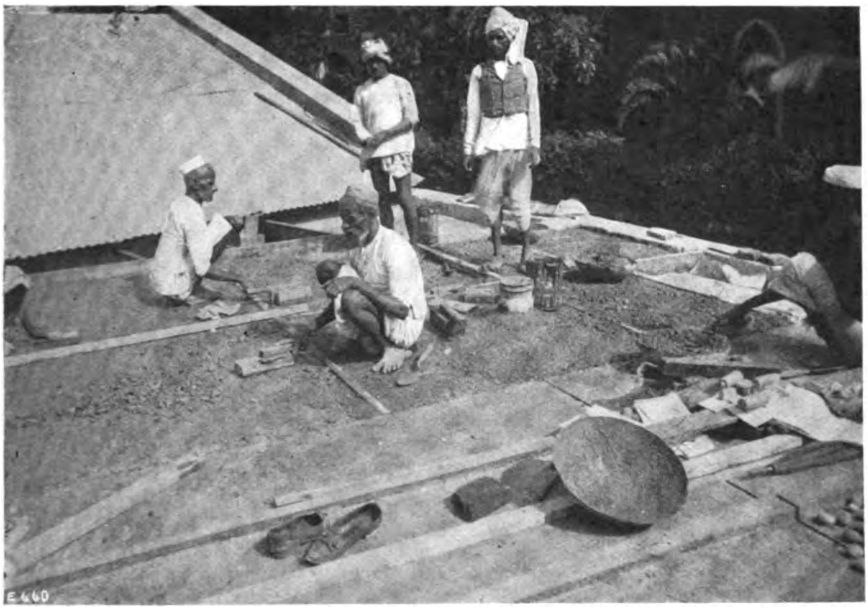


Fig. 2. A Test Roof Cover in course of construction in Bombay.
REINFORCED CONCRETE ROOFS IN INDIA.

well trowelled on face to make them watertight, so the only part where water is likely to get through is at the junction of the roof with walls or at eaves. For the former is it usual to turn up the slab to form a fillet, which must be made as *one* mass with the rest of the cover, and carry this well under the wall. The latter defect is overcome by projecting the roof slabs (see Sketch A, *Fig.* 1) over the outer face of the wall and forming a weathering groove on underside by placing or fixing fillets of wood on the centering before filling the concrete, care being taken to have this in perfect alignment, otherwise the groove will look unsightly when centering, with the wood fillet, is removed.

Another style of this class of roof which gave satisfaction is shown in *Fig.* No. 3. Here the slabs are formed diagonally to sides of building, and each slab has a fillet round all the slab, except at the two opposite corners in the slope of the roof. The rain falling on roof can only get away through these "gates," where fillets stop short. The small length of joint—2 to 4 in.—at this part is more carefully made than the rest of the joint, the space being well caulked with mastic and oakum, and water passing over this (the only place it is likely to cause trouble) is prevented getting through. It is desirable to give as much slope as possible (not less than 1 in 40) to the roof. The eaves slabs, properly throated, discharge into an ordinary C.I. gutter.

The above examples are on the double layer principle, which has much to commend it for such places as India, but roofing consisting of one thickness, finished complete, has also been largely employed in reinforced concrete. The question of cracking of large slabs, due to contraction and expansion, forces itself upon one, and mastic joints between slabs cannot well be employed in this case to give-and-take with the movement of the slabs.

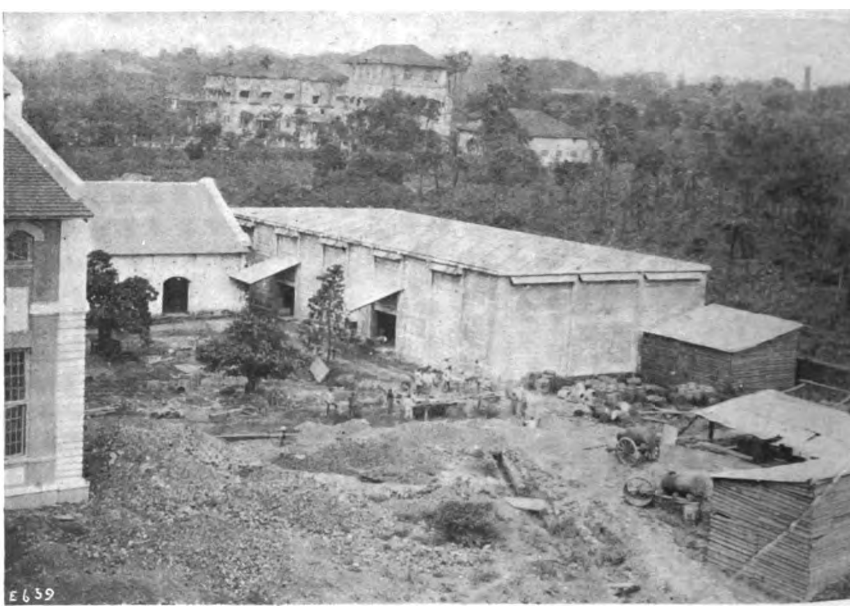


Fig. 3. Illustrating another example of the type of Roof shown in Fig 2.
REINFORCED CONCRETE ROOFS IN INDIA.

A useful form of roof section is found in the T-beam, which the writer has employed in several cases successfully. It is known that a reinforced concrete T-beam is economical for any required strength, and for spans of about 25 ft. is specially convenient for roofing.

Fig. 4 shows such a section of roofing slabs, constructed as a test. In this case the concrete roof replaced a corrugated iron roof, which, being over a smithy, had to be renewed every year or two. This concrete roof has been in use now for about fifteen years and has not been touched since erection.

The sections are each 24 ft. span between column centres, 7 ft. wide and 15 in. deep from top of slab, which is 3 in. thick at outer edges, and 3½ in. thick at centre. It may be mentioned that the test above referred to was made on a " T " only 12 in. deep, without top reinforcement and without stirrups, resulting in the concrete giving way first or the steel slipping, it was not quite clear which, under the weight of the slab alone. This early experiment was carried out some time before books on reinforced concrete were published in English, one of the only books then available being Bétôn Armée.

The junction between sections is made watertight by means of small fillets along the long edges of the slabs, made at the same time as the rest of the section. A cap covers each adjacent pair of fillets, thus covering the joint and throwing off the rain-water (see Sketch B, *Fig.* 1) on to the slab, which is slightly sloped to middle or backbone of the sections and again toward one or both sides of the building. The water is then discharged through gargoyles or into an ordinary C.I. gutter.

For large spans two such sections may be used to form a double sloped roof, having side walls and centre wall or beam for supports. In this case fillets are formed on top edges of sections as well as the sides, and covered in

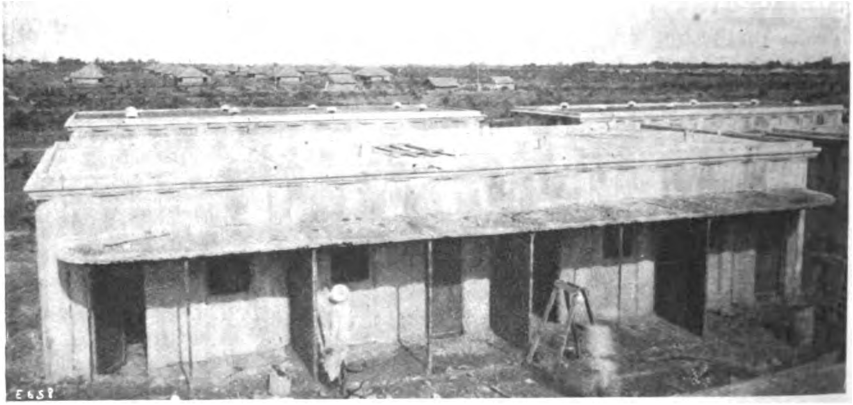
Fig. 4. A Section of Roofing Slabs constructed as a test.
REINFORCED CONCRETE ROOFS IN INDIA.

the same way with special corner super-covers. For small spans, such as are usually found in verandahs, the sections can be conveniently made beforehand (pre-cast), then lifted by mechanical means and fixed in position.

It should be noted that the fillets should be small and sharp and the cover should not touch the fillet, otherwise capillary attraction soon shows its power in a creeping damp spot just under the joint at that point—not so much harmful as disfiguring.

In the above description it has been taken for granted that the concrete slab itself is watertight, and this should be, and is, possible with proper care and supervision. The upper part of the mass of concrete should be finer and made wetter than the body, but all filled at one time and well tamped. While being trowelled a sprinkling of dry cement and sand, 1 to 1½ or 1 to 2, to take up any excess water, is efficacious; pure cement will not do. The use of advertised concrete waterproof materials demands discretion in choice and particular care in adoption. Without minimising their effectiveness it is, however, quite possible to have watertight concrete, with care in grading the materials and thorough supervision, without employing them.

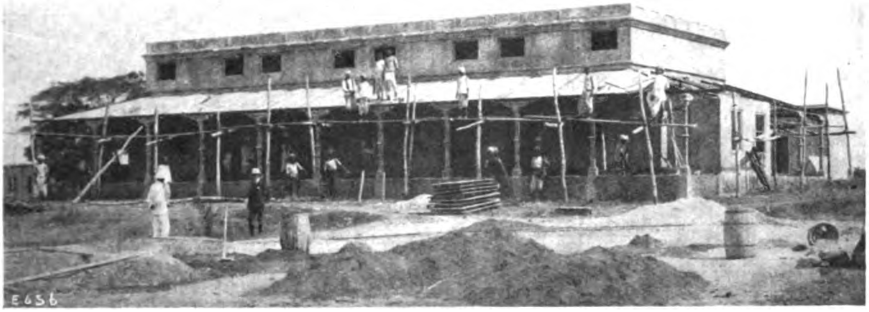
Tar, bitumen, and asphalte coverings to flat roofs are not much used in India owing to the extreme heat of summer and cold in winter, causing the mass to flow or become brittle and crack. Other coverings, having a lime or cement basis, are, however, used with more or less success.

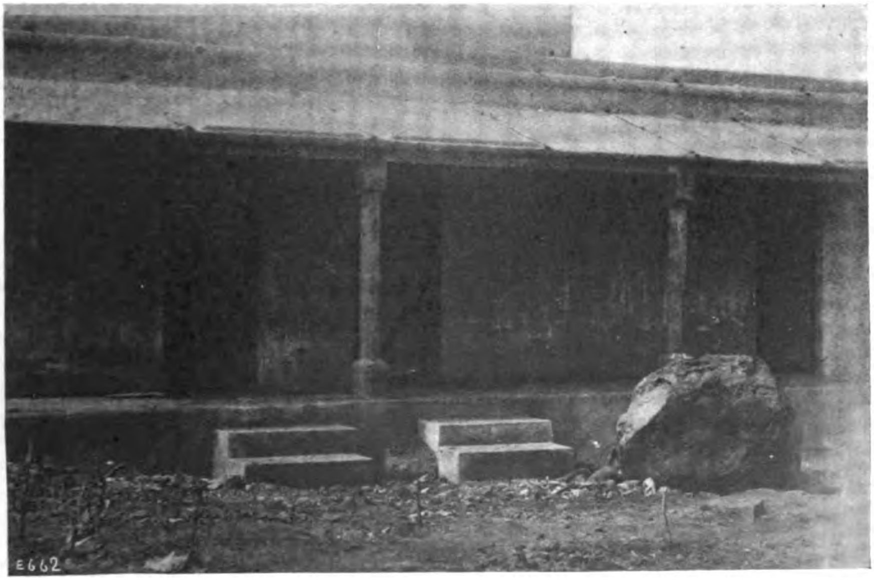


Figs. 5 & 6. A view of part of Khargpur Village.
Showing Artisans Dwellings cast "en bloc" in Concrete.
REINFORCED CONCRETE ROOFS IN INDIA.

A somewhat common practice on the Western side of India in ordinary lime concrete as well as reinforced concrete, is to disregard the body of the concrete as a watertight medium and merely treat it as a support for the top layer of small French or Italian tiles or china mosaic. When newly done this method appeals to one as very satisfactory, but it is not without its failures.

In one case a reinforced concrete roof was constructed (not intended to be in itself watertight) and covered with Italian tiles about 4 in. side, laid on a bed of 1 in. cement mortar. During the first summer the tiling, laid by the best men to be got, came up ("blew up") in hollow patches all over the roof and had to be relaid. There seems to be an expansive action set up in the





Figs. 7 & 8. Showing Concrete Roofs (and Buildings complete) built in Kirkee (Poona)

REINFORCED CONCRETE ROOFS IN INDIA.

tiles after they have been laid for some time, causing them to leave their bed and form a flat dome. This action may be again repeated, but usually only to a small extent after the first upheaval, and this even does not always occur.

The smaller the tile or chip of mosaic the less chance of trouble, and the better for this covering.

An objection to the white mosaic is that in the glare of the sunlight it is hurtful, almost dangerous, to the eyesight.

Concrete roofs have been constructed in various parts of India, but chiefly in the Bombay Presidency. The winter is almost invariably the best time to do such work, but not to the exclusion of the hotter months, when work can be done, provided, as above explained, due care is taken to keep the concrete from drying before it is set.

Among other places such roofs, under hot weather conditions, have been carried out under the writer's control in Delhi, Kamptee, Khargpur, Nasik, Poona, and Nellore district.

Figs. Nos. 5 and 6 give a view of part of Khargpur Village, consisting largely of Artisans' Buildings cast *en bloc* in concrete. The roofs were formed as a support to a second layer of fine concrete, laid in sections of about 5 ft. square, the joints being "run in" with a bituminous mastic after complete setting.

Figs. Nos. 7 and 8 show concrete roofs (and buildings complete) in reinforced concrete built in Kirkee (Poona). These are of the T-beam type, filletted slabs also covering over the verandahs, all in single layers, of reinforced concrete.

Fig. No. 9 shows a part of the "chawls" (workmen's tenements) erected entirely in concrete, except doors and stair railings, for the B.B. and C.I. Railway in Bombay. In the main part a reinforced roof table having been constructed, slabs 1½ in. to 2 in. thick were formed *in situ* afterwards on top of this, bituminous mastic being run in hot into joints. The verandah covering in this case was of moulded, filletted slabs, made beforehand, and the sections hoisted and set into position when required.

Before the introduction of reinforced concrete into Bombay, flat roofs, which were seldom advocated, were made of wood or steel beams and joints filled in with brick-bat lime concrete 9 in. to 12 in. thick, then covered with a 2-in. layer of special "surki" mortar, tamped by gangs of ten to twenty women with flat wood beaters or rammers. This cover was sometimes topped with a thin layer (practically a skin) of rich cement mortar, applied with a trowel and well worked to a hard, smooth surface.

In one case known to the writer there was a double application of the above system, with open 1½-in. channels between the two layers, which brought the thickness of this roof up to 25 inches!

CONCLUSION.

Advocates of this class of roof depend largely on the beating or tamping of the several layers and the after-trowelling they get. This is also a *sine qua non* in reinforced concrete roofs applied in a slightly different manner. The concrete must not be sloppy, but must be sufficiently wet to make it cream up on being tamped and worked by trowel or wood floats. This cream should be evaporated during towelling, then the surface kept moist at first, and after a few hours flooded with water. It is, of course, understood that each section of the roof is such that the reinforcement will hold it together without cracking. The joints between sections have then to be treated as joints and made

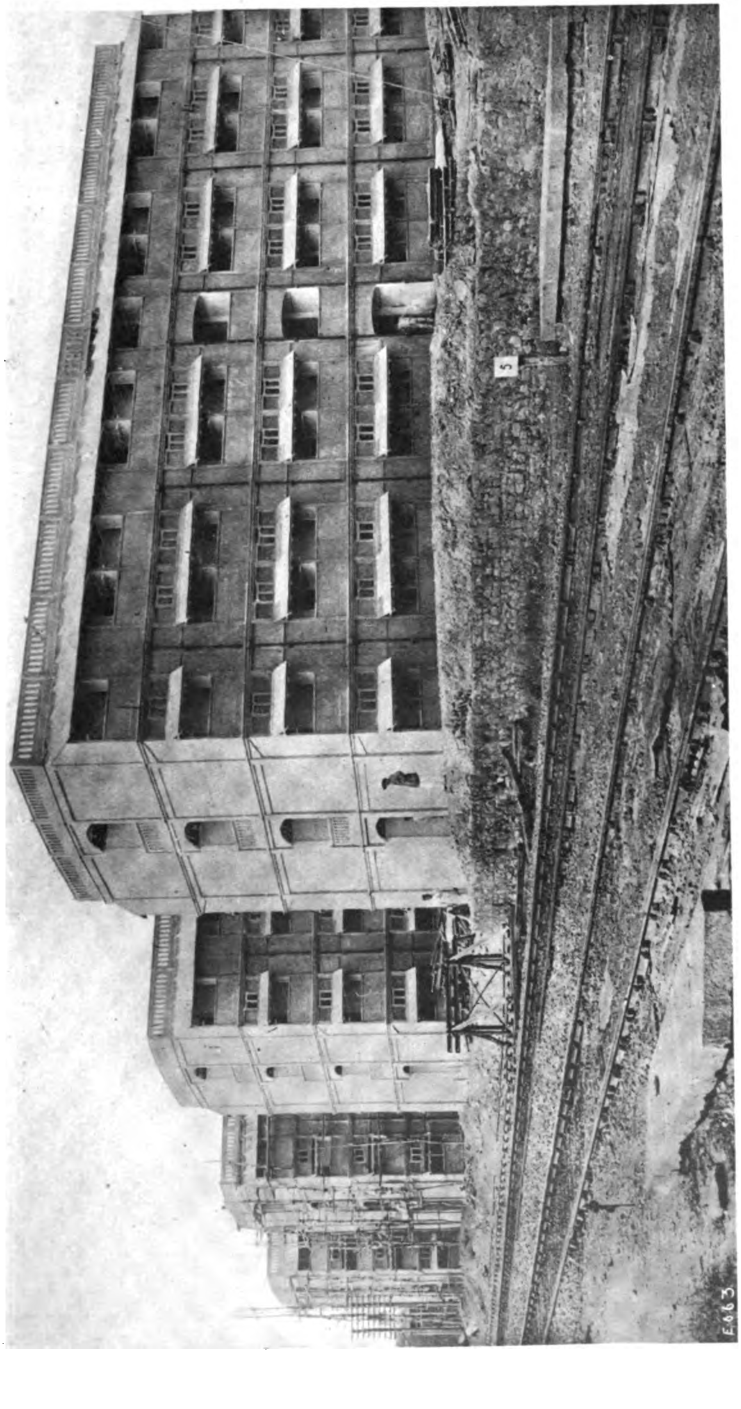


Fig. 9. Workmen's Tenements, B.B. and C.I. Railway, Bombay.
REINFORCED CONCRETE ROOFS IN INDIA.

impervious to water. This has been done as here described, and can be done again with still greater assurance. From experience gained during sixteen years of design and construction in reinforced concrete in India the writer has no hesitation in commending this construction for flat roofs. It has many advantages. Among others may be mentioned first cost, utility, durability, heat-, cold-, water-, fire-, vermin-proof, and upkeep.

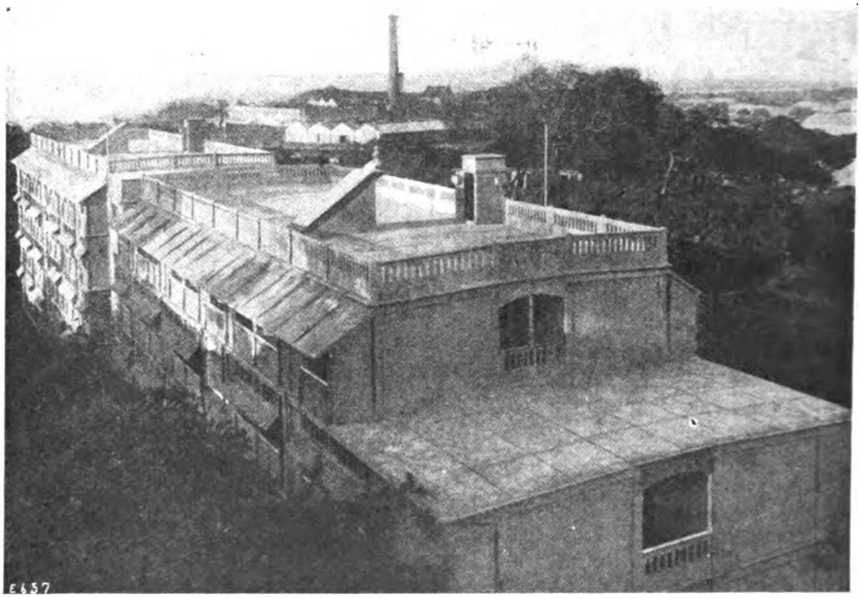


Fig. 10. Showing Terrace Roof of Reinforced Concrete on the G.I.P. Ry., India.
REINFORCED CONCRETE ROOFS IN INDIA.

CORRESPONDENCE.

Under this heading we invite correspondence.

REINFORCED CONCRETE WHARVES.

To the Editor, CONCRETE AND CONSTRUCTIONAL ENGINEERING.

The following letter is a reply to Mr. Jackson's letter, which appeared in our issue of June on p. 336.

DEAR SIR,—I am very much obliged for the sight of a copy of the interesting note you received from Mr. Jackson with reference to my paper on Reinforced Concrete Wharves, etc.

In the main issues I quite agree with his remarks. I fear, however, that, owing to the fact that the report of my paper in CONCRETE is an abstract and therefore incomplete, coupled with the fact that there are no diagrams, wrong inferences are likely to be formed as to my actual views.

In the first place, the wharves referred to in my paper are supported at the back by the natural ground, and are not pure jetties wholly supported by piles at dredged level only, as mentioned in his third paragraph. Most of my remarks would, however, apply in the case of such jetties also.

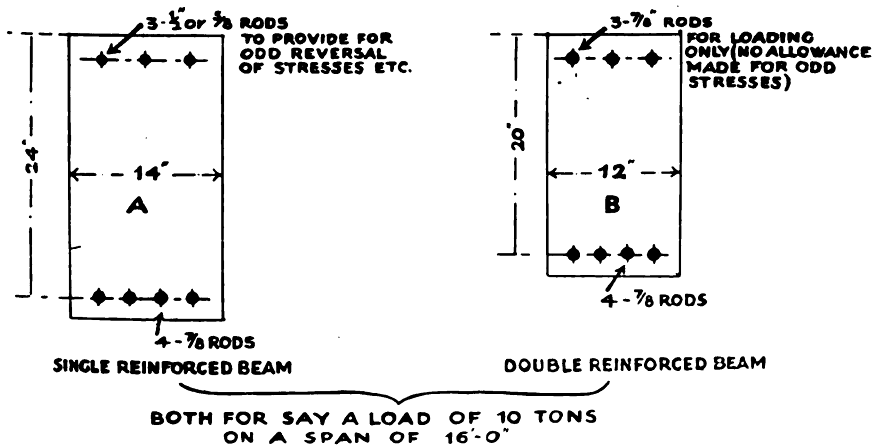
Regarding double reinforcement, my statement on page 273 in the May issue does not mean that I do not advocate compressional steel reinforcement, even when depth of beams is unrestricted.

As a matter of fact, I am, and always have been, a firm believer in steel reinforcement in the compression area, for the very purpose which he indicates in his note—that is, as a provision against occasional reversal of stresses, etc., *and for much the same reason as cross-bracing is provided, say, in the centre of a lattice girder.*

What I wish to convey in my paper, however, is this: that I do not recommend the use of steel reinforcement in the compression area, calculated to resist a portion of the actual loading, simply in order to reduce the size of beams and amount of concrete to the lowest limits, unless compelled to by force of circumstances, such as restricted space, where the maximum size of beam would not be possible.

The enclosed sketch will probably make my statement clearer. Assume, for instance, a beam is required in a wharf (or similar structures mentioned in my paper) to support 10 tons on a span of 16 ft.

Sketch A would be a suitable beam with single reinforcement, whereas a beam as per sketch B, with double reinforcement, would support the same load with less concrete but more steel, the most expensive item of the two. Therefore, why waste



the steel when in the first place we assume there is plenty of room for beam A, and, *secondly, the additional mass is also of very great value in resisting shock*, as stated, and no steel is required at all in the compression area to resist the known loading?

Now, once this view is accepted, I am with him all the way regarding other possible stresses.

By all means, even in beam A, insert a reasonable amount of steel in the compression area, say three ½-in. or ⅜-in. rods as shown, as they serve not only to provide for any odd strains or reversal of stresses, as indicated in the note, but they are also exceedingly useful as ties and supports for the shear reinforcement, to the actual tensional reinforcement.

In the case of double reinforced beams, the steel in the compressional area is actually required to resist the ordinary loading; and although it is then ready and does, of course, take up the odd stresses mentioned when the compression area of the beam is temporarily in tension, *it should not be counted on to do so, and additional steel should be provided for this purpose in exactly the same manner as the small rods indicated by me in sketch A.*

I trust these few remarks will put my views in a correct light.

Yours faithfully,

W. Cleaver.

THE PROPORTIONING OF CONCRETE.

To the Editor, Concrete and Constructional Engineering.

Dear Sir,—Taking a keen interest in concrete questions, I shall be very pleased if you will publish, under my name, a few remarks on the important question of the best proportioning of concrete. These are suggested to me by a very interesting article entitled "What is a 1 : 2 : 4 concrete?" by Mr. H. C. Johnson, of University College, Cork, which appeared in the February, 1915, issue of your journal.

Unfortunately, I have no personal laboratory tests on which I could base the conclusions of my investigations. I am only deducing them from the very few experiments made by Mr. Johnson and related in the above-mentioned article.

Mr. Johnson's object was to improve specifications as regards the definition of a 1 : 2 : 4 mixture, which, as a rule, do not define the amount of cement to be used, and he proposes that this amount should be based on the finished volume of concrete. I entirely agree with him, but not quite with the assumed correct specification he proposes for proportioning. From his suggested method of mixing it follows that the percentage of cement will be always the same, say 20 per cent. by loose volume of dry cement; but it does not follow that for this given expenditure of cement the proportions of sand and coarse material arrived at, for given materials, will be the best ones in order to obtain the maximum strength. I do not pretend to suggest any better method. I am only trying to improve the question, and hope that my remarks will help to find out the best method of proportioning.

My conclusions refer only to 1 : 2 : 4 mixtures, and to the extent of Mr. Johnson's tests. Other experiments are required to show whether these conclusions may be extended to other mixtures, and I wish greatly that Mr. Johnson himself or other engineers in charge of laboratory tests would investigate the question more profoundly by making other tests of a similar kind on a larger scale.

Before going any further, it would be useful to make quite clear how the percentage of voids in *washed* aggregates has been ascertained in Mr. Johnson's tests. I understand that, first, materials have been measured loose, then washed; then the *remaining* materials have been dried and used in mixes. The voids for washed materials given are those of the remaining materials after drying. But I am not at all certain of this. Anyway, it does not affect my conclusions whichever may be the manner employed; I am only drawing attention to experimenters, so that the method may be always identical and results may not be affected in the wrong way.

Concerning 1 : 2 : 4 mixtures, let us see now what are the conclusions. The tables below are deducted mathematically from Mr. Johnson's table of tests (page 88 of the Concrete issue of February, 1915). In order to make still clearer the conclusions which we will draw from these tables, let us also give a diagram stating the finished volumes of concrete corresponding to the total amount of voids in small and large aggregates.

MIXTURES 1:2:4

Number of mix	Total amount of voids in sand and coarse material, v.	Finished volumes of concrete V.	Products $v \times V$	Percentage of voids $100\frac{v}{V}$	Percentage of loose cement $100\frac{1}{V}$	Percentage shrinkage of aggregates $\frac{6-V}{6}$	Weight per cubic foot of concrete (wet) in lbs.	Nature of aggregates. Sizes and individual percentage of voids.
			1.	Washed	Aggregates.			
12	2·09	5·38	11·24 (Average = 12·05)	38·83	18·58	10·33	146½	Gravel, ¾"-¼" (34¾ per cent. voids). Special sand, quite clean ⅛"-1/78" (35 per cent voids).
11	2·23	5·26	11·72	42·20	19·01	12·33	144	Gravel, ¾"-¼" (34¾ per cent.) — sand, ⅛"-1/78 (42 per cent.).
14	2·50	5·00	12·50	50·00	20·00	16.66	149½	Crushed limestone. ¾" ¼" (45 per cent.)—sand. ⅛"-1/78" (40 per cent.)
13	2·64	4·83	12·75	54·65	20·70	19·50	148½	Crushed limestone, ¾"-¼" (45 per cent.)—sand, ⅛"-1/78" (42 per cent.)
				2. Dry	Aggregates.			
2	2·32	5·60	12·99 (Average = 13·25)	41·42	17·85	6·66	140	Gravel, ¾"-¼" (38 per cent.)—sand, ⅛"-1/78". (40 per cent.).
3	2·50	5·25	13·12	47·61	19·04	12·50	143	Gravel, ½"-¾" (42½ per cent.)—sand, ⅛"-1/78" (40 per cent.)
7	2·60	5·10	13·26	50·98	19·60	15·00	144	Gravel, ¾"-½" (43 per cent.)—sand, ⅛"-1/20" (44 per cent.).
4	2·62	4·92	12·89	53·25	20·32	18·00	143	Crushed limestone, ¾"-¼" (45½ per cent.)—sand, ⅛"-1/78" (40 per cent.).
5	2·75	4·90	13·47	56·12	20·40	18·33	144	Crushed limestone, ½"-¾" (48¾ per cent.)—sand, ⅛"-1/78" (40 per cent.)
6	2·80	4·80	13·44	58·33	20·83	20·00	149	Crushed limestone, ¾"-½" (48 per cent.)—sand ⅛"-1/20" (44 per cent.).
			3.	Mixtures with	Fine Sand.			
10	2·80	4·33	12·12	64·66	23·09	27·83	144	Crushed whinstone ¾"-¼" (46 per cent.)—sand, 1/20"-1/78" (48 per cent.).

The diagram shows these remarkable facts :—

1. That mixes 12, 11, 14, 13, in which *washed* materials have been used, stand very approximately on a straight line.

2. That mixes 2, 3, 7, 5, 6, in which *dry* materials have been used, are very approximately in another straight line.

3. That mix with fine sand is completely out of these two lines.

Now the conclusions of the tests are these :—

(*a*) The final volume of the concrete, V, decreases when the total amount of voids, v, in aggregates (small and large) increases—

For dry materials ... ... $V = \frac{13·25}{v}$

For washed ,, ... $V = \frac{12·05}{v}$

For fine sand ... ... $V = \frac{12·12}{v}$

The co-efficients will be different with other mixtures than 1 : 2 : 4. It is very interesting and useful, when materials are given, to know beforehand what the final volume of concrete will be.

(*b*) The shrinkage of aggregates and the percentage volume of loose cement increase when the total amount of voids in aggregates decrease. The increase is greater with washed materials and still greater when fine sand is used.

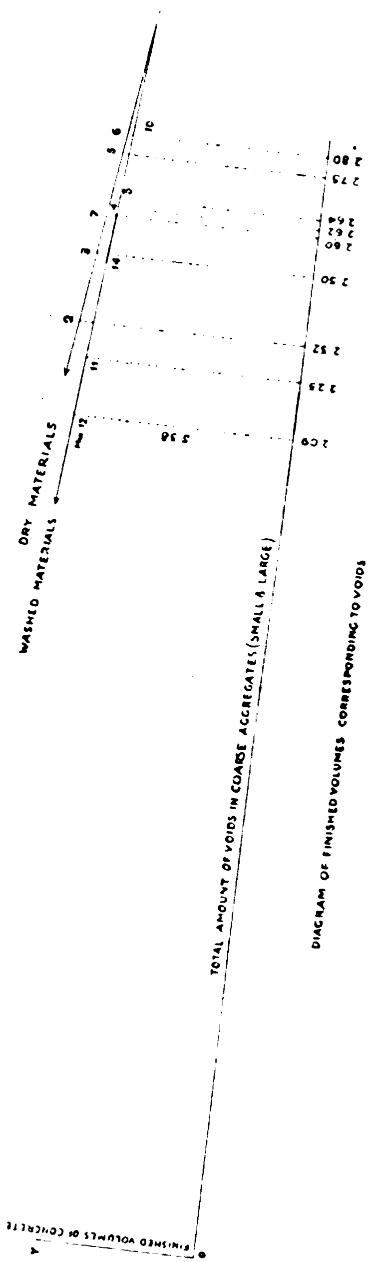
(*c*) With *dry* materials of the same nature—say all gravels, for instance—the density of concrete increases when the voids increase.

With *washed* materials of the same nature the density of concrete decreases when voids increase. Concretes are generally heavier with washed materials.

(*d*) The best concretes as regards great density, and very likely resistance, will, therefore, be obtained with washed materials as compact as possible—that is to say, with less total amount of voids possible.

I wish to point out also that in the tests to be made it would be useful to state the density of loose materials used—say, cement, sand, and coarse materials—and also the amount of water used in each mix, so that the same dry working consistency of concrete is obtained, and, finally, the crushing resistance per sq. in. of the concretes after one or more periods of time. This additional information would lead to the calculation of the density obtainable before undertaking any work.

In conclusion of these remarks, I believe that, contrary to one of the conclusions of the microscopic study in concrete, stated in different issues of your journal, void measurements are not at all useless for finding best proportioning; but at the same time I do not agree with the theory which says that the amount of cement must be such as to fill the voids of sand, and the amount of sand such as to fill the voids of coarse aggregate. The filling of the voids is *never complete*, as the microscopic study shows, and does not depend on the good will of the operator, nor on the quantities used. In my opinion it is *the total amount of voids in coarse material, small and large*, and the final volume obtained which are to be compared for finding the rational method of mixing. And by comparing the whole lot of tests that I suggest be made it is very likely that an accurate, scientific, and practical method of good proportioning will be found.



Hoping that my suggestions will interest your readers,

I remain, dear sir,

Yours faithfully,

CH. AMAR, Engineer.

Salonica.

Mr. Johnson's reply to above:—

To the Editor, CONCRETE AND CONSTRUCTIONAL ENGINEERING.

University College, Cork.

DEAR SIR,—I was pleased to read M. Charles Amar's letter in which he referred to the article, "What is a 1 : 2 : 4 Concrete?" and beg to offer the following remarks upon it.

I would clearly state, in connection with his third paragraph, that I do not consider it possible to improve any specification on 1 : 2 : 4 concretes, which proportions I condemn as obsolete; but I do believe that there is a correct method for specifying proportions, and if my last paper before the Concrete Institute proved my method we have it now; if not, I hope we are closely on its heels.

He suggests that my method might not give the maximum strength for any given set of aggregates. I will not claim that it does, but I believe it is not very far wrong, since the heaviest concrete—using these materials—cannot be far from the strongest for a given percentage of cement, as our tests here prove.

With regard to his uncertainty about method of measuring washed materials, the *unwashed* materials (not really dirty, but containing some silty material) were measured loose—*i.e.*, without rattling into the pail. The *washed* materials were dried and measured *after* drying, *not* before, the voids also found *after* drying.

With regard to conclusion (*b*), I think if it read: "The shrinkage of aggregates and the percentage volume of loose cement *decrease* when the total amount of voids in aggregates also *decreases*" that it would be correct.

As he rightly says, "the filling of the voids is never complete," but, if a waterproof concrete (not one of highest strength necessarily) is desired, it can be obtained by using a sufficiency of fine material, which must be thoroughly incorporated. It will be very dense, but still have a small percentage of voids.

Yours truly,

H. C. JOHNSON.

ENQUIRY.

We shall be pleased to receive any replies from our readers as to their experience on the point raised in the following letter.—ED.

To the Editor of CONCRETE AND CONSTRUCTIONAL ENGINEERING.

SIR,—Can you advise me what materials (non-proprietary) I ought to use as a surface to a concrete floor to allay dust trouble? Drugs and food-stuffs are manipulated in the factory, which is of reinforced concrete, and the considerable amount of dust always arising constitutes a serious problem.

Yours faithfully,

D. W. WOOD.

REPLY.

Our correspondent does not mention the composition of the concrete, but it is well known that a surface which has to withstand heavy wear should not contain more than about 3 parts of aggregate to 1 of cement, and a well-made concrete floor should not dust up even under heavy wear. Floors which are subject to excessive abrasion, for example, where heavy casks bound with iron hoops are continually being moved about, naturally wear more quickly than others not subject to such severe treatment, but as a rule where dusting up of the surface has been observed in a concrete floor, which is otherwise hard and sound, it has been due to over-trowelling during laying in order to obtain a smooth surface. The trowelling has the effect of bringing the fine particles of cement to the surface together with the surplus water, with the result that the floor is covered with a thin skin of neat cement grout. This, owing to its slushy condition and the trowelling it receives, does not become as hard as the body of the work, and has a tendency to "dust up." A hard-wearing floor which is smooth enough for all practical purposes can be obtained without the excessive amount of trowelling often done. It has been the custom with some workmen to allow the concrete to partly set, and then go over the surface again with a steel trowel or float. In other cases we have known a partly set surface to be wetted and neat cement powder dusted on and rubbed in with a float. The result of this treatment is that the surface is comparatively soft and friable and dusts up under traffic.

Although it is easy to indicate the precautions which must be taken during laying to prevent subsequent dusting up of a concrete floor, it is not so easy to suggest a remedy where such dusting up has in fact taken place. Two or three applications of a solution of silicate of soda (water glass) after first thoroughly washing and brushing the floor has been recommended, and is stated to have been successful in some cases. There are also on the market compounds consisting in the main of iron filings, which are stated to obviate any risk of subsequent dusting if they are mixed with the surface rendering when the floor is laid. It is also claimed that a dusty floor can be cured by roughening the surface and applying a fresh rendering of these compounds mixed with the cement.

Reply.—I have had some experience in rendering concrete floors dustless, and it is a very difficult problem. A great deal depends on the quality of the work as executed, but probably the most effective method is to cover the concrete with a good granolithic finish, and, after this has been laid at least twenty-eight days, make a saturated solution of silicate of soda and water and dilute with four times the quantity of water added and sprinkle over the surface of the floor, taking care that every part is treated.

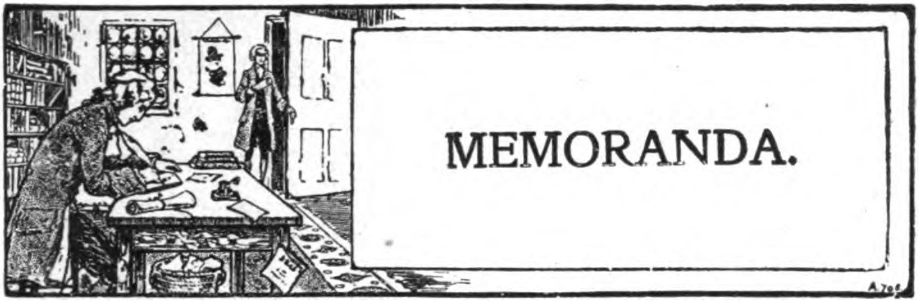
Another method that is sometimes adopted is that of using boiled linseed oil, which is painted over the floor surface to give three coats. I do not personally like this method as it makes the floor slippery and spoils the appearance, and, furthermore, cannot be considered lasting.

Where expense is not a great factor the best way is to lay "Battleship" linoleum, this being pasted down; but this may, of course, not be practicable; and, although the wear is not everlasting, it will remain sound for many years.

If the concrete is screeded over with cement and sand to give a fairly level surface the lino can be laid down without the necessity of granolithic or other expensive floor surface.

If the first method, which is the simplest, is adopted, the dust trouble should be so small as to prove negligible: and I may say it has been adopted in buildings where explosives are ground and where dust is a serious matter.

A. L.



Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Concrete Roofs as a Protection to Buildings in Air Raids.—In connection with the recent air raid over London, the daily press reported an interesting fact regarding the protection afforded to a building by a concrete roof. It is stated that a bomb fell on a furniture factory which was covered with a layer of concrete 12 in. in thickness; the bomb fell on this concrete and exploded, but no damage was done to the building, save to a few pieces of furniture on the top floor.

Concrete Emplacements at the Front.—In a recent issue of the *Illustrated London News* a series of photographs were reproduced from the Canadian War Records illustrating some of the German guns and emplacements which have recently fallen into British hands in connection with the attack on Vimy Ridge. On page 406 we reproduce two of these photographs, which will probably be of interest to our readers, as they show two different types of concrete emplacements.

Concrete Groynes.—At the forty-fourth annual meeting of the Institution of Municipal and County Engineers, Mr. G. F. Miller, Deputy Borough Engineer of Hastings, read an interesting paper on the municipal works of Hastings, and in the course of the paper he referred to the construction of groynes undertaken from time to time. In the course of the paper he also drew a brief comparison between timber and concrete groynes, and on this point he stated the following:—

"The construction of groynes with timber or concrete is simply a question of initial cost and maintenance. The initial cost of concrete groynes is governed by the presence of rock or hard foundation at a moderate depth, and the easy reach of suitable materials; in some districts the foreshore is such that only pile groynes are practicable at a reasonable expenditure. The average cost of a concrete groyne has been £600 to £700; the average cost of a wooden groyne of the same length, of which many are existing on this foreshore, has been £500. The great advantage of the concrete groyne is the low cost of maintenance. Ten years ago the cost of annual repairs to the groynes in the borough was £1,200 to £1,500 per annum; at the present time between £200 and £300 is all that is necessary. With wooden groynes underruns occur; planks are frequently knocked off, wallings and bolts deteriorate. The life of a wooden groyne is greatly increased if planked on both sides, as one or two examples which are still in good order prove, although constructed in 1892, and have not received any great amount of repair; but no less then twenty-six concrete groynes have been constructed, replacing many wooden ones, which had become worn out. Thirty-four wooden groynes still remain; no wooden groyne stands on the foreshore to-day of earlier date than 1878, and these have either been greatly strengthened and repaired, or will be replaced with concrete groynes as soon as borrowing powers are again resumed. The Local Government Board usually sanctions loans for the sea walls for twenty years, concrete groynes twenty years, and wooden groynes ten years.

"The whole of the sea defence works here have been carried out by administration, to the design and under the supervision of the Borough Engineer."

Reinforced Concrete Transmission Poles.—A recent issue of *Indian Industries and Power* contained a contributed article describing the experimental ferro-concrete poles which have been produced by the Military Works Services at Lahore. Both

An Example of a German Concrete Emplacement.—A Captured 8-in. Naval Gun in its Emplacement at Farbus.

Another Type of Concrete Emplacement built above ground.—A German Gun Captured by the Canadians in Farbus Wood.

(Official Photographs: Canadian War Records.)

solid and hollow poles were tried, of varying mixture and percentage reinforcement, a fairly rich aggregate being ultimately adopted. The best results for ballast were obtained with limestone broken to pass through a ½-in. sieve; good results were also obtained with a mixture of crushed pebbles. The reinforcement comprised ½-in. square rods braced laterally at 1-ft. intervals with ¼-in. diameter rods, which were welded to make them continuous.

All ironwork was cut to gauge, and ends of cross-braces bent over the gauge, thus ensuring correct spacing and rapid assembling.

Most poles have four full-length corner rods and four intermediate side rods to a point about half way up the pole, these rods terminating at intervals of 3 in. to avoid a sudden change in the percentage of reinforcement, and being deformed to give greater adhesion; the ends were also turned in to avoid any movement when under tension. An earthing wire was carried down inside the concrete, and bound to each vertical rod to obviate any chance of electrolysis, tails being left out to earth cross-arms, etc. The street poles are 31 ft. long, 10 in. sq. at the bottom, and 6 in. sq. at the top; the 29-ft. poles are 9 in. and 5 in. sq. respectively. Both these poles have been used in pairs as H poles.

The method of casting the poles is as follows:—A number of sleepers are laid in the ground, tops flush with the ground level, six rows parallel with each other at 5 ft. apart. Across each sleeper three bottoms are securely fastened, wooden chocks being fixed to each sleeper 3 in. clear of the bottom boards, against which the sides are wedged when required for casting. To each set of three bottoms one pair of sides are provided, and this constitutes a unit for turning out one pole a day. The first day the sides are wedged up to No. 1 bottom and the pole cast; the following day the sides are taken off and put up to the second bottom, and that pole cast, and similarly for the third day; on the fourth day the pole on No. 1 bottom is pulled off endwise on to level ground, and the cycle of operations repeated.

This system was adopted for both solid and hollow poles, though the extra labour involved in the hollow poles made their advantage over the solid ones rather doubtful, except as regards weight.

To obtain a hollow core, if desired, a hollow tapering steel tube, flush rivetted, is placed inside the mould, small concrete saddles supporting it at each end and the middle; this protrudes at the small end 2 ft., and, after the concrete has been in six hours, is tapped back flush at the small end to relieve it from the concrete. It is soft-soaped prior to casting, and withdrawn the next day. The moulds are smooth inside and whitewashed; fillets are inserted at the corners to bevel the poles.

The constituents, including the water in the concrete, were carefully measured, and it was made slightly wet to facilitate casting; with solid poles, 2 in. of concrete was first laid in, and the reinforcement laid on that, the mould being then filled up.

After casting the poles were kept covered with damp straw and gunny bags for three weeks, dried out for a week, and erected when a month old. Ordinary methods of carrying and erecting were employed; the root of the pole was set 5 ft. in the ground on 6 in. of lime concrete, with another foot of concrete rammed round the end after erection.

Ordinary methods of staying were adopted in line construction; in some cases the sizes of feeders ranged up to 3/0 B. and S.

No cement was used having an initial setting time under sixty minutes, the casting of one pole taking about forty-five minutes. The poles have been made both departmentally and by contract, the cost at the present time being Rs. 50, including cement at Rs. 81 per ton and steel rods at Rs. 28 per cwt. At pre-war prices the costs might be reduced to Rs. 20 per pole.—*Electrical Review.*

Concrete Flooring.—Mr. W. P. Anderson, in an article in the *Engineering News Record*, entitled "To Secure Good Concrete Floors," makes a suggestion as to how attack by acids can be prevented. He says:—

"Cement floors, even when properly laid, may become damaged by injurious substances, such as acids, strong alkali, animal and vegetable oils, and fruit juices, sugar solutions, etc., containing weak acids that will act on the free lime in the cement to form compounds soluble in water. Moist coal has been known to injure floors, due possibly to the water forming a weak acid with the sulphur in the coal.

Several means can be used to prevent dusting and prevent or retard the injurious effects of acids. These methods consist of treating the floor with a liquid hardener that acts chemically on the free lime in the cement, by coating the floor with a paint or other substance or by a combination of the two. The liquid hardeners convert the free lime to a calcium compound insoluble in water, which fills the pores of the finish, thus hardening the surface and preventing dusting The calcium compound may be less subject to attack by acids than the original free lime, and it forms a protection to the underlying material, which has not been changed."

Model Concrete Tenements in U.S.A.—In a recent issue of *Concrete Age* it is stated that the two units of the model concrete tenement building completed on the west side of Logan Street, midway between Findlay and Elder Streets, Cincinnati, O., have aroused considerable interest. The use of reinforced concrete construction for this type of building was a new departure, but it has proved entirely successful, not only from the viewpoint of economy of space, but it is considerably cheaper than structural steel columns and beams, with hollow tile and concrete joist floors.

Mr. William Emerson, of New York City, who has made a study of tenement construction, drew up the plans for these model tenements. The structural columns, beams, and floors are of reinforced concrete.

The rental charge will probably be $1·10 per room per week, this to include heat from a modern vapour system. The apartments vary in size from one or four rooms. There are also public baths and showers, and an office for the superintendent of the building. The location is very close to several crowded industrial centres and within fifteen to twenty minutes' walk of the heart of the city. This location in such a crowded district, while particularly convenient for the workers, necessitates extreme compactness of the apartments.

Besides the modern heating system in each apartment there is a gas stove and other necessary conveniences. Screens are supplied for all windows. The children throughout each tenement have the advantage of a well-equipped playground and nursery on the roof.

Licences for Building Work.—With a view to removing misconceptions which have recently arisen in various parts of the country, the Minister of Munitions directs attention to the fact (1) that no building or construction work costing over £500, or involving the use of constructional steel, can be undertaken without a licence from the Ministry, and (2) that such a licence is as necessary for work involved in the restoration of property destroyed or damaged by fire or aircraft as for work undertaken in other circumstances.

Failures of Concrete.—In a paper read before the American Water Works Association, Mr. R. J. Wig, of the United States Bureau of Standards, urged the importance of consistency of concrete in securing strength and soundness. He expressed the opinion that more failures or partial failures were caused by the use of too liquid concrete than by any other defect. A slight addition of water beyond that which produced the most effective consistency had been known to cut the strength of the concrete by 50 per cent. For this reason he contended that chutes used for distributing concrete should make an angle of not less than 20 deg. with the horizontal, since concrete would not flow at the latter grades unless more liquid than it should be.

PROPOSED WORKS.

Dutch Tariffs.—The Government of the Netherlands has decided to admit reinforced cement slabs for roofing free of duty.

Ancoats—Buildings.—The Manchester Corporation Buildings Committee have passed revised plans of reinforced concrete construction to a factory in Great Ancoats Street and for stables in Great Ancoats Street.

Argentine.—A Presidential Decree has been issued approving the plans for the construction of 22 grain elevators at different places along the system of the Central Argentine Railway. The materials for construction will be allowed to be imported free of Customs duty.

Sydney.—According to a report £500,000 is to be invested in transforming Balls

Head, Sydney Harbour, into the largest bunkering establishment in the Southern Hemisphere. Two large jetties are included in the scheme.

Scarborough.—The Local Government Board has held an inquiry into the application of the Corporation for sanction to borrow £6,000 for the construction of a toe and apron to a section of the wall of the Royal Albert Drive.

Galway.—The Harbour Board has requested Mr. Binns, its engineer, to furnish an estimate for a scheme of harbour development, to include the construction of a landing stage to Ulton Island.

Portsmouth.—Tenders have been invited by the Corporation for the construction of a concrete seat, 350 feet long, on the Esplanade, Southsea.

Hull.—The Corporation has invited tenders for the reinforced concrete work in connection with the foundation work for water-cooling towers at the generating station.

Wolverhampton.—During the month the Corporation has called for tenders for the design and erection of reinforced concrete coal bunkers and skeleton structures in connection with the electricity works.

PUBLICATIONS RECEIVED

We would call the attention of our readers to an excellent handbook of photographic illustrations published by the British Reinforced Concrete Engineering Co., Ltd., of Manchester, which shows in a comprehensive way the many applications of the B.R.C. reinforcement, as used for floors, beams and columns, large buildings, safes, workshops, bridges, roads, etc., etc. Special floor slab tables are given for continuous spans for roofs, warehouses, heavy machinery, schools and public buildings; the figures in each table indicating the standard reference number of B.R.C. fabric to be used for the purpose or loading indicated at the head of the table.

Single Copies, 1s. nett. *Annual, Post Free, 12s. 6d.*

CONCRETE AND CONSTRUCTIONAL ENGINEERING

AUGUST 1917. VOL. XII. No. 8.

A MONTHLY JOURNAL FOR ENGINEERS, ARCHITECTS, SURVEYORS & CONTRACTORS and all interested in CEMENT, CONCRETE, REINFORCED CONCRETE, FIRE-RESISTING CONSTRUCTION and STRUCTURAL STEEL.

ISSUED MONTHLY

CONTENTS.

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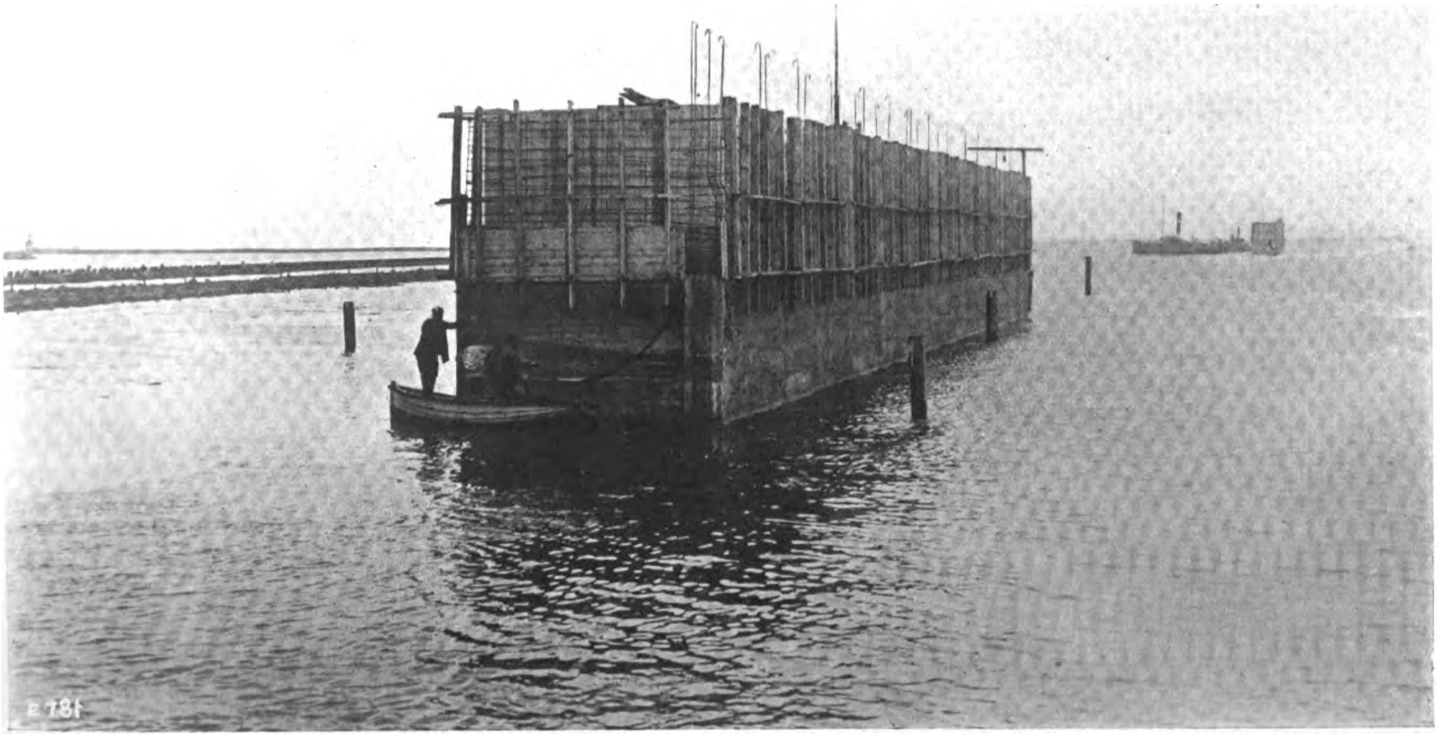


Concrete Caissons at Copenhagen.
(See page 413.)

CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume XII., No. 8. LONDON, AUGUST, 1917.

EDITORIAL NOTES.

CONCRETE ROADS.

A MUCH keener interest has been evinced of late in the possibilities of concrete as a material for road construction, and in view of the large amount of road building which will be necessary at the conclusion of the war, the report "On Concrete Roads," just published, from the pen of Mr. H. Percy Boulnois, M.Inst.C.E., a well-known authority on all classes of road construction, will doubtless be read with the greatest interest by all engineers and surveyors who are specially concerned with this particular branch of work. The report, which is in pamphlet form, has been prepared by Mr. Boulnois at the request of the Roads Improvement Association*, and forms a valuable contribution to the literature on this important subject.

We do not think we can do better than briefly indicate the contents of the report.

The author commences by referring to the work carried out in the United States and Canada, and points out that in 1914 "it was estimated that no less than 17,000,000 sq. yd. of concrete roads were constructed in America, and that at the present time there must be at least 50,000,000 sq. yd. of such roads in the United States."

The opinions of some of the leading American engineers are given in regard to the adaptability and cost of concrete roads, as well as stating the reasons why they should prove a success. The manner in which American engineers deal with the construction of a road is set forth in much detail, and examples given of the proper methods of mixing and laying the concrete, in addition to a description of the materials to be used.

Mr. Boulnois then gives particulars of the various concrete roads that have been constructed in this country, from which it would appear that, comparatively speaking, but slight progress has been made, and the roads limited to only a few districts, the City of Chester and Dunfermline in Scotland being two of the principal ones.

The most interesting experiment in the construction of concrete roads in this country, however, was that on a portion of a road near Gravesend in Kent in 1914, which is fully described, a copy of the specification to which the road was constructed being given, as well as the results of the experiment.

The suggestions for the preparation of specifications for concrete roads are based on the experience of American practice, and after a careful study

*Copies can be obtained from the Association at 15 Dartmouth Street, Westminster, S.W.1. (Price 7d. by post.)

of the subject by the author. It is hoped that these may be helpful to any highway engineer who contemplates the construction of a road on the principles laid down in the report, in concluding which the author says:—"There is no doubt that the future traffic on our roads and streets will become more and more intense in weight, speed and quantity, and the roads of the future will be expected to carry this traffic.

"It will be the duty of all highway engineers carefully to consider the best manner in which to meet these greater demands on the strength and durability of our roads, and possibly it will be found that properly constructed concrete roads may, in some cases, meet the requirements."

We call the special attention of our readers to this report, as it forms a useful guide to anyone contemplating the making of a concrete road.

Above all, the report points to the fact that concrete roads have proved a great success in America, as is shown by the testimony of the highest engineering authorities in that country.

We think the Roads Improvement Association are to be congratulated on having taken up this important question, and we trust the report will lead to a more extensive trial of concrete roads in our own islands.

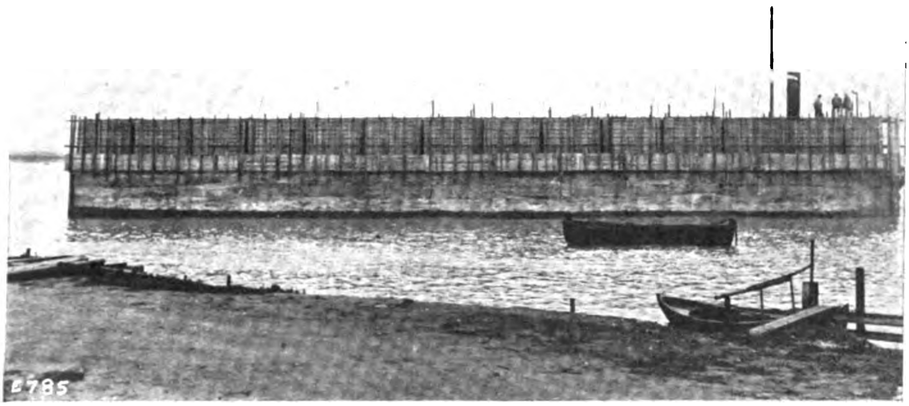


FIG. 1. REINFORCED CONCRETE CAISSON AT COPENHAGEN BEING TOWED TO POSITION.

REINFORCED CONCRETE CAISSONS.

The following notes on the construction of reinforced concrete caissons will, no doubt, be of interest to many of our readers. We hope in succeeding issues to present particulars and illustrations of concrete shipbuilding work in this country. We draw attention to the notes on this subject under Memoranda.—ED.

PUBLIC interest in reinforced concrete work has during the past few weeks been greatly stimulated by the numerous articles in the professional and lay press dealing with ships and floating objects constructed of this material.

Several objections have been raised against the use of reinforced concrete in this connection, and the following notes on caissons which have been floated out to their position and then sunk may therefore prove to be of interest, as the principle involved in both cases is in some ways the same.

Fig. 7 shows the launching of one of the reinforced concrete caissons which were used for the wharves of Norresundby Harbour. These caissons, which are 25 ft. high, 8 ft. 4 in. wide, and 32 ft. 6 in. long, were constructed on land, as shown in *Fig.* 2, and were then launched and towed to their final positions by tugs, after which they were sunk and filled with sand.

The walls are of surprising thinness, being but 5·1 in. thick at base and 3·5 in. at top, but despite these dimensions no failure or cracking has occurred.

Such small constructions have been, however, quite eclipsed by the large caissons used in the construction of the walls to the new harbour basin at Copenhagen which has been recently completed. This wall is 3,300 ft. long and has been formed with twenty-two reinforced concrete caissons, the majority being 162 ft. long, 32 ft. high, and 16 ft. wide. *Fig.* 3 gives outline plan and sections of their construction, and *Figs.* 4-7 photographs of them during construction and whilst they were being floated to their destination.

The mixture for the concrete was 1 : 2 : 3, and they were built in a temporary dry dock large enough to accommodate three at one time. On their

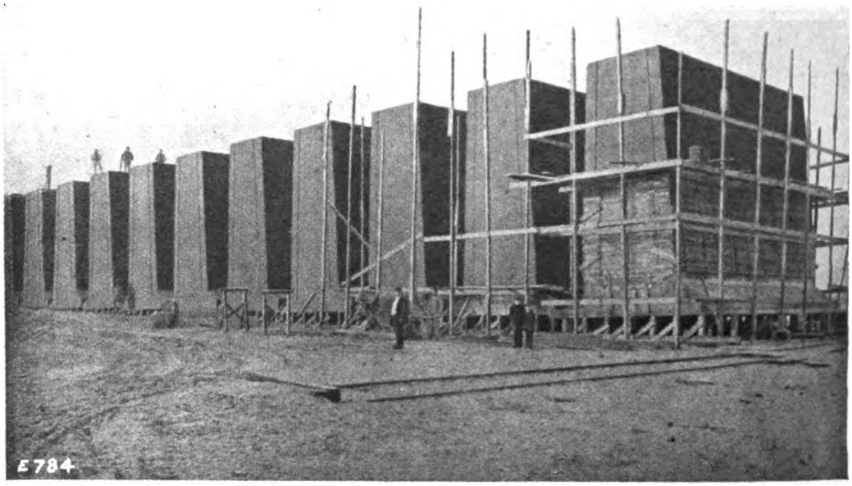


FIG 2. REINFORCED CONCRETE CAISSONS PRIOR TO LAUNCHING AT NORRESUNDBY, DENMARK

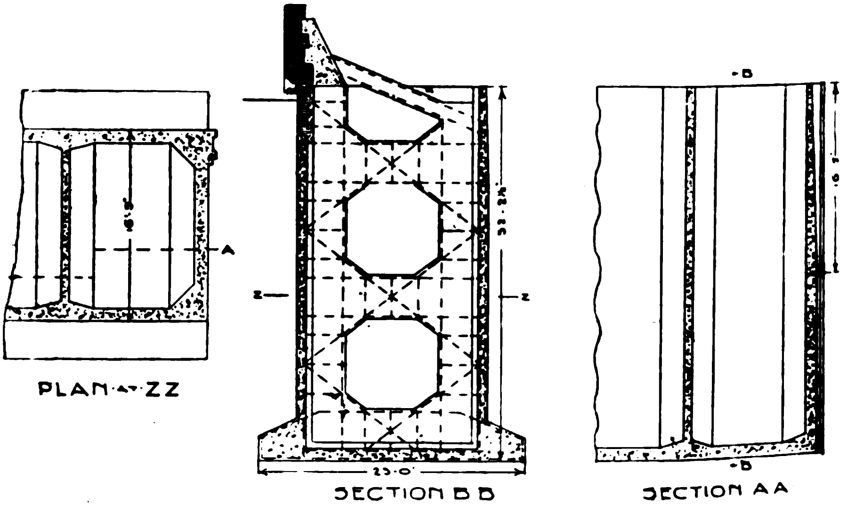


FIG. 3. REINFORCED CONCRETE CAISSONS AT COPENHAGEN.

completion, and after allowing a reasonable time for the concrete to harden, water was admitted to the dock and they were towed by tugs to their final position in the structure.

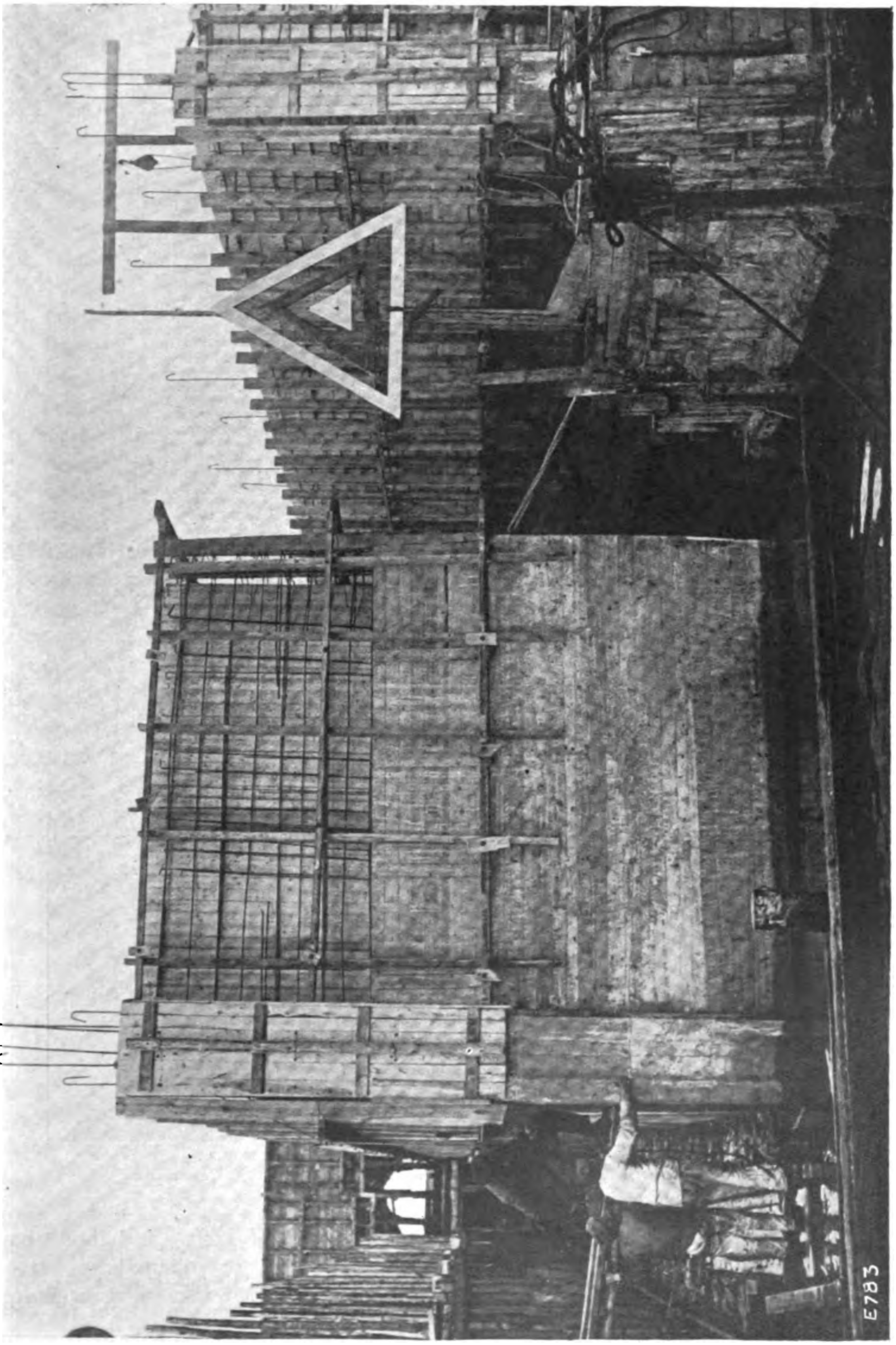


Fig. 4. View showing construction in dry dock.

REINFORCED CONCRETE CAISSONS IN COPENHAGEN HARBOUR.

The depth of the water at the front of the walls is 31 ft., and to protect this wall from the impact of vessels the top portion, 4 ft. 3 in. in depth, is recessed to receive a thin granite facing.

Fig. 3 as mentioned gives the system of construction, and it will be seen

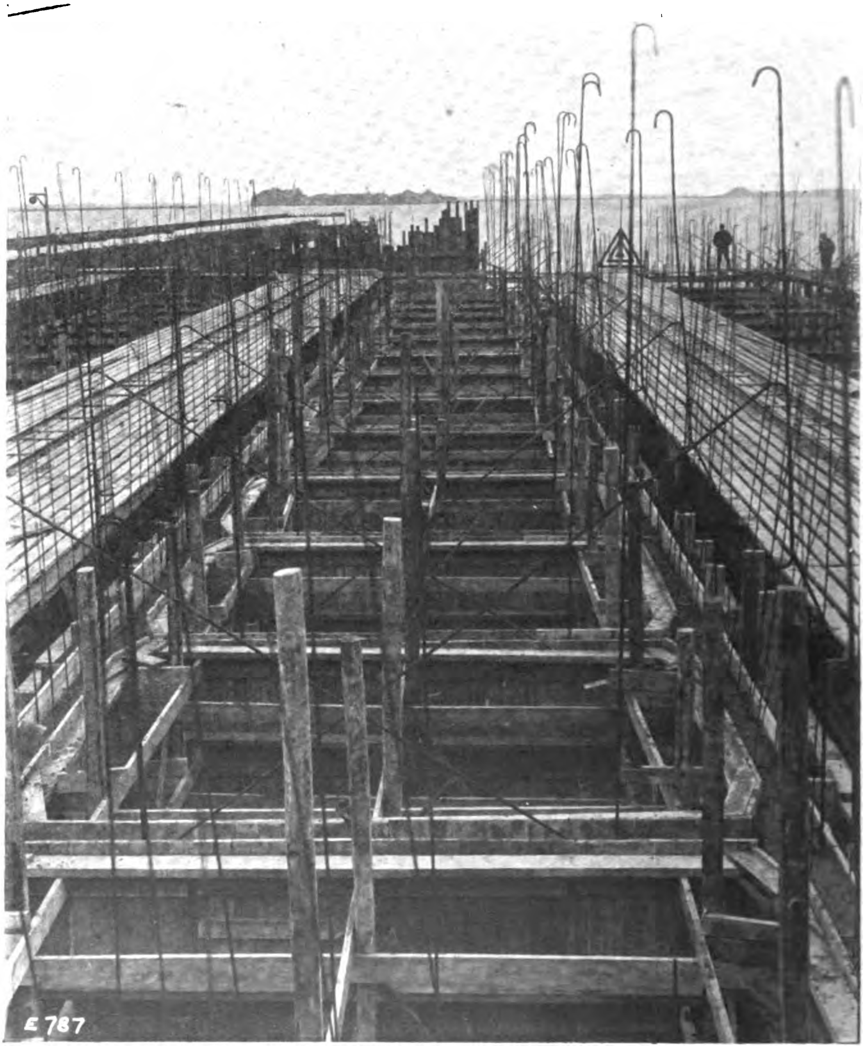


FIG. 5. REINFORCED CONCRETE CAISSON, SHOWING CONSTRUCTION, AT COPENHAGEN.

that each caisson spreads out at the base to a width of 23 ft., and thus two longitudinal beams are formed at either side. These are stiffened by cross beams 4 ft. 3 in. deep spaced at 10 ft. 9 in. centres, which also form the base of the transverse struts, which consist of slabs $7\frac{7}{8}$ in. thick pierced at intervals, as shown on section A.A. The front wall is $10\frac{1}{2}$ in. thick up to the point where it is broken back for granite facing, and the back wall $10\frac{1}{2}$ in. to a point

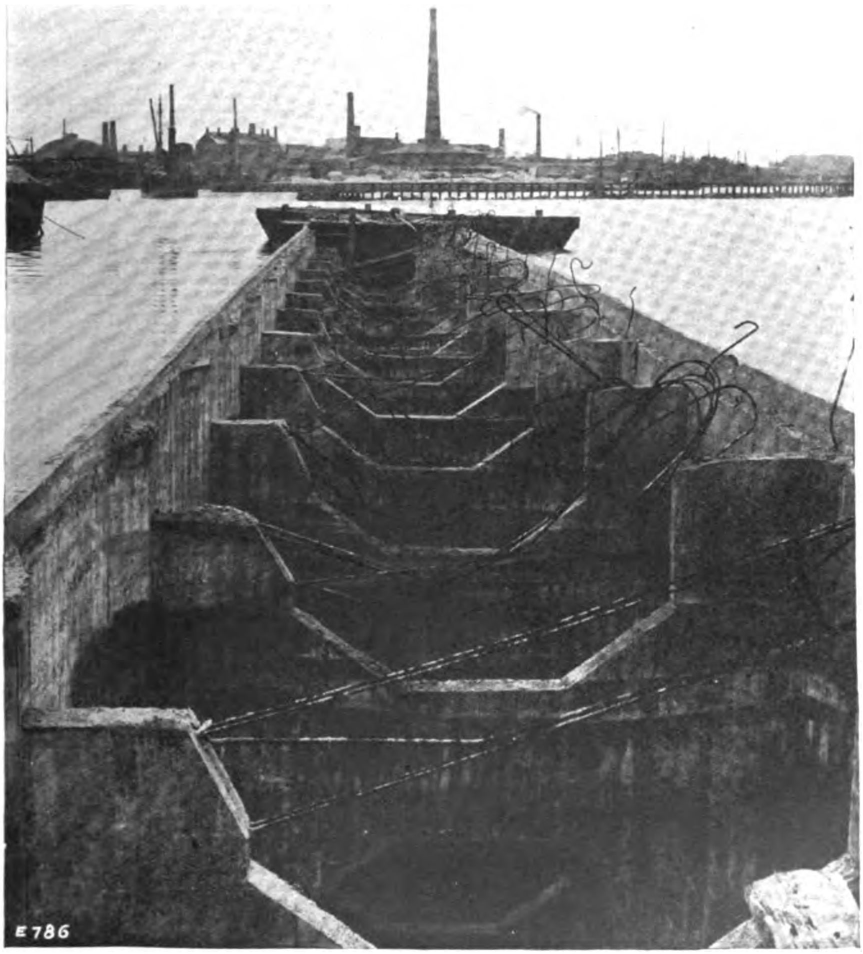


FIG. 6. REINFORCED CONCRETE CAISSON, IN COURSE OF CONSTRUCTION, AT COPENHAGEN.

8 ft. 3 in. below the top, from which point it regularly diminishes to 6 in. thickness.

Attention is also drawn to the granite-faced wall above the caissons, which is 7 ft. high and projects 1 ft. $1\frac{1}{2}$ in. beyond face of wall below, and thus receives any strain caused by vessels mooring or being moored alongside. This superimposed wall is backed by concrete and is stiffened by reinforced struts to the back wall of the caisson.

As in the first example, these caissons when in position were filled with sand.

The whole of the work was designed and executed by Messrs. Christiani and Nielsen, of 25, Victoria Street, Westminster, to whom we are indebted for the foregoing information.

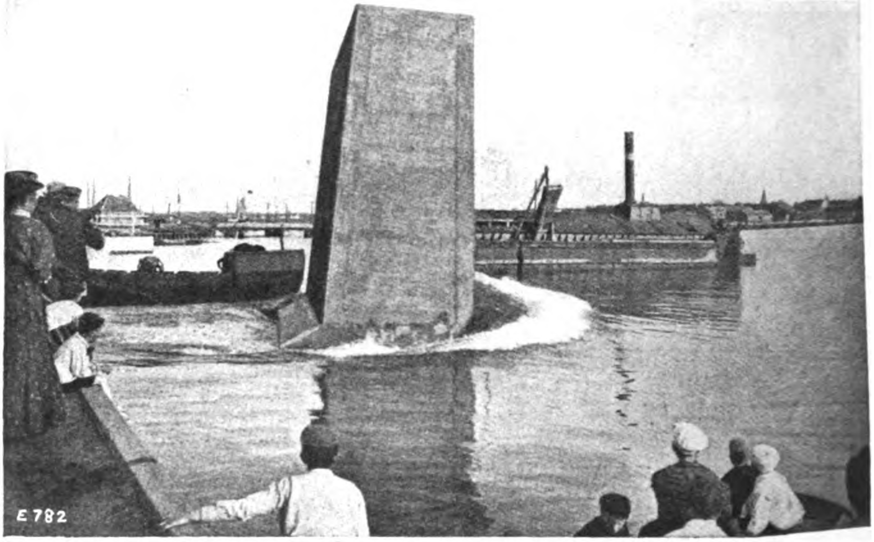


FIG. 7. REINFORCED CONCRETE CAISSON BEING LAUNCHED AT NORRESUNDBY, DENMARK.

RESEARCHES ON REINFORCED CONCRETE BEAMS.

With New Formulæ for Resistance to Shear.

By OSCAR FABER, D.Sc., A.M.Inst.C.E., etc.

Continued from December, 1916, p. 596.—ED.

PART V.

SHEAR TESTS ON CONTINUOUS BEAMS (1911 SERIES).

(*a*) *Description of experiments.*

Practically no tests to destruction under scientific observation have been made on continuous beams, and yet they are used almost exclusively in modern practice.

This has no doubt been due almost entirely to the practical difficulties of making tests on continuous beams.

The writer does not know of any testing machines arranged for loading several spans, and even if one confines oneself to a single span fixed at both ends there is great difficulty in really fixing the end.

Having these difficulties in mind, the writer devised the form of specimen used in these tests, in which end fixity is obtained by constructing massive ends, into which two beams are made monolithic one on top and one on the bottom.

It will be seen that during the testing of the upper beam the presence of the lower fixes the massive ends in direction and so gives the condition required.

A valuable economy of material is also obtained, since the specimen may then be inverted and the other beam tested under similar conditions.

Figs. 64-67 show specimens 1 to 8 made in this manner. Each contains two beams, one marked (*a*) of uniform depth and one marked (*b*) provided with haunches. Beams 1 to 4 were tested with a single concentrated load and 5 to 8 with two loads at the third points. Beams 1 and 2, 3 and 4, 5 and 6, and 7 and 8 differ from each other only in the odd numbers being devoid of stirrups and the even numbers provided with them.

By such systematic arrangement the drawing of conclusions from the tests is much simplified.

The steel was commercial mild steel with an elastic limit of about 40,000 lb. and an ultimate of about 62,000 lb.

The concrete was composed of

⅜-in. granite chips	3 parts
Sand	1½ ,,
Portland cement	1 ,,

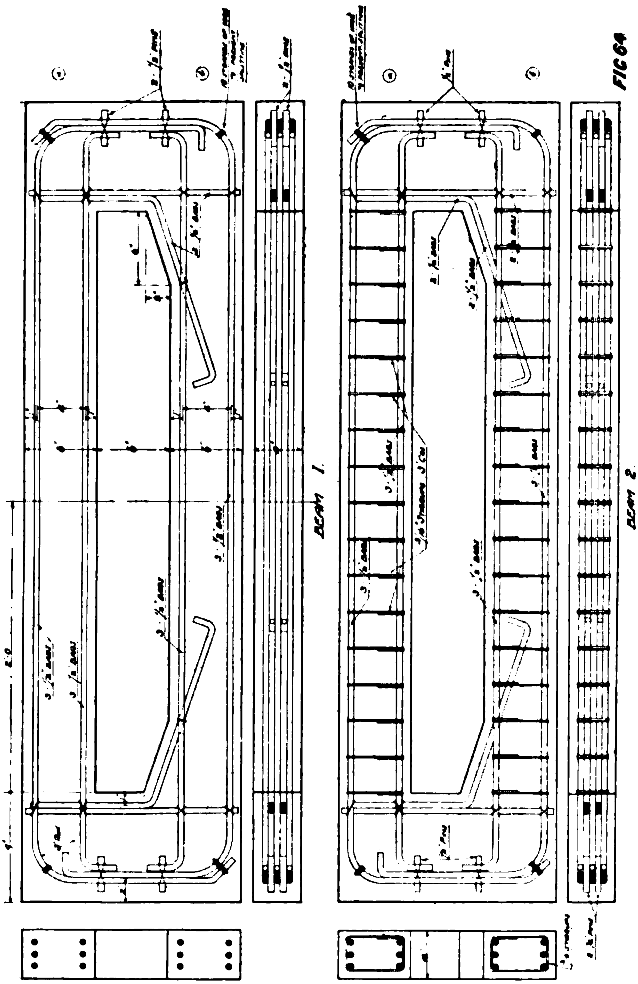
Although having a greater proportion of cement, this concrete was no stronger than the usual 4–2–1 concrete, since the smallness of the particles necessary with such small beams offsets the greater richness.

The beams were made late in February and early in March, 1911, and tested late in April and early in May at an age of about two months. The exact dates are given on *Figs.* 68-83, which give records of the loadings and the cracks.

The beams were concreted on their side in one operation. To avoid any displacement of the steel it was all wired together securely into a complete frame, shown in the photographs of *Figs.* 84-86.

The beams were made at the Northern Polytechnic in connection with some courses of instruction given by the writer.

They were tested in a small Buckton machine taking 10 tons, or 11 tons by the addition of an extra weight to the rider.



Records of deflection were made at frequent intervals as shown on *Figs.* 68-83.

To make the tests more easily intelligible to the students the writer painted on the beam sides the position of the reinforcement, so that when a crack occurred it was easy to see what members were immediately strained by it. These lines also make the photos of *Figs.* 87-94 more interesting and instructive.

The photographs were taken by the writer by flashlight in the evenings under some difficulty, and are not as good or as complete as he would have wished.

(*b*) *Calculation of Resistance by R.I.B.A.* (1911) *Rules.*

	lb.
Beam 1.	
Resistance by concrete $60 \times 4 \times 4 =$	960
Beam 2.	
Resistance by concrete	960
,, ,, stirrups $0{\cdot}055 \times 16{,}000 \times \frac{4}{3} =$	1,170
	2,130

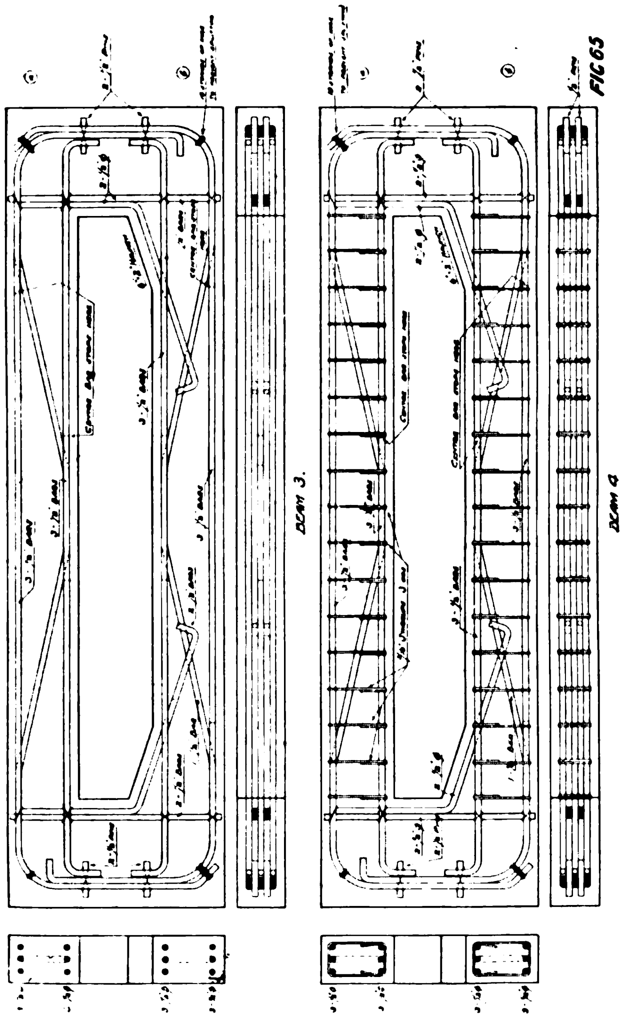
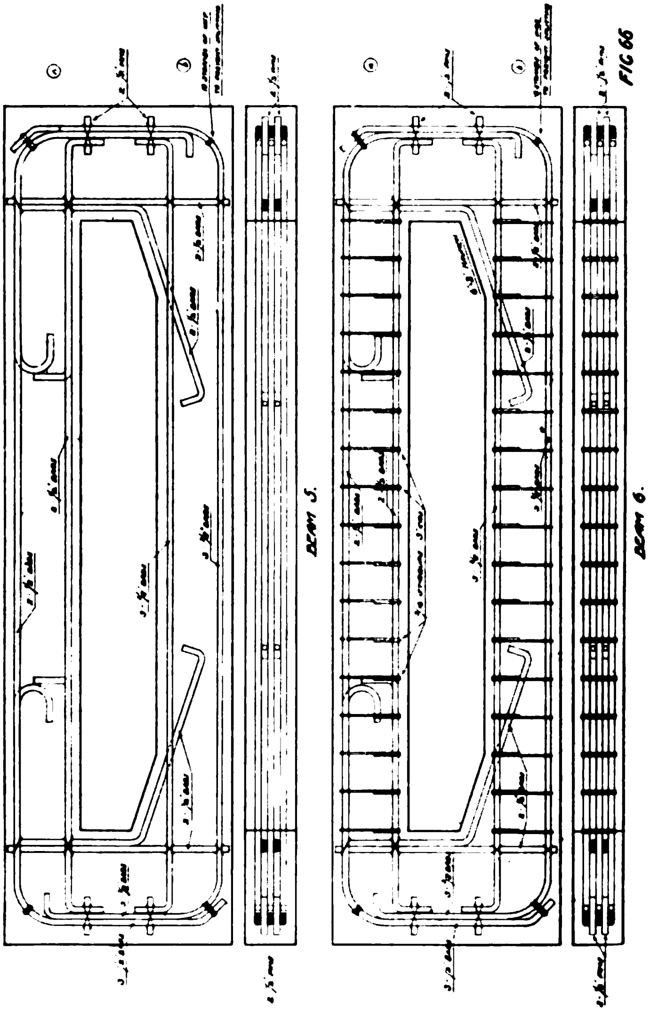


FIG 65

Beam 3.	
Resistance by concrete	960
,, ,, bent up bar $0{\cdot}2 \times 16{,}000 \times \frac{4}{18\frac{1}{2}} =$	690
	1,650

Beam 4.

Resistance by concrete	960
,, ,, stirrups	1,170
,, ,, inclined bar	690
	2,820



Beam 5.

Resistance by concrete	960

Beam 6.

Resistance by concrete	960
,, ,, stirrups	1,170
	2,130

Beam 7.

Resistance by concrete	960
,, ,, inclined bar $0 \cdot 2 \times 16{,}000 \times \frac{4}{10} =$	1,280
	2,240

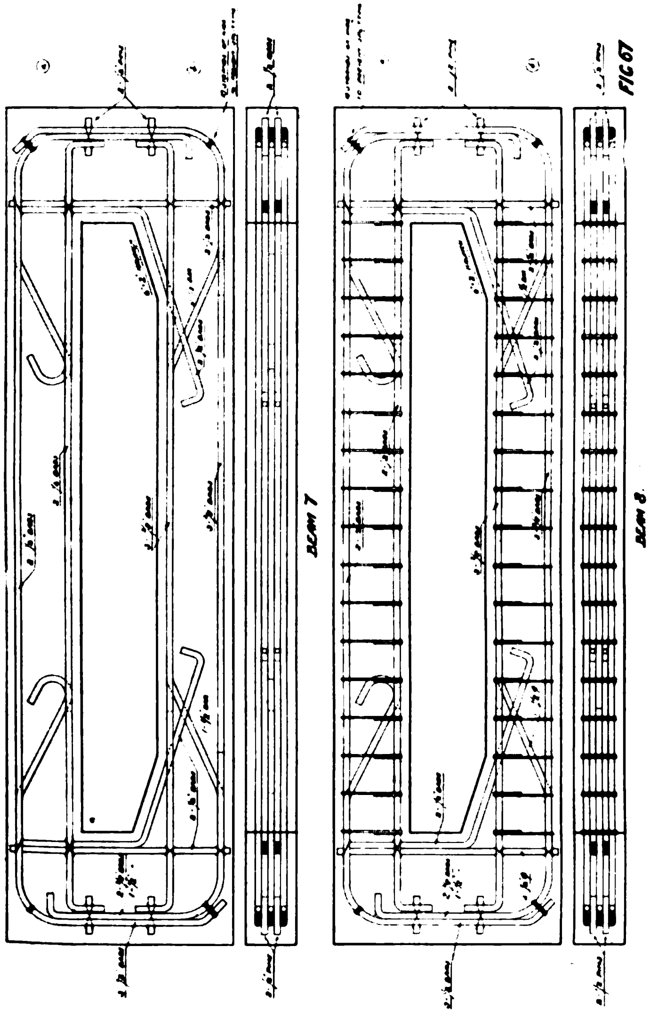


FIG 67

Beam 8.

Resistance by concrete	960
,, ,, inclined bar	1,280
,, ,, stirrups	1,170
	3,410

(*c*) *Calculation of Resistance by L.C.C.* (1909) *Regulations.*

These were given in paragraph *c* of Part IV.,* and it will be remembered that the resistance of concrete may in no case to be taken simultaneously with other resistances.

We accordingly have—

Beam 1.	Resistance of concrete...	... ...		960
Beam 2.	,, ,, stirrups	... ...		1,170
Beam 3.	,, ,, concrete	... ...		960
Beam 4.	,, ,, inclined bar	... ...	690	1,860
	,, ,, stirrups	... ...	1,170	
Beam 5.	... ...	... ...	Zero	960
Beam 6.	Resistance of stirrups	... ...		1,170
Beam 7.	,, ,, inclined bar	... ...		1,280
Beam 8.	,, ,, ,, ,,	... ...	1,280	2,450
	,, ,, stirrups	... ...	1,170	

(*d*) *Calculation of Resistance by Inclined Compression Method.*

Beam 1*a*.

Referring to Part III., Section 17, we will use the simple formula

$$S = 225 \frac{b\,h^2}{l_1}$$

since we have steel top and bottom.

Note that this requires $0{\cdot}012 \times b \times h = 0{\cdot}012 \times 4 \times 6 = 0{\cdot}288$ in.^{2} of steel carried through, whereas 0·6 in.^{2} is actually provided in each flange.

This formula gives $S = \frac{225 \times 4 \times 36}{48} = 675$ lb.

Beam 1*b*.

The effect of the haunch is to increase the obliquity of the inclined compression and so its resistance.

This is accurately allowed for by taking the length in which the rise is measured to the commencement of the haunch only, making $l_1 = 36$ in.

$$S = \frac{225 \times 4 \times 36}{36} = 900 \text{ lb.}$$

Beam 2*a*.

Resistance of stirrups (as before) 1,170

This produces a concrete stress of—

$$c = \frac{1{,}170 \times 2}{4 \times 4} = 146 \text{ lb./in.}^2,$$

if we assume it to act at 45° and to be uniform across the section. Hence shear by inclined compression must be reduced to

$$675 \times \frac{454}{600} = \qquad 510$$

1,680

The figure 454, obtained by subtracting 146 from 600, should strictly be obtained graphically as in Part III., Section 16. Simple subtraction gives sufficiently accurate results and is much quicker.

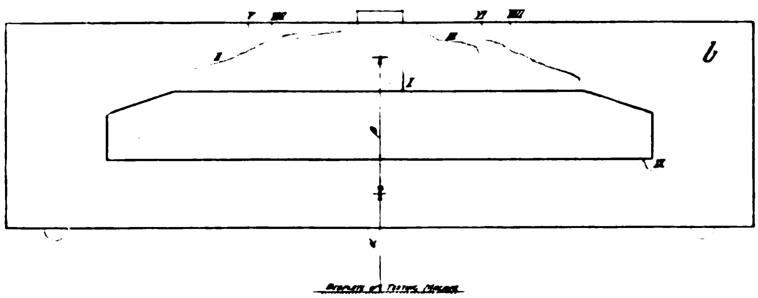
Beam 2*b*.

Resistance of stirrups 1,170
causing $C = 146$

Inclined compression reduced to $900 \times \frac{454}{600} =$ 680

1,850

* See October issue, 1916, p. 35.

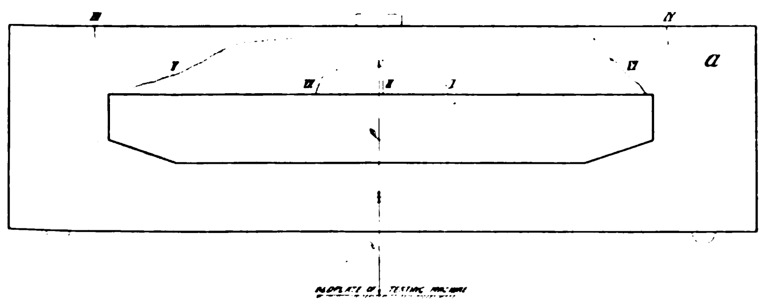


CRACKS	REMARKS
I	hair crack at 6000 lbs
II	opened suddenly at 7000 lbs
III	" " "
IV	" " "
V, VI, VII, VIII	observed at 8620 lbs extending right across top of beam
IX	small hair crack – not through; II & IX follow line of bars

LOAD	LOAD CORRECTED	a	b	DEFLECTION OF a	DEFLECTION OF b	REMARKS
370	–	8.957	11.629	–		
3000	2630	8.947	11.649	.01	.01	
6000	5630	8.94	11.632	.017	.037	
7000	6630	8.94	11.583	.017	.076	
7500	7130	8.94	11.555	.017	.106	
8000	7630	8.938	11.530	.019	.130	cracks .06 thick
8500	8130	8.938	11.50	.019	.159	" .085 "
9000	8630	8.938	11.43	.019	.229	failed slowly

FIG 68

BEAM 1b



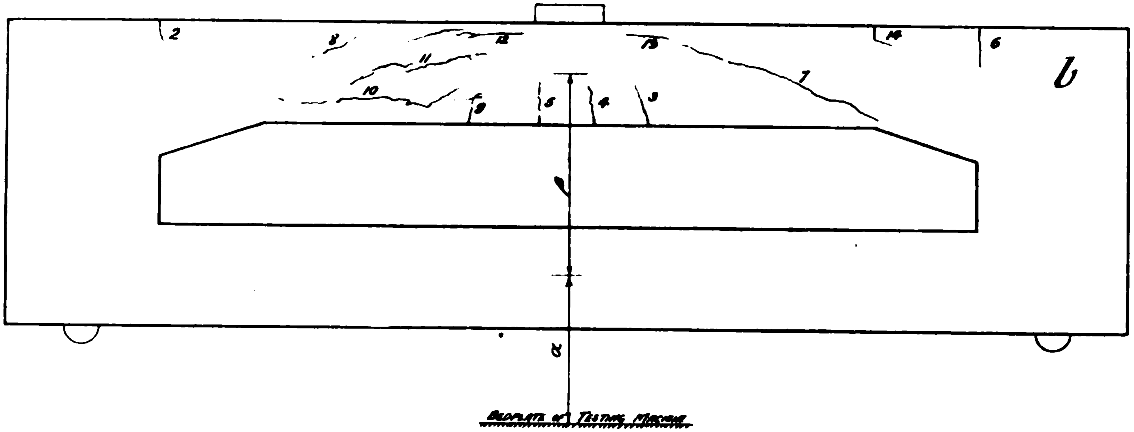
CRACKS	REMARKS
I & II	hair cracks at 3800 extended up to top bar at 7000 lbs
III & IV	very fine hair cracks at 5000; at 7000 all cracks quite small
V	shear crack – opened suddenly at 7000
VI	" " " (hair fine)
VII	noted at 7000
	The secondary effect of failure was to continue V along dotted line following bar

LOAD	LOAD CORRECTED	a	b	DEFLECTION OF b	DEFLECTION OF a	REMARKS
363	–	9.529	11.363			
3000	2635	9.519	11.333	.006	.018	
5000	4635	9.506	11.338	.013	.025	
6000	5635	9.503	11.523	.016	.042	
7000	6635	9.501		.018		Beam failed at [illegible]

FIG 69

Beam 1a.

Tested	4/5/1911
Made	27/2/1911
Age	67 Days



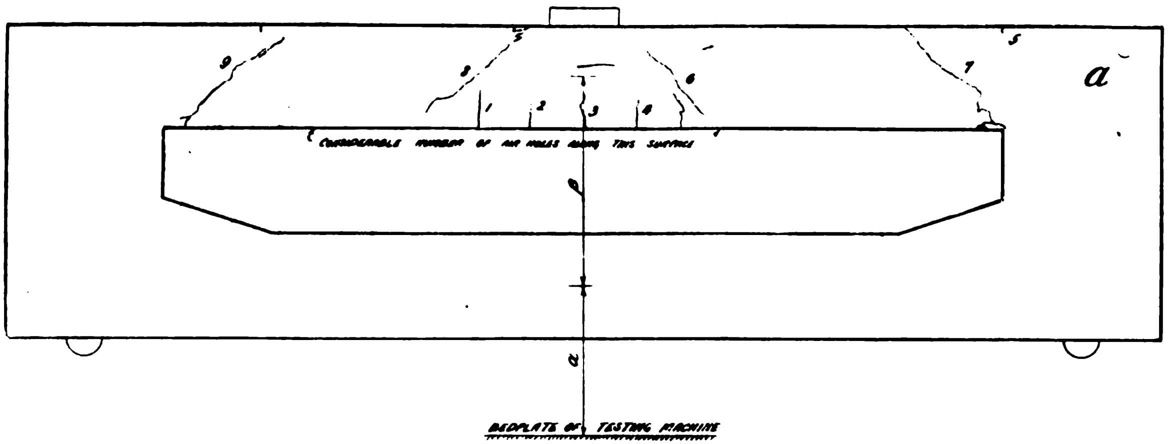
LOADS	REMARKS
6000	Cracks 1 and 2 appeared followed by 3
9000	4 and 5 developed. 3 enlarged and 6 appeared
9950	7 appeared accompanied by a sudden drop of arm of machine. 3 opened still further. 8 – very faint. All cracks right through the beam
11 250	7 followed line of [illegible] bar to the edge of [illegible] 9 and 10
12,000	11, 12 and 13 also 14. Finally 12 and 13 extended to top of beam. Concrete spalling. No cracks were observed in a due to testing of b.

LOAD	LOAD CORRECTED	α (inches)	β (inches)	DEFLECTION OF a *	DEFLECTION OF b †	REMARKS
360	-	8 758	11·860	—	—	Arm of testing machine dropped considerably between 6000 and 9000 lbs. – end of arm dropped about ½" while readings were taken, say 3 minutes
3000	2640	8 744	11 857	014	·003	
6000	5640	8 702	11 839	016	·021	
9000	8640	8·735	11·809	·023	·051	
9950	9590					Arm of machine gave two sudden dips. Beam failed
12000	11640					
360	–	8·752	11 726	006	·134	Load removed

BEAM 2 b

* Measured relative to [illegible]
† " " " a

FIG 70



LOADS	REMARKS
6000	CRACKS 1. 2 3 & 4
7000	5 NOTICED
8000	6
9000	6 EXTENDING AND 7 APPEARED AT 45° TO HORIZONTAL
10083	8 APPEARED ALSO 9
11120	9 REACHED TOP OF BEAM IN TWO PLACES AND 7 EXTENDED ACROSS TO THE CORNER
11580	BEAM FAILED AT SHARP CORNERS AT THE ENDS OF CRACKS 7 AND 9 AND NEAR END AT TOP OF CRACK 8 BY WHAT SEEMED TO BE COMPRESSION OF CONCRETE

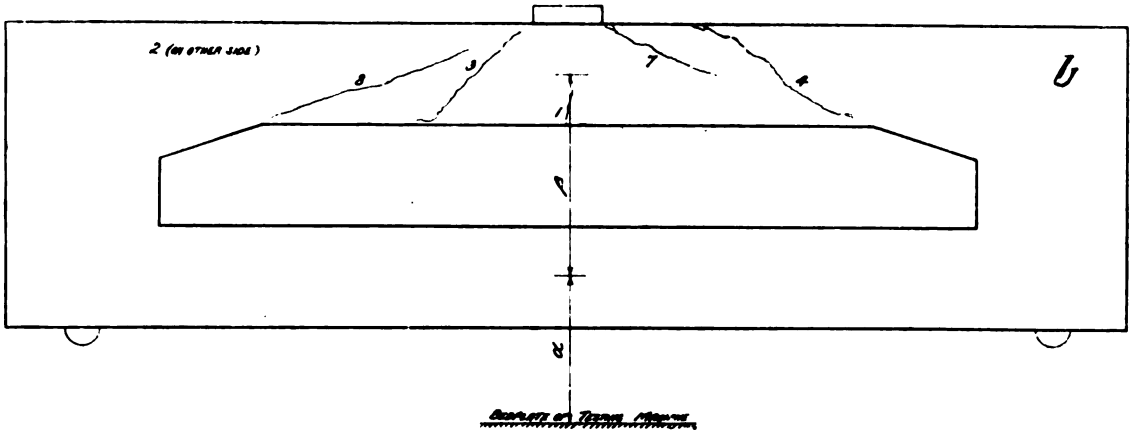
LOAD	LOAD CORRECTED	a (INCHES)	b (INCHES)	DEFLECTION OF b *	DEFLECTION OF a †	REMARKS
360	-	9·480	11·758			
3000	2640	9 470	11 739	·01	·819	
6000	5640	9 462	11·720	·018	·038	
9000	8640	9 460	11 673	·020	·085	
11580	11220					BEAM FAILED
360	-	9 469	11 49	·011	·268	LOAD REMOVED

* MEASURED RELATIVE TO BASE
† " " " b

FIG 71

BEAM 2a.

Tested	27/4/11
Made	27/2/11
Age	59 Days



LOADS	REMARKS
6000	Crack 1 at centre. up to bars
9000	2 appeared on far side. 1 not developing but extended right across beam.
10.000	3 appeared but did not go right through beam
11 000	4 observed
12.500	2 now extended through the beam
14600	3 developed at bottom. 4 also developed from centre to edge of load 8 a slight crack nearly horizontal crack connecting 3 and 8
	Note: b was tested after a had failed

LOAD	LOAD CORRECTED	a (inches)	β (inches)	Deflection of a *	Deflection of b †	REMARKS
380	-	9·159	11·75	-	-	
3000	2620	9·157	11·75	·002	-	
6000	5620	9·15	11·748	·009	·002	
9000	8620	9·145	11·732	·014	·018	
11.000	10620	9·145	11·694	·014	·056	Cracks noted
12000	11620	9·143	11·685	·016	·065	
13000	12620	9·14	11·67	·019	·08	
14000	13620	9·139	11·642	·020	·108	
14600	14220					Beam failed
380		9·16	11·69	-·001	06	Load removed

* Measured relative to base
† " " " a

FIG 72

BEAM 3b

Beam 3*a*.

Resistance of inclined bars (as before) 690

This produces a concrete stress of—

$$C=\frac{690\times 2}{5\times 4}=69 \text{ lb./in.}^2$$

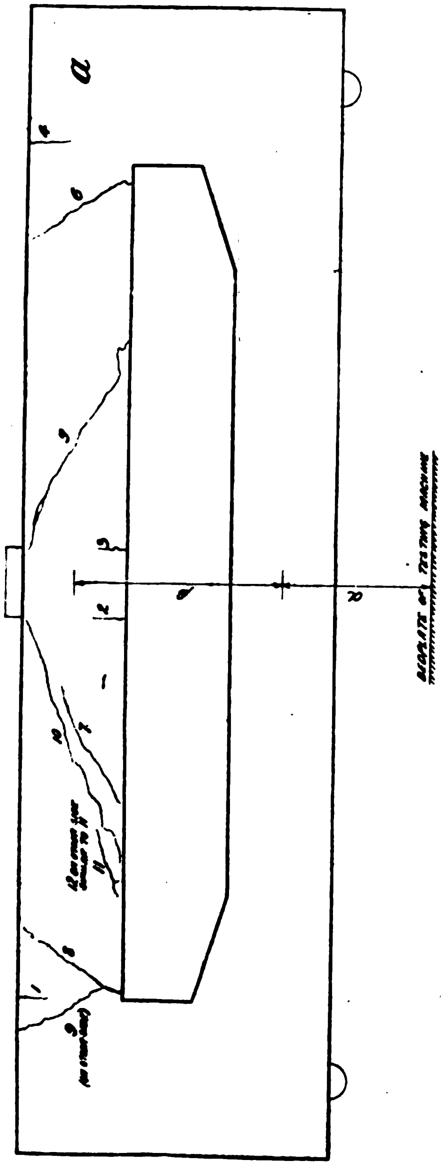
if we assume it to act at 45°, and to be uniform on a belt having a horizontal width equal to the depth.

Hence shear by inclined compression $=675\times\frac{531}{600}=$ 595

1,285

* indicated relative to +

FIG 73



LOAD	LOAD CORRECTED	a (inches)	b (inches)	Deflection at b	Deflection at a	REMARKS
380	-	9.603	11.824			
3000	2620	9.595	11.810	.008	.014	
6000	5620	9.582	11.792	.021	.032	
8000	7620					First hair cracks
9000	8620	9.574	11.772	.029	.052	
11700	10620					Beam failed

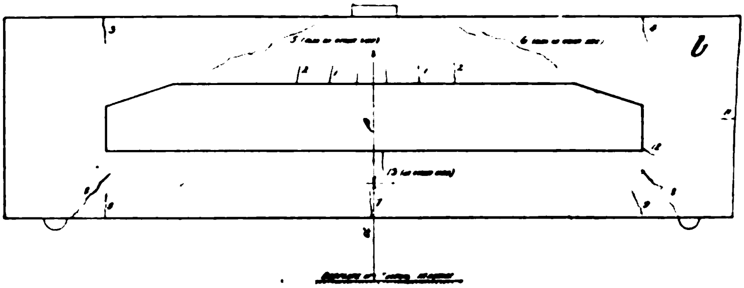
LOADS	REMARKS
8000	1, 2, 3, 4 hair cracks
11,000	5 from edge of load 6 elsewhere also 7 and 8 9 on far side [illegible] to centre
11,700	Failure crack 10 appeared also 11 parallel to 10 B.M. cracks [illegible] 5 curled round [illegible] 12 [illegible] All cracks through the beam

BEAM 3a.

Tested 27/4/11

Made 23/2/11

Age ... ... 63 Days



SECOND TESTING

LOAD	[illegible]	a	β	Deflection of a *	Deflection of b †	REMARKS
380		9 32	11·67			
3000	2620	9 31	11 65	·01	·01	
6000	5620	9·308	11 64	·012	·03	
9000	8620	9 298	11 62	·022	·05	
12 000	11620	9·292	11 605	·028	·065	
13500	13120	9·290	11 592	·030	·073	
15000	14620	9 283	11 584	·037	·086	
16500	16120	9·281	11 572	·030	·008	[illegible]
18000	17620	9 26	11 55	·06	·12	
19500	19120	9 252	11·50	·068	·17	
	[illegible]	9 252	11·465	·068	·205	[illegible]
20.000	19620	9 205		·075		

FIG 74

BEAM 4 b

Loads.	Remarks.	Loads.	Remarks.
9,000	1 up to bars, 2 rather longer	13,200	8 noticed almost up to corner of beam; also 9. These cracks both sides of beam
10,000	3 appeared, left-hand crack, 2 extended right across underside	14,160	Cracks not developing appreciably, but nearly all through the beam
10,500	4 similar to 3	15,000	11 and 12 observed; also 13, on far side of *a*
11,000	Several tension cracks (vertical) between 2 and 2 at centre of beam	15,500	At this load it was discovered that the load was applied on near side of beam, the oak pad being dented by ridge on concrete, and a small piece spalled off on this side. No sign of failure could be seen in the haunches, several small cracks at bends of bar near 2; for this reason the load was removed and re-applied. (See Table of Deflections.)
12,000	5 started from near top of beam, across middle of bent up bar; also small tension crack at centre, and small crack about 3 in. inside 3, over left support		
13,000	6 almost exactly similar to 5, and following apparently closely the line of the haunch bar. This crack went at once through the beam; 5 through also; 7 first noticed in bottom of *a*, very nearly at centre of beam		

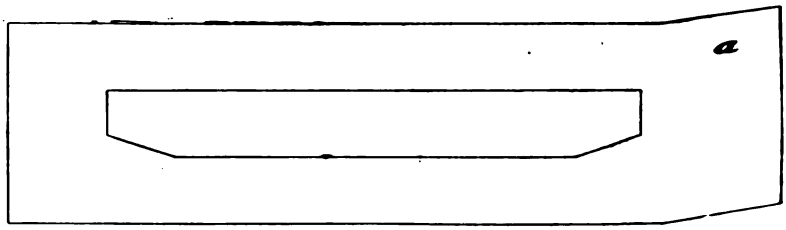


FIG. 75.

BEAM 4.

Tested	27/4/11
Made	23/2/11
Age	63 Days

Beam 3b.

Resistance of inclined bars	690
Inclined compression $900 \times \frac{531}{600} =$	800
	1,490

Beam 4a.

Resistance of inclined bars	690
" " stirrups	1,170
These produce concrete stress of 146+69=215, leaving 600—215=385 for inclined compression.	
Resistance of inclined compression $675 \times \frac{385}{600} =$	433
	2,293

Beam 4b.

Resistance of inclined bars	690
" " stirrups	1,170
These produce a concrete stress of 146+69=215, leaving 600—215=385 for inclined compression.	
Resistance of inclined compression $900 \times \frac{385}{600} =$	580
	2,440

(*To be continued.*)

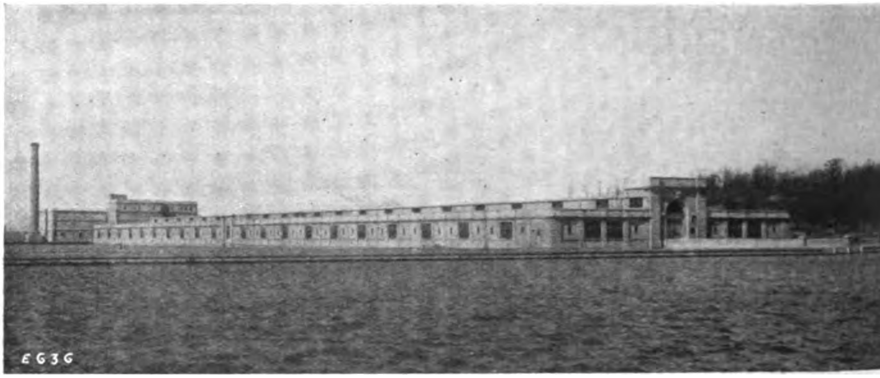


Fig. 1. General View of Filter Plant.

A LARGE FILTRATION PLANT AT ST. LOUIS, U.S.A.

The following particulars and illustrations regarding the use of reinforced concrete in the construction of the above works have been taken from an article by Mr. J. C. Pritchard which appeared in our contemporary, "Concrete," U.S.A.—ED.

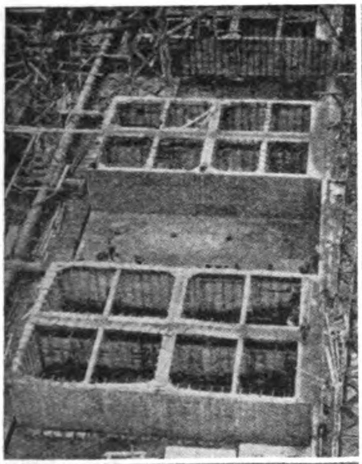
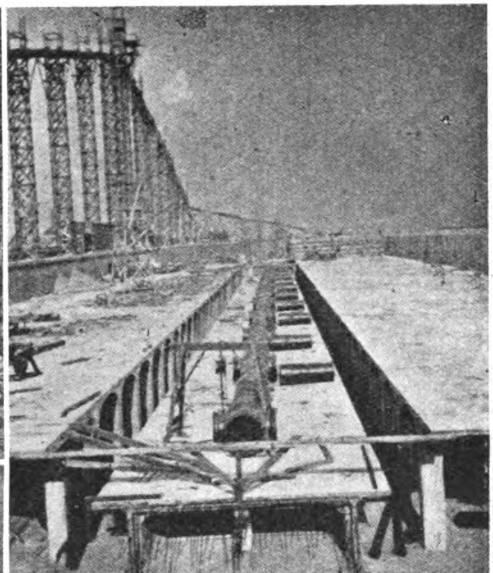
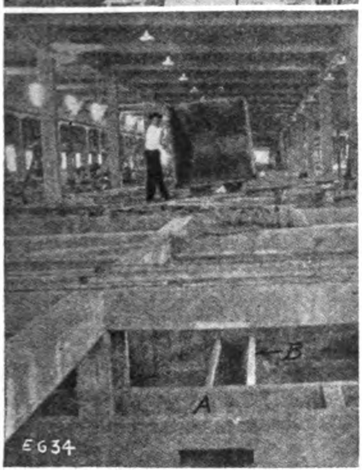
DUE to the rapid increase in the water consumption in the city of St. Louis, it has become necessary to increase the capacity of the purification system. After estimates as to the comparative costs of additional sedimentation basins and a filtration plant, to be used in connection with the present treatment, the latter was decided upon, both from the reason of economy and for the more uniformly satisfactory effluent obtained therefrom.

The plant is of the rapid filtration type and consists of 40 units, each having 1,400 sq. ft. of effective area and a normal capacity of 4,000,000 gal. in 24 hr., giving a total capacity of 160,000,000 gal. The units are arranged in two rows, with the effluent conduit, pipe gallery and influent flume between the rows. The top of the influent flume and the tops of the filter boxes are at the same elevation, forming the operating floor. The plant is located in one of the sedimentation basins and is 700 ft. by 133 ft. over all, with a 50-ft. extension at the south end. The filter units are built over a series of groined arches, supported on groined inverts which, in turn, rest on the original basin bottom. The soil pressure amounts to about 1,200 lb. per sq. ft., a little less than the pressure existing when the basin was filled with water.

CONSTRUCTION PLANT.

The entire area of the plan was covered four times at four elevations, first with the inverts, then the groined arches, then the filter boxes and then the roof. The location of the plant inside the basin enabled the contractor to build an economical plant for handling the concrete.

The walls of the basin are of reinforced concrete of the buttress type. A pit was dug between two buttresses, approximately at the centre of the plant, outside the west wall and down to the footing. A Lakewood mixer and engine of 22 c. ft. capacity was installed in the pit. An elevator tower, resting on the old footing and about 150 ft. high, was built directly in front of the mixers. On either side of the elevator tower auxiliary towers were built, 45 ft. o. c., carrying the main concrete chutes on a grade of 20 per

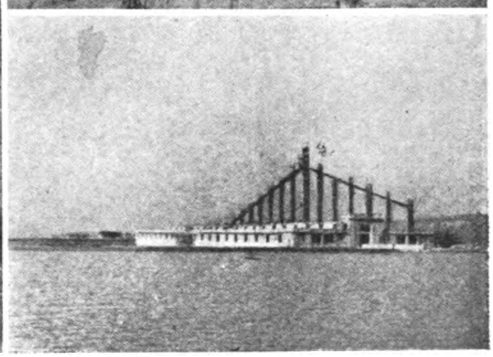


Fig. 2. View f.om Tower, showing Filter Boxes.
Fig. 3. Filter Boxes from Operating Floor.
Fig. 4. General View, showing Influent Conduit and Arched Floor.
Fig. 5. General View of Construction, showing Arrangement of Plant.

A Large Filtration Plant at St. Louis, U.S.A.

cent. Down-spouts were arranged at several auxiliary towers so that concrete could be taken off at any point desired and deposited directly in place.

The concrete was first poured in the groined inverts. These inverts are inverted segmental groined arches, 23 in. thick at the column base or spring line and 8 in. at the crown. Over the column centre a wooden collar was erected 20 in. by 20 in. and 23 in. above the floor. From each corner a wooden screed radiated, cut to the curve of the intersection of the inverted arches. The concrete was piled up under this collar and cut off with a straightedge across the screeds. After several hours, the screeds were removed, the holes filled with soft concrete and the whole invert shovel-finished.

Columns and Arches.—The columns and groined arches were next poured, the arch forms having been made previously in the contractors' shop. The arches are elliptical in section, with a clear span of 9 ft. 4 in. north and south, and 8 ft. 7 in. east and west.

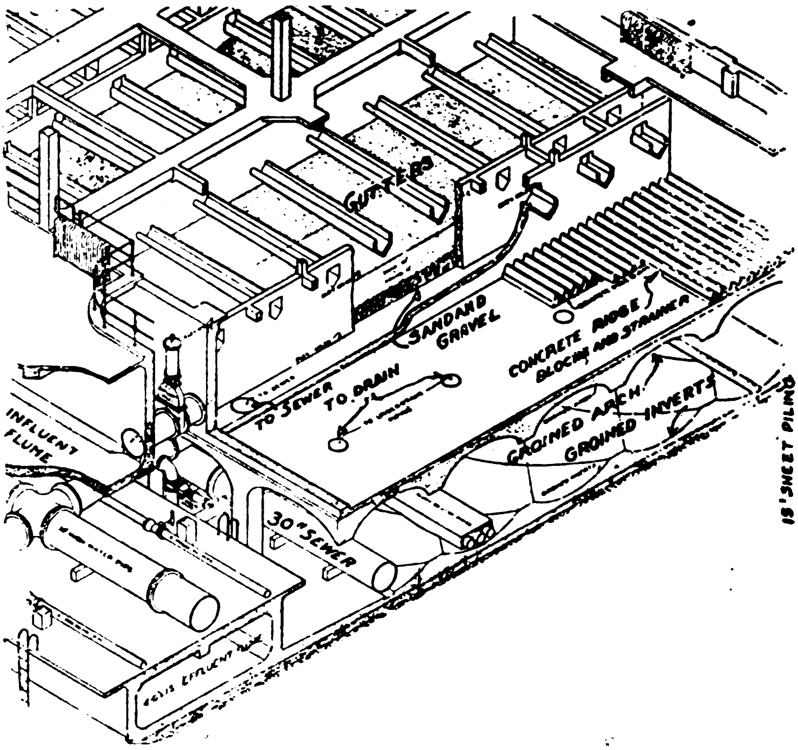


Fig. 6. Isometric View, showing Construction of Filters.
A LARGE FILTRATION PLANT AT ST. LOUIS, U.S.A.

In erecting these forms, the column forms, each having a 4-in. by 4-in. belt at the top, were erected first, lined and levelled. The tops of the concrete arches were brought up level to form a floor to receive the filter boxes, the concrete being 6 in. thick at the crown and 2 ft. 6 in. at the spring line. The arches were reinforced with ½-in. bars 9 in. o. c., running both ways, about 3 in. below the flat top.

Filter Boxes.—The filter boxes were erected on top of the arches (Fig. 2). These boxes were 33 ft. by 51 ft. 9 in. outside dimensions and 31 ft. 6 in. by 50 ft. inside. The side and the back walls are 9 in. thick; the front wall is 12 in. thick. Longitudinally in the centre of the box is a channel 2 ft.

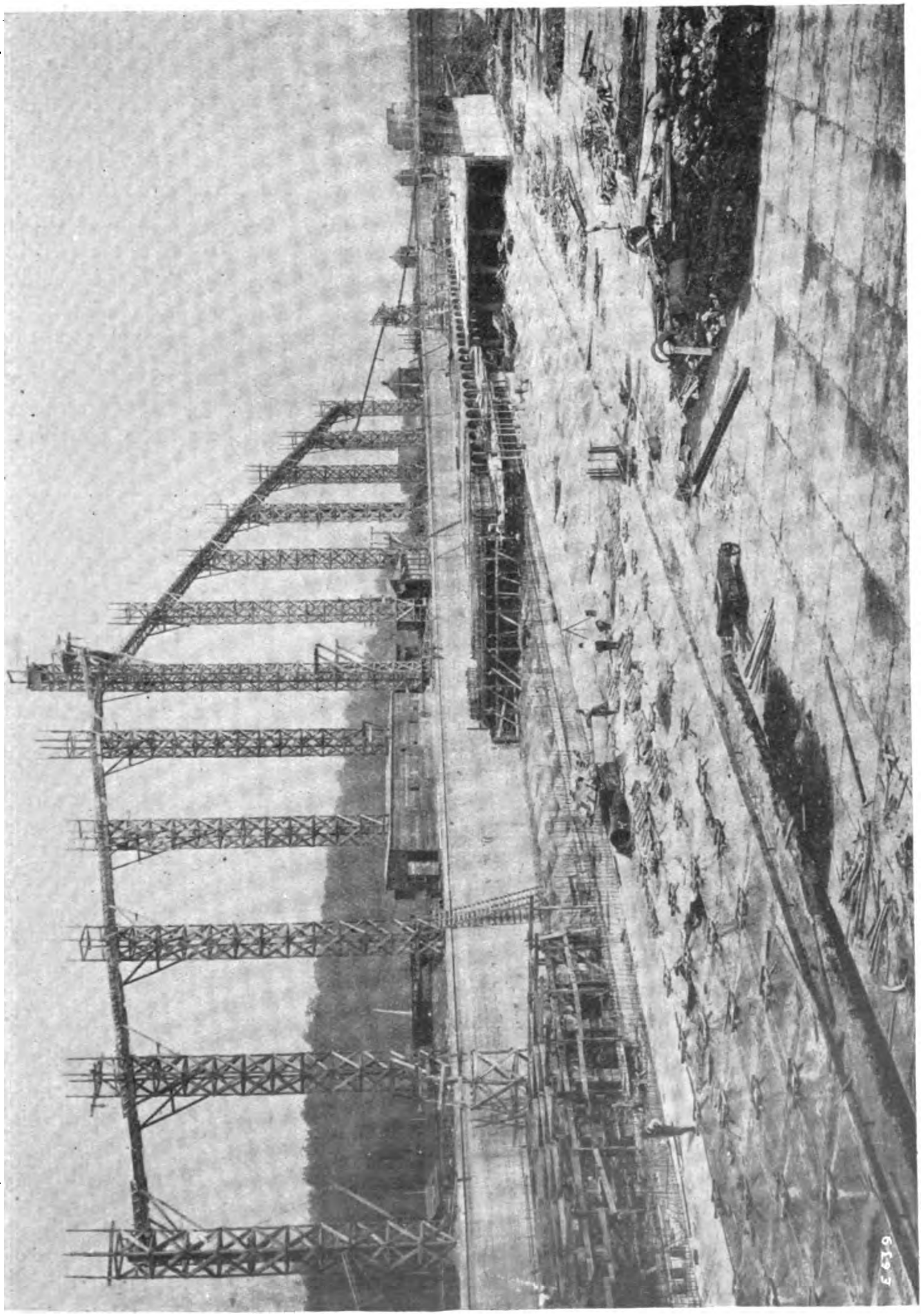


Fig. 7. Inverts Complete.– Erecting Forms and Pouring Groined Arches.
A Large Filtration Plant at St. Louis, U.S.A.

wide with 6-in. walls 7 ft. 3 in. high above the 6-in. bottom of the box. This channel receives the water from the influent flume and distributes it by means of 16 lateral gutters, eight on either side of the channel. Each box was required by the specifications to be poured as a monolith. The interior wall forms were supported on 2-in. by 4-in. legs, which were removed the day after pouring and the holes filled with mortar. Each box contained 107 c. yd. of concrete.

Flumes and Pipe Gallery.—Between the two rows of filters are located the effluent conduit, the pipe gallery and the influent flume. The walls and top of the conduit are 12 in. thick, the inside height being from 4 ft. 6 in. to 6 ft., as the footing follows the slope of the old basin bottom. The conduit is 15 ft. wide in the clear and has a 12-in. by 28-in. beam in the centre on 12-in. circular columns, to support the 36-in. wash water pipe.

The pipe gallery is between the effluent conduit and influent flume and is 4 ft. 6 in. high. It contains the wash water pipe with connections every 33 ft. for the filters and two 6-in. pressure lines to operate the hydraulic valves.

The influent flume forms the roof of the pipe gallery. It has 12-in. side walls and a 12-in. bottom, supported on columns 11 ft. o. c., which rest on the walls of the effluent conduit. The roof slab of the flume is a 4-in. slab supported on beams.

Distributing Gutters.—The lateral distributing gutters are 14 ft. in length and were cast of concrete 3 in. thick. For proper operation of the filters it was essential that the edges of these gutters, over which the water flows when washing the filters, should be absolutely true and level. In order to accomplish this, the gutters were cast in an inverted position, on a concrete slab which had been very carefully levelled.

CONCRETE DATA.

The proportions of the concrete for the groined inverts, arches and walls were 1 part cement, 2½ sand, and 5 of gravel. For all reinforced concrete the proportions were approximately 1 : 2 : 4. In the filter boxes about 5 lb. of hydrated lime were added for each sack of cement. No leakage has appeared through the sides or bottom, showing that the hydrated lime has acted as a successful waterproofing.

HOW THE WATER IS PURIFIED.

A brief description of the operation of the plant will make the construction more clear.

The treatment the water receives between the time it is taken from the river and the time it leaves the filter plant for the city is divided into a number of stages, which may be separated as follows:—

1. Lifted from 27 ft. to 65 ft., depending on the stage of the river. 2. Freed from heavier sand and sediment. 3. Treated with lime and softened. 4. Treated with sulphate of iron and a coagulant to remove most of the turbidity, and passes into settling basins, where from 95 per cent. to 99 per cent. of sediment and bacteria are deposited. 5. Treated with sulphate of

alumina to remove colour and provide a coagulation satisfactory for filtration. 6. Filtered through sand, as a finishing process to remove all the coagulation and sediment and most of the remaining colour and bacteria. 7. Treated with liquid chloride to kill any bacteria that may pass through the filters.

The water, after treatment, as it leaves the filter plant will be sparkling, clear, and free from bacteria of any kind that might produce disease.

METHODS OF OPERATION.

The water, drawn from the river at the intake towers, will pass through tunnels to the screen chambers and wet well and to the masonry delivery well. Leaving the well, it will pass to the grit chamber, a reinforced concrete basin 96 ft. long, 65 ft. wide, and from 15 ft. to 24 ft. deep, designed to reduce

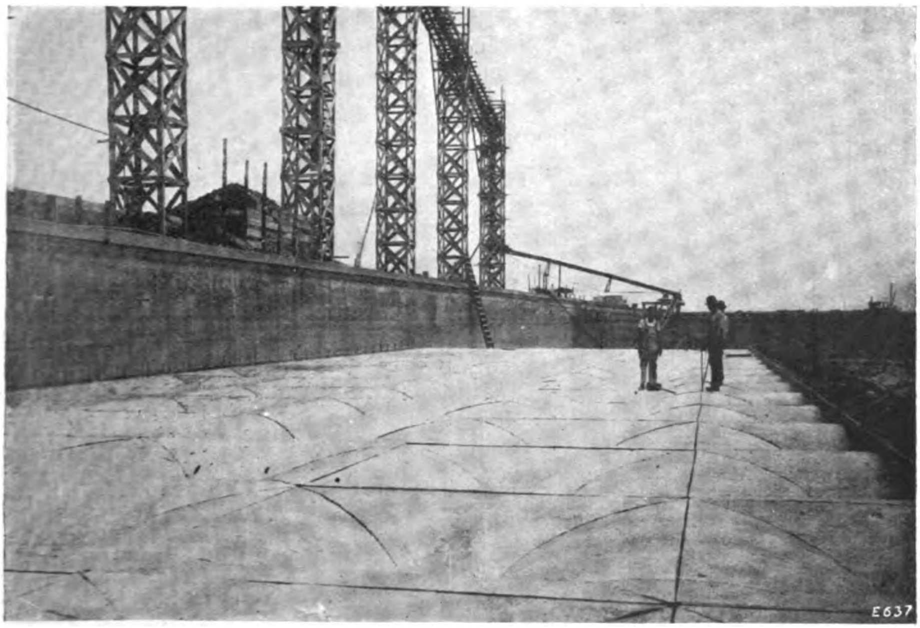


Fig. 8. Groined Arch Forms
A Large Filtration Plant at St. Louis, U.S.A.

the velocity of flow to permit the deposit of the heavier matter in suspension, principally sand, before any treatment with chemical.

Leaving the grit chamber, the water flows through a reinforced concrete passage to the lime-mixing conduit, receiving the charge of lime as it enters the conduit. The lime-mixing conduit is a reinforced concrete box, 2,382 ft. long, 32 ft. 1 in. wide, and 12 ft. 6 in. high, divided longitudinally into four compartments, each 7 ft. wide and 11 ft. high.

Leaving the conduit, the softened water receives the charge of coagulant, sulphate of iron in solution, and enters the filling conduit, through which it passes to the sedimentation basins.

The basins have a total working capacity, with one empty for cleaning, of 172,000,000 gal.

From the collecting conduit the water passes through the Venturi meters into the coagulation chamber, receiving the secondary charge of coagulant, sulphate of alumina, in solution just after it passes the throats of the meters and before it enters the chamber.

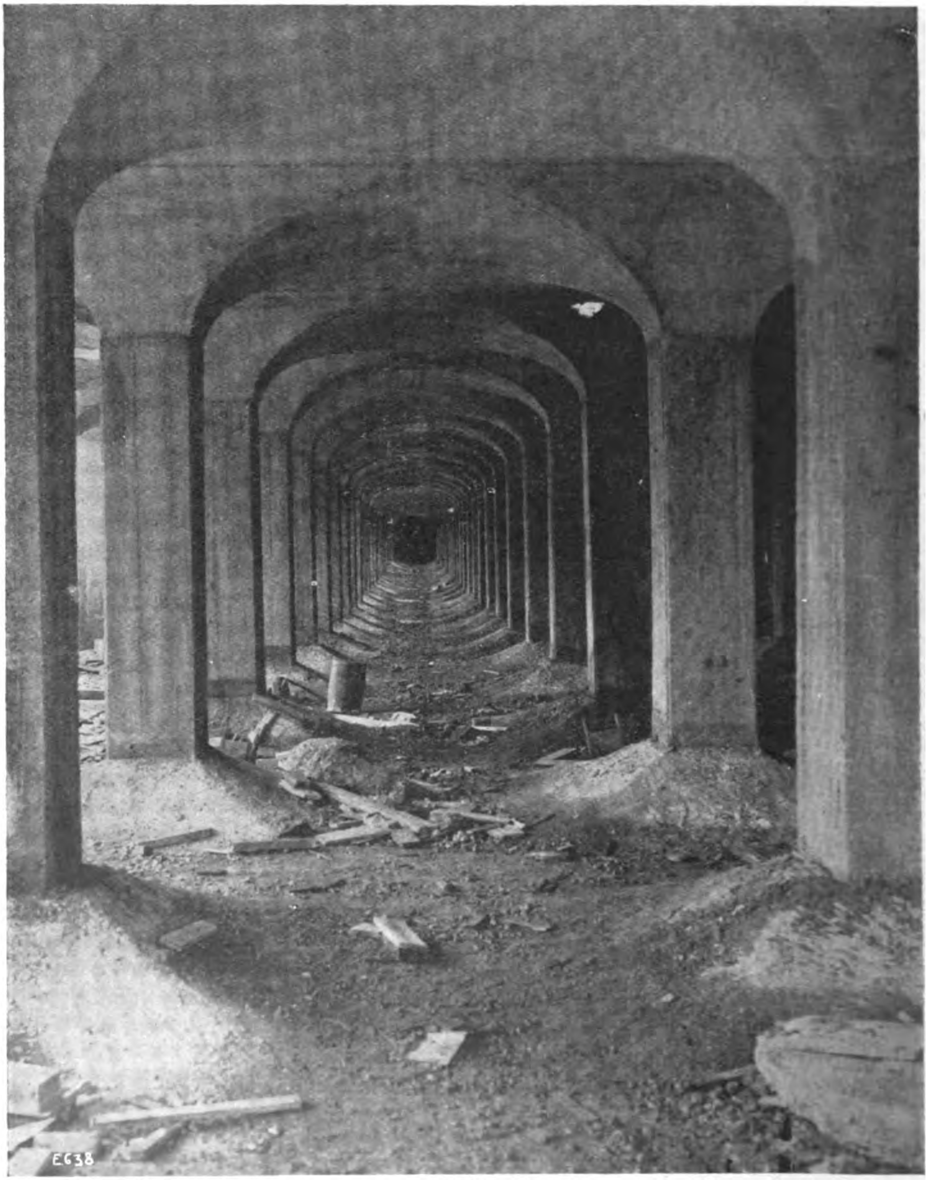


Fig. 9. View under Groined Arches.
A LARGE FILTRATION PLANT AT ST. LOUIS, U.S.A.

The coagulated water flows through the coagulation chamber, Basin 7½, and enters the secondary sedimentation Basins 7 and 8, through stop plank openings. It will remain in the coagulation chamber about 1 hr. and in the basins about 9 hr. before entering the flume leading to the filters.

Leaving the basins, the settled water enters the concrete influent flume which extends the full length of the filters, and from this flume is drawn on to any or all of the forty filter units.

Entering the filter unit by the gutters at the centre of the box, the water rises and flows on to the sand on either side of the central gutters. The sand layer, 30 in. deep, rests on a 12-in. bed of gravel, which is in turn supported by the strainer system. The water passes down through the sand and gravel through the 1/8-in. holes in the bronze strainer plates to the concrete passages under the plates to the 10-in. openings connected to the cast iron under-drain piping, which may be seen in place under the filters, supported from the arches (*Fig.* 6). This piping delivers the water to the concrete clear-water conduit under the raw-water conduit, which connects to the old drawing conduit at three points and delivers the water to the drawing conduit chamber, where a small charge of chlorine is added to kill any bacteria that may have come through the sand. From this chamber it enters the main conduit, from which it is drawn into the mains.

Filtering is continued until the dirt, coagulant, etc., collect in and on the sand to such an extent as to prevent the desired quantity of water from passing through without requiring high differences in head that might open up holes through the sand bed and permit the passage of muddy water. The filter must then be taken out of service and cleaned. This is done by reversing the flow—that is, passing filtered water, under pressure, through the cast iron under-drains, the concrete passages under the strainers and the holes in the bronze strainer plates, up through the gravel and sand at a high velocity, so that the dirt, coagulant, and bacteria are washed out of the sand and carried with the water into the V-shaped concrete troughs that discharge into the central gutter, which now discharges into the sewer, carrying the muddy water back to the river

SUPERSTRUCTURE, CHAIN OF ROCK FILTERS.

The superstructure or filter house over the filters and operating floor is an all-concrete structure, the roof being supported on a system of columns and pilasters resting on the filter box walls. The building is 700 ft. long, 133 ft. wide, and 11 ft. high at the outside, the roof rising with a pitch of ½ in. to the ft. toward a monitor over the operating floor, which is 6 ft. high and about 28 ft. wide.

The roof system consists of four main girders running longitudinally with the building, supported on columns 33 ft. o. c., this dimension being the out to out width of a filter box (*Fig.* 10). These girders carry the roof beams, which are 16 ft. 6 in. o. c. and about 26 ft. in span, the outer end being carried on pilasters which were later incorporated in the outer walls. These roof beams carry the roof, which is an arched slab 3 in. thick at the crown and 6 in. at the spring line. The north and south walls are the only bearing walls.

WALLS.

The exterior walls are of poured concrete. As the building is 700 ft. long and only 11 ft. high, it was necessary for architectural reasons to break the surface with frequent vertical lines. This was accomplished by means of rusticated pilasters about 11 ft. o. c., 3 ft. 8 in. wide, and 4 in. deep. Above the roof was a parapet or fire wall about 30 in. high, making the total wall height about 13 ft. 6 in.

SPECIAL FORMS DEVELOPED TO SECURE PLEASING SURFACE.

After the roof was finished a section of wall form was erected on the monitor, to work the kinks out of this type of form, where it would not be visible except at a distance. Tongue and groove lumber was used, covered with canvas. The cornice forms were not canvas-covered, but were painted with white lead and sanded with white sand. These forms gave an excellent surface, but every joint between the boards showed in the concrete, which was not permissible. A series of experimental panels was then erected on the monitor. Combinations of canvas on building paper, the latter being stuck to the lumber with hot pitch, canvas on asbestos paper treated in the same manner, and canvas on board forms whose joints were filled with plaster-of-Paris were tried, but none of them proved satisfactory. Finally a combination of pitch, asbestos paper, beaver board, and canvas was tried, proved thoroughly satisfactory, and was used throughout the remainder of the building. It was found possible to use the beaver board as many as eight times, but it was necessary to renew the canvas each time the panel was used. The forms as finally used for the exterior consisted of 2-in. by 6-in. verticals sheeted with 1-in. lumber. This was covered with a layer of beaver board and then a layer of asbestos paper and finally a layer of tightly-stretched canvas. The cornice forms were not covered.

ROOF.

The concrete roof was in place about four months before any roofing material was placed upon it and proved fairly watertight, though a few slight leaks developed. One expansion joint was provided in the roof and the walls at the centre of the building. Careful measurement over two brass plugs set in the roof for this purpose showed a difference of about $\frac{3}{8}$ in. in 300 ft. for a difference in temperature of 34° F.

Fig. 10. South Side—Heat House.
A LARGE FILTRATION PLANT AT ST. LOUIS, U.S.A.

LABOURERS' COTTAGES IN AGRICULTURAL DISTRICTS.

By THOMAS POTTER.

The author of the following article may be considered the doyen of the concrete industry, and any suggestions and recommendations of this well-known authority on the subject claim most careful consideration, though we do not necessarily agree with all the contentions put forward.

There can be no doubt that the question of economical cottage building is one of the great post-war problems, and that the use of concrete, if suitably applied, should materially assist in the solution of the problem.

Apart from any other advantages, as far as post-war work and economy are concerned, it should always be borne in mind that the use of concrete means a great economy in transportation, the ready use of local materials, and the ready employment of much unskilled labour.

THE Chancellor of the Exchequer stated in the House of Commons lately, in reply to a member, that he saw no advantage in appointing a small technical committee to deal with concrete and its uses, in many cases, as a substitute for wood and other materials. In view of the large number of houses that will be wanted after the war for the working classes this is unfortunate. The use of concrete in country districts for cottages and other purposes has not been developed to anything like the extent that was at one time anticipated.

The objections that prevail against the employment of new materials in place of those which have been in use from time immemorial are not so much doubts of efficiency as prejudice against anything new and misgivings as to their durability.

Although the majority of new houses will be required in town or urban areas, and bricks will be used principally for these, there will be many thousands of others required in rural and agricultural districts, and for these concrete should, to some extent, be used in place of bricks. Timber will be a prohibitive price for a considerable period after the proclamation of peace, and transport rate by rail and road will be very high.

On the other hand, suitable aggregates for concrete can be obtained almost anywhere within reasonable distance, and at a small cost, and cement is not likely to be much higher in price than at present.

Flat roofs of concrete can be made watertight at a less cost than tiled or slated roofs, and would be more durable. It would be a misfortune to lose the picturesque appearance in country districts of tiled roofs; but tiles will always be used to a certain extent.

The nature of the work in country districts and the purposes for which concrete is suitable are far more numerous than in large towns, and are of quite a different character.

For the latter it is limited to a great extent to suspended floors, columns, beams, occasionally roofs, and as a core or backing to steel-framed construction.

In country districts, however, besides being useful for cottage construction, it is invaluable for farm buildings, water tanks, pavings, fence posts, water troughs, cattle mangers, and many other things for which wood is unsuitable and brick and stone are too costly.

For purposes of this description it is largely employed in the United States, where the Government fosters its use by issuing pamphlets broadcast, giving full particulars and instructions regarding the purposes for which it is adapted.

In this country the Government takes no interest apparently in the subject except so far as munition factories are concerned.

A wrong impression prevails as to the necessity of having skilled workmen for concrete work, but this is not so.

The more intelligent agricultural labourers are superior in every way to ordinary town labourers. They are not so obsessed with the idea that their method of doing things is the proper way, and they are more willing to follow instructions than the average town labourer, and I write this after many years' experience in various parts of the country where agricultural labour only was employed. An extra sixpence a day above their usual wages appears to give them an interest in their work and a desire to do their best.

If work of this kind were more common in country districts it would be an inducement to keep returned soldiers from the war to their native villages, and possibly to remain there, where they will be greatly needed for agricultural pursuits.

The erection of cottages and other buildings, as well as much other work for which concrete is well adapted in agricultural neighbourhoods, is not a business which can be advantageously carried on by large builders or by companies formed for the purpose.

Villages and cottages are too scattered, often miles away from any station or town of importance, and other difficulties exist which are best known to those who have experienced them, but in every small town and village of considerable size there are builders in a small or moderate way of business who are capable of undertaking work of this character, if means existed for affording them some information and personal instructions at the commencement, and some authority to whom they could refer in case of further knowledge being necessary.

This is practised in America to a considerable extent, but here it is no one's business, and the builder can only rely upon what he has heard or been told or acquired from one or other of the numerous treatises on concrete, which consist mainly of matter devoted to reinforcing steel construction and other details of little use for country work of a simple character.

The aggregates for walls permitted by the London County Council are limited, and do not include many that are available in most country districts or obtainable within a reasonable distance at a cheap rate, such as coke breeze, ashes from locomotive or other boilers, river and pit gravel if clean or washed to eliminate the clayey particles, pottery and brick yard *débris*, slag, and other products.

Besides the suitability of the nearest available aggregate, there are other points that require discrimination, as, for instance, whether slab-block or monolithic construction is the more suitable; an aggregate that is adapted for one is not always the right for the others—the method and cost of the wood shuttering or forms if monolithic construction is adopted; whether to use a raft foundation to effect a saving in cost, and as a still further saving, whether to form the floor if cemented, of tiles, or boards nailed thereto.

Although the aggregates named are condemned by many authorities, ample evidence as to whether buildings erected therewith a generation since are in as good condition now as when built would no doubt be forthcoming, so far as the walls are concerned.

No society or authority cares apparently to undertake the responsibility and cost of an enquiry of this kind, but a Government Committee with full power to ascertain the merits and objections to concrete in country districts should be able to deal with it thoroughly and exhaustively.

Reports by authorised competent persons appointed for the purpose of ascertaining the present condition of buildings erected in different parts of the country with one or other of the aggregates named, not less than twenty-five years since, should settle the question of their suitability in a general way. The thickness of the walls, if damp-proof, if coated with cement or rough cast, if free from cracks, and much other information would be desirable and readily ascertained.

A Government pamphlet containing the information obtained by the Committee would lead to more interest being taken in the use of concrete in country districts and to its more extended employment.

The survival of the feudal system under which the labourer is bound to serve the lord of the manor whenever required has resulted in the necessity for supplying him with some kind of a home, and the labourer's cottage is considered as part and parcel of his wages in the shape of a nominal rent. Until this system is changed for one on commercial lines, in which the wages are sufficient to enable workmen to pay an economic rent, the cottage question will remain a difficult one to deal with. Whether the profits arising from the cultivation of the land will in normal times permit of this increase in wages is a question for the future, and does not solve the present difficulty of the shortage of labour caused by the want of habitable cottages. The war has brought home to us the danger of relying on foreign help for our food to so large an extent that this want has become a national problem.

I have outlined how the Government could aid the erection of cottages and the use of concrete generally in agricultural districts, and the advantages that would accrue therefrom. If, however, it became its own builder, an economic rent would be out of the question.

Owners or a combination of owners of land or property in local centres to whom advances were made on cottages of 80 to 90 per cent. of their prime cost, exclusive of the value of the land, at a low rate of interest and a long period of redemption, should meet the difficulty.

RECENT BRITISH PATENTS RELATING TO CONCRETE.

We propose to present at intervals particulars of British Patents issued in connection with concrete and reinforced concrete. The last article appeared in our issue of April, 1917.—ED.

Concrete Cottages, etc.—*No.* 104526. *H. Jackson,* 39, *Newhall Street, Birmingham. Dated March* 1/16.—In accordance with this invention the walls of cottages and other buildings are formed of concrete slabs, the length of which greatly exceeds the breadth, the slabs being arranged in rows, and alternate rows having their long sides

Fig 1

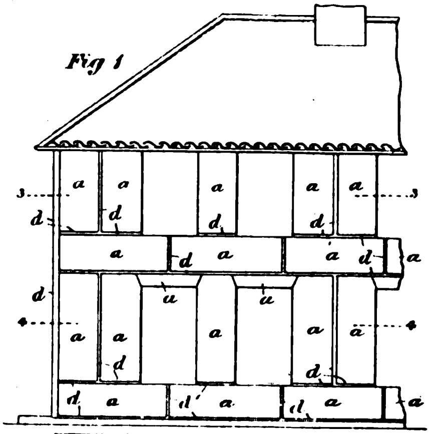


Fig. 6.

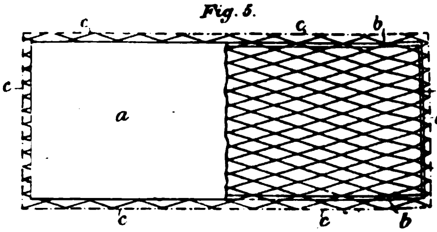


Fig. 15.

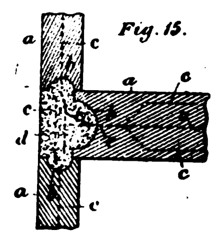


Fig. 17.

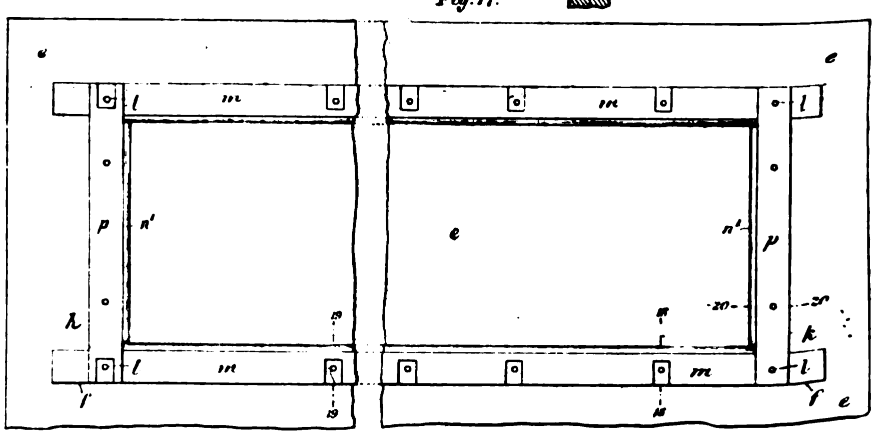


Fig. 19.

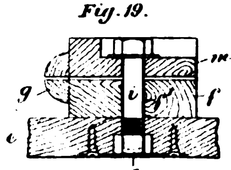


Fig. 18.

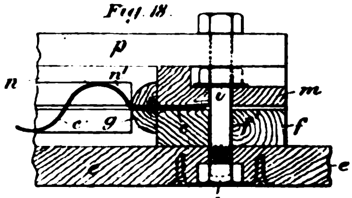
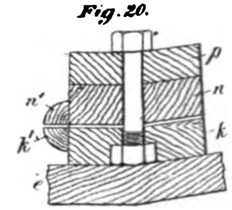


Fig. 20.



at right angles to those in the rows above and below. The slabs have continuous grooves in their contacting edges, and are temporarily supported by timber form-work, the spaces being then filled with cement grout.

The slabs *a*, *Fig.* 5, are preferably reinforced with corrugated expanded metal, the metal projecting on all sides, as shown, to about 1½ in. These projecting edges may overlap at the joints, as indicated in *Fig.* 15.

The moulds in which the slabs are made are formed in halves, *Figs.* 17-20; the lower half comprises a base board *e*, having parallel longitudinal battens, *f*, about one and a half times the thickness of the slab, fixed to it. Fillets *g*, to form the grooves, are fixed to the upper edges of the battens *f*. A number of nuts *h* are secured to the underside of the board to receive bolts *i*. The length of the slabs is determined by pairs of cross-bars *k*, *n*, each pair being carried by an upper bar *p*. The corrugated sheets *c* are secured by upper bars *m*, *n*, which are clamped in position by the bolts.

Reinforcing Timber Receptacles.—*No.* 104017. *W. R. Jones, 2, Wentworth Studios, Chelsea, and E. O. Williams, 22, Albert Mansions, Albert Bridge Road, S.W. Dated February* 15/16.—In accordance with this invention, timber vessels, tanks, tuns, bins, silos, etc., are strengthened by the addition of a reinforced lining of cement and sand. An old or new timber vessel is provided with reinforcement consisting of metal rods, wire mesh, or expanded metal, fixed at a suitable distance from the surface by clips, screws, nails, etc. A coating of cement and sand is applied to the reinforcement by plastering or by a cement gun, and additional coatings of cement and sand, with or without reinforcement, may be added. Waterproofing or acid-resisting composition may be mixed with the cement and sand, and a waterproofing or acid-resisting enamel may be subsequently applied.

Reinforced Concrete Tanks, Silos, etc.—*No.* 17719/15. *W. R. Jones and E. O. Williams, addresses as above. Accepted December* 18/16.—This invention deals with the construction of tanks, bins, silos, etc., from pre-cast reinforced concrete units, and is characterised by the employment of vertical units, each of which has an enlarged integral base; these units may be combined with horizontal ones, and the various units are held together by means of tie-rods, preferably interlacing with members cast in the units.

Special units of L, T, or cross section are employed at corners, and the line of intersection of the walls contains a reinforcing rod, to which the slab reinforcement

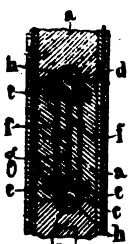


Fig. 2.

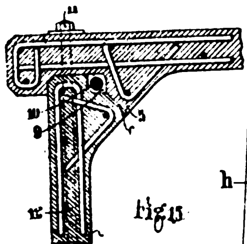


Fig. 3.

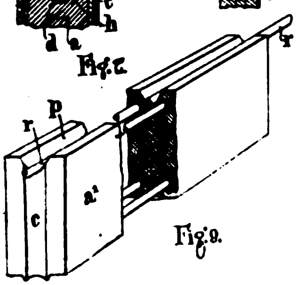


Fig. 9.

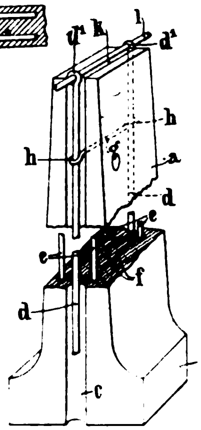


Fig. 4

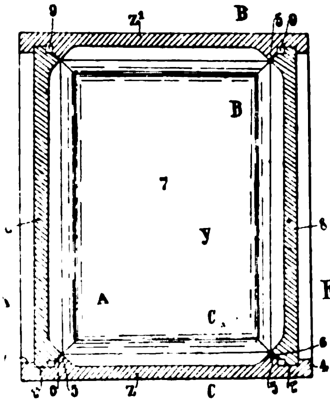


Fig. 13.

is attached. When the surfaces of the walls require covering with mortar, reinforcing wires project from the wall and are interlocked with meshwork *x*, to which the rendering is fixed.

Each vertical unit *a*, *Figs.* 2, 4, has an enlarged base *b*, and a number of such units are placed side by side, the grooves *c* serving to form a hole in which bars *d* are placed, which pass through stirrups *g* cast in the units; the holes are subsequently filled by grouting. Each unit is strengthened by rods *e* and stirrups *f*, and a groove *k* is provided at the top of each unit to accommodate a reinforcing bar *l*, over which the bars *d* are bent. The base of the tank, etc., may be formed of precast reinforced concrete slabs, and when the receptacle is to be roofed in, the vertical units are widened towards their tops to form ledges upon which the roof slabs are placed, the whole being made monolithic by grouting. Horizontal units a^1 of the form shown in *Fig.* 9, may extend between vertical corner ones; they are provided with grooves *p*, in which reinforcing bars *r* are placed.

A reinforced concrete receptacle may be constructed in accordance with the invention with sides and ends each comprising a single reinforced slab 8, *Figs.* 13, 15, grooved at their sides and ends; the base *z* and cover z^1 are each formed of a single slab, moulded so as to present a thickened edge all round and to fit in with the sides as shown. The box is stiffened by rods 10 in the cavities 9, and bolts 12 are provided to enable the receptacle to be opened at the side or bottom.

Waterproofing Compositions.—*No.* 104087. *F. S. Plant, Deeping St. James, Lincolnshire. Dated May* 4/16.—A waterproofing composition for cement or concrete is composed, in accordance with this invention, of 2 oz. each of Russian tallow, mutton fat, and lampblack, 4 oz. of shellac spirit varnish, and 2 lb. of whiting mixed with water.

Beam Stirrups.—*No.* 104551. *J. B. Griffith, "Strathmore," Bramhall Lane, Stockport. Dated March* 14/16.—The stirrup *a* for reinforced concrete beams constucted in accordance with this invention is formed at its looped end with two coils *b*, which are disposed at an angle to each other. The coils are preferably formed

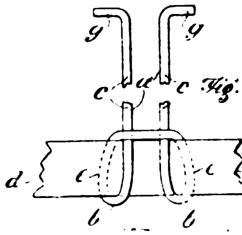


Fig. 1.

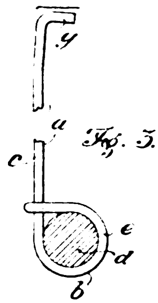


Fig. 3.

by passing the free ends of the limbs *c* of the stirrup through its looped end, and are of only very slightly larger diameter than that of the main reinforcing bar *d*, so that it is necessary to press the divergent parts *e* of the coils towards each other until they are parallel in order to place them on the bar. The tension on the bars *c* in use increases the grip on the bar.

Concrete Mixers.—*No.* 104628. *L. R. Ferguson, 218, East Sedgwick Street, Philadelphia, U.S.A., and R. J. Wig, and W. A. McIntyre. Dated August* 1/16.—The leading feature of this invention is that controlling means are provided which lock the discharging device when the mixer is charged, so that a predetermined number of mixing operations must be carried out before the mixer can be emptied.

A charging hopper D is attached to a shaft *d*, by which it is hinged to one side of the frame and is adapted when raised to discharge the materials into the mixing drum A. A discharge chute E is hinged on a shaft F on the opposite side, and is held in the inoperative position shown in full lines in *Fig.* 1 when the drum is rotated.

A longitudinally movable bar 1 is moved by a cam 2, when the charging hopper D is raised, to engage a cam 3 connected by a link 3*c* to a crank arm of the shaft F on which the discharge chute is mounted, thereby locking the latter in the position shown. When the charging hopper is lowered, the cam 2 is returned to normal position, but the cam 3 remains locked until the bar 1 is automatically retracted after a certain number of revolutions of the mixer. The bar 1 carries a rack 1*a* engaging a pinion 4*a*, adapted to be clutched to a splinted shaft 4; this shaft carries a worm wheel 4*c*, meshing with a worm 6, which carries tappets 6*b*, adapted to be engaged by projections 6*e* on the drum, which will thus cause the bar 1 to be retracted if the clutch is in gear.

The clutch 6*c*, *Fig.* 4, is operated by a bell-crank lever 7, the outer arm 7*b* of which is adapted to be engaged by a dog 8*a* pivoted on a sliding rod 8*b* operated

Fig. 1.

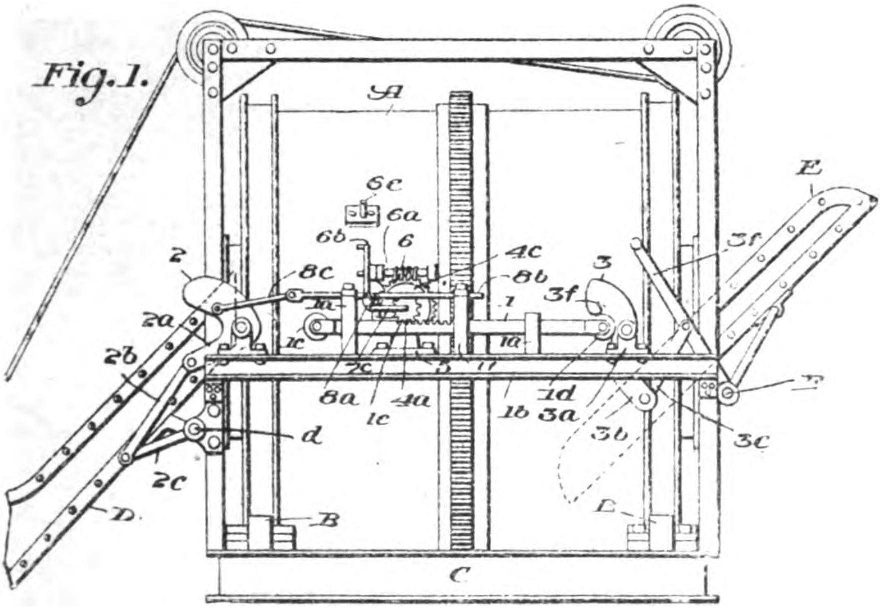
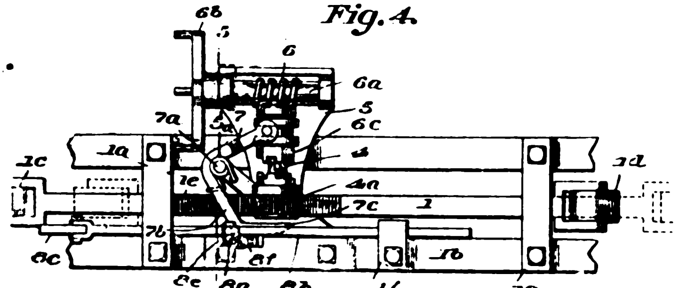


Fig. 4.

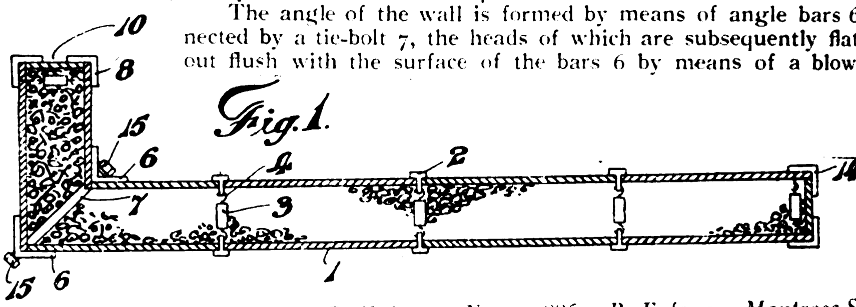


from the cam 2, so that the clutch is held out of action while the arm 1 is being moved to the right to lock the cam 3, whereupon the clutch lever is released and the clutch is closed by a spring 5*b*, ready to move the bar 1 back in accordance with the drive through the tappets 6*b*. The parts are so proportioned that after the requisite number of revolutions of the mixing drum the bar 1 will have been moved back far enough for the roller 1*d* to have cleared the bight in the cam 3, and thus allow the discharge chute to be lowered.

Concrete Buildings.—*No.* 105008. *W. A. Laming*, 348, *Matthenesserlaan, Rotterdam, Holland. Dated July* 25/16.—According to this invention the outer and inner surfaces of walls, partitions, floors, and other parts of buildings are formed of asbestos cement sheeting, the two layers being held together by a framework of rolled steel sections and the space between them being filled with cement or concrete.

The asbestos cement sheeting is preferably in slabs about 6 ft. by 3 ft., and the steel bars 2 of T or I section are retained in position by distance pieces 3, preferably of tubular form, and provided with hooks 4.

The angle of the wall is formed by means of angle bars 6 connected by a tie-bolt 7, the heads of which are subsequently flattened out flush with the surface of the bars 6 by means of a blow-pipe.

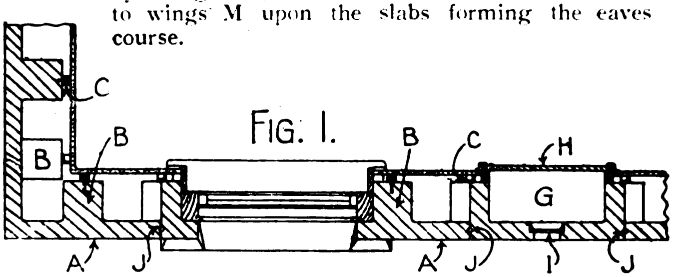


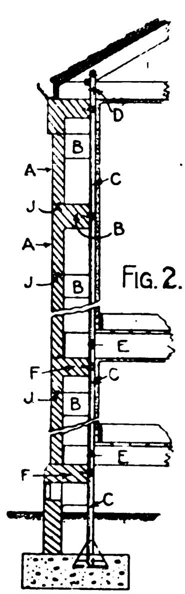
Wall Slabs for Concrete Buildings.—*No.* 103886. *P. Fyfe,* 23, *Montrose Street, Glasgow. Dated February* 28/16.—The walls of concrete buildings are constructed, in accordance with this invention, of slabs A having projections B formed on their inner faces so that the usual covering materials H to constitute inside walls can be attached directly to the projections so as to provide hollow spaces of considerable size between the inner and outer walls.

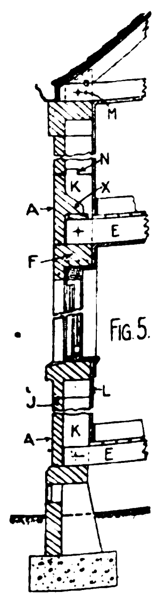
The projections may be extended in depth where required to give cupboard space in the rooms.

In the construction shown in *Figs.* 1, 2 angle bars are bolted to the projections B and to the roof truss D. The flooring joists E rest upon a lintel course F, each joist being embedded in the projection and bolted to the angle bars. Half-circular grooves J are formed around each slab, which, when grouted, serve to key the slabs together.

In a modified construction, *Fig.* 5, the slabs A are provided with narrow projections K to the inner edges of which lathing is secured. The joists E are secured by bolts to these projections by wedges X, and the roof timbers are bolted to wings M upon the slabs forming the eaves course.

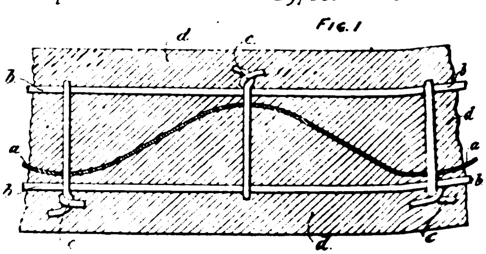


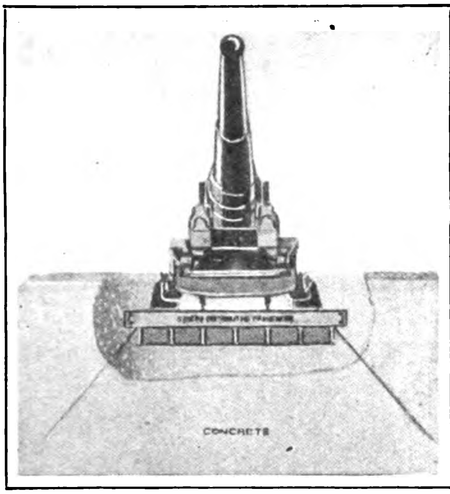




Corrugated Reinforcement.—*No.* 18108/15. *F. M. Du-Plat-Taylor, Tilbury Gardens, Tilbury, Essex. Accepted December* 29/16. — According to this invention, corrugated sheet metal is reinforced by wires or rods stretched longitudinally on both sides in a direction at right angles to the corrugations, the wires or rods being secured together in pairs.

The wires or rods *b* are arranged as shown, and are held in place by transverse clips *c* which pass through the corrugated metal.





CONCRETE GUN BASES.

The following is an article which appeared in "Engineering News-Record" on the subject of concrete for gun bases.—ED.

HEAVY artillery fired from railway cars, already successful in Europe, may be utilised, according to plans submitted to the War Department, at a total cost considerably below the expense of building a single battleship. The application of such guns to coast defence, where moving targets that must be fired at through a considerable angular range are involved, presents a different problem from the use of cars of this kind in land attack. This problem is thought to be best solved by locking car and gun into a concrete emplacement of sufficient size to absorb the recoil of the gun when fired from any angle with the axis of the car. Other schemes proposed for using these guns, such as pointing them in azimuth by moving them around a circular track, have raised civil-engineering questions as to the relative speed and economy of construction necessary for the different systems proposed and the allied surveying problem of range finding with the two types of emplacement.

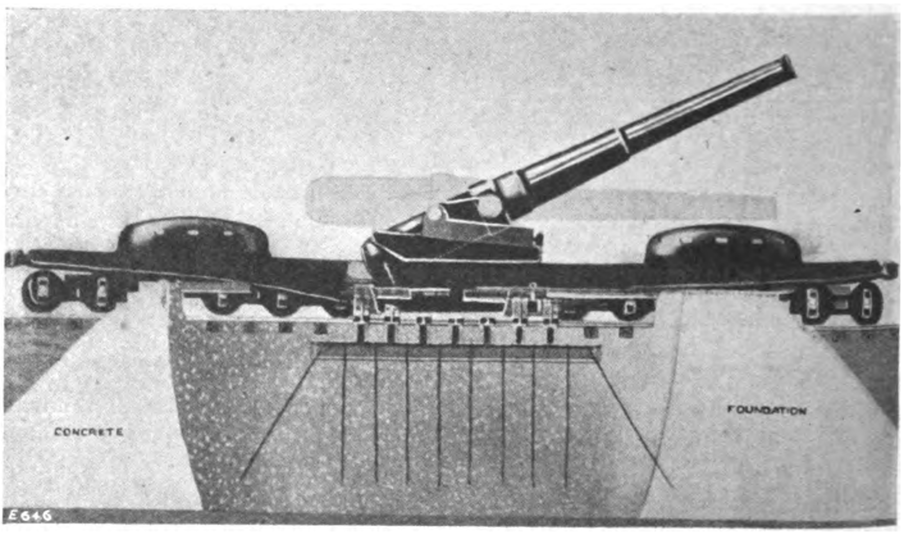
SCHEME SUGGESTED TWO YEARS AGO.

Firing heavy coast-defence guns from railway cars was first suggested to the War Department by L. W. Luellen and C. F. Dawson, New York manufacturers, who were subsequently allowed claims for patents covering the invention of car-mounted guns to be fired from concrete emplacements or to be fired in line with the car and allowed to recoil on additional supports along the track. Since then, guns of 12-in., 14-in. and even 16-in. calibre, mostly designed according to the latter plan, have been successfully developed and put into service by France in the European War. As at first used abroad, large guns mounted on railway cars took up the recoil by sliding along the track, heavy brake shoes, engaging extra I-beam rails of special section laid outside the regular rails, being employed for this purpose. It is stated that with this arrangement the gun cannot be turned at any appreciable angle with the long axis of the car in firing.

It has already been found, however, that even with guns as small as 6 in. no outriggers or other arrangements short of a permanent foundation can be devised to prevent the recoil, when firing broadside to the car, from disturbing the position of the entire mounting and seriously affecting the accuracy of the fire. The large guns mounted to recoil along the track, therefore, are fired from a circular section of track, which permits their being aimed within a given sector by moving the car along the track. Since the targets at which these guns fire in land operations are fixed, the range-finding problem is greatly simplified and there is plenty of time in which to set the car and lay the gun. It is reported, however, that a very well constructed and well ballasted track on firm ground is required for such a mounting.

FIXED EMPLACEMENTS CHEAPER THAN TRACKS.

It appears that for firing a 12-in. gun so mounted through a sector of approximately 180 deg., which would be necessary in coast-defence work,



SHOWING GUN (14 IN.) MOUNTED ON CONCRETE FOUNDATION.

some 1,500 ft. of track on a radius of about 1,000 ft. would be needed. Such track, including plain grading and ballast, which would be essential, and including the extra rail section, which is about equivalent to a 10-in. I-beam, might cost about $10 per ft., if laid with 90-lb. rail according to American standards. Moreover, curves on existing railways could not be utilised, because the super-elevation would interfere with aiming the gun. A concrete emplacement sufficient to take up the recoil from a 12-in. gun under ordinary soil conditions would be roughly 22 ft. by 64 ft. in plan, contain about 450 c. yd. of concrete and approximately 4 or 5 tons of anchor bolts and I-beam reinforcements. Such emplacements would cost to build, it is estimated, from $5,000 to $12,000, depending on the location and other variable factors. Because of the far greater speed in firing, it is estimated that a gun mounted on such an emplacement would be as effective as several such guns fired from circular tracks, disregarding the greater accuracy of fire to be attained from an emplacement.

From motion pictures of railway artillery which have reached this country, it is apparent that the car guns allowed to recoil along the track take several minutes between shots, owing to the necessity for moving the car after each shot, uncoupling and taking away the supply cars and removing the gun crew entirely from the car when the piece is fired, which is apparently required by the uncertainty as to the stability of the mount and by the severe shocks produced.

It has been argued that circular tracks for firing railway-mounted guns could be constructed at numerous level locations on our coast in a very short time in emergency. Those who do not agree with this contention, however, point out that a first-class roadbed cannot be built in this way and that a temporary track thrown down on the ground could not be used to support heavy artillery during firing. Furthermore, while many locations would favour hasty construction, a larger part of our coast line would require very heavy grading to put in such tracks at the required points. It would appear, according to these arguments, that since advance construction of some sort would be required in any case, the emplacements, being cheaper than circular track, would be preferable.

RANGE FINDING AND FIRE CONTROL.

There are other reasons, however, why the emplacement mount is preferred by coast-artillery officers who have studied the problem. Artillery officers of the former Department of the East have worked up a simple method of range finding for car guns locked in concrete emplacements and fired at any angle. By this means the car guns would be made as effective and could be fired as rapidly as guns mounted in permanent emplacements in our coast fortifications.

With the circular track the gun must be moved before it can be aimed. The probable position of the target must be calculated a good many minutes in advance; the position on the circular track for the car, so as to bring the axis of the piece within a few degrees of being in direct line with the target, must be figured; the car must be moved to that location; and then the usual process of determining the range and training the piece begins. Should the target change its course in the meantime, the whole performance must be repeated.

MOBILITY OF BIG GUNS.

While it has already been demonstrated that large guns mounted in this way can be transported over ordinary railroads, it should be mentioned that the estimated weight of the 12-in. coast-defence gun, including its car mount, is about 150 tons, which, with a 56-ft. car on 12 wheels, could be transported practically anywhere in the eastern section of the country. The 14-in. gun so mounted would be considerably heavier, possibly exceeding 200 tons, and would require four 6-wheel trucks.

Plans for such coast-defence guns have been under consideration by the Ordnance Department of the United States Army. They have been developed so far by L. W. Luellen and Cecil F. Dawson, with the assistance of United States Army officers and of a number of civilian engineers who have developed solutions to the civil-engineering and construction problems involved.

PORTLAND CEMENT PAINT AS A PROTECTION TO STRUCTURAL STEEL.

As indicated in our last issue, p. 380, we give below fuller particulars of the experiments undertaken relative to Portland cement as a protective covering to steel, and as described some time ago by Mr. Giesecke in "Cement Age."—ED.

THE following article, by Professor Giesecke, brings up an important subject and is accompanied by reports of extremely interesting experiments conducted by him.

The new features brought out by his research are:—

First, the practical application of this knowledge in the painting of steel in order to get temporary protection for all the steel and permanent protection for those parts which, by chance or bad workmanship, will not come in contact with the concrete.

Second, the discovery that this cement coating, in addition to its protective influence, also materially increases the adhesion between the steel and the concrete, and possibly also affording better fire protection for the steel.

In regard to protective coatings for structural steel, it may be said that in the case of at least one of the leading bridge companies no special theories are entertained, nor have they any specifications from architects and engineers used by a sufficient number to justify them in assuming that any one method has points of superiority over another. In the subway construction in New York City the engineers insisted that all steel embedded in concrete should not be painted, regarding a slight coating of rust as not detrimental. On the other hand, some engineers insist that metal shall be entirely free from rust and mill scale. Various pigments are also employed, according to the views of architects and engineers. The galvanising of metal is also adopted in some instances, as in the foundation material for the Prudential Life Building in Newark. Therefore the experiments recorded below will be noted with interest.

Structural steel enters very largely into the construction of modern buildings, and frequently to such an extent that the life of the building depends upon the life of the steel. It is, therefore, of the utmost importance to design and erect the steel so that its strength will never be impaired. To do this it is necessary to protect the steel against rusting.

It is generally conceded that steel embedded in neat cement or in dense concrete will not rust. It does not matter if the aggregate employed in making the concrete is gravel or cinders, so long as the concrete is free from voids and is applied in a liquid form to the steel, so as to come into actual contact with the steel and form a cement coating over its surface. In reinforced concrete construction, where small bars or rods are used, it is comparatively easy to cover the same perfectly with concrete, but when large beams are to be covered it is much more difficult, partly because it is difficult to make the concrete run so as to fill all cavities between the forms and the steel, and partly because the larger beams are exposed to the weather for a considerable time before the concrete can be poured, and are, therefore, apt to be partially covered with scales of rust, which prevents a contact between the concrete and the steel, and which may act as carriers for carbon dioxide and moisture, thus producing a continuation of the rusting process under the concrete coating. The accompanying figure shows cavities which are very apt to occur when concrete is poured around structural steel, even when the concrete is tamped as well as can be done.

It seems, therefore, very desirable to thoroughly coat the structural steel before it has begun to rust with some material which prevents rusting, and which has no injurious effect on the adhesion between the concrete and the steel.

To determine the effects of different coatings the following tests were made :—

Sixteen steel rods, $\frac{3}{8}$ in. in diameter and about 18 in. long, were selected. Four were painted with red lead, four with boiled linseed oil, and four with neat Portland cement, while the remaining four were not treated in any way. The painted rods were allowed to dry in the shade for one week, and then all rods were embedded, 5 in. deep, in concrete composed of one part Portland cement and three parts of sand. Two different kinds of Portland cement were used for these tests, but both were of good quality. The sand was clean and had been screened through a 20-mesh sieve and retained by a 30-mesh sieve. Each rod was placed in a cylindrical tin can, so that one end projected about 1 in. through a hole in the centre of the bottom, and so that the rod formed the axis of the can. The cans were then filled with concrete and stored in a shaded place, where the concrete was allowed to set.

When the concrete was one week old one half of the specimens were tested in an Olsen testing machine by pulling the steel rods out of the concrete. The adhesion found is tabulated below, expressed in pounds per square inch :—

Oil-coated rod	34
Red lead-coated rod	68
Uncoated rod	136
Cement-coated rod	170

The remaining specimens were tested when the concrete was nine weeks old, the following adhesion being found :—

Red lead-coated rod	38
Oil-coated rod	72
Uncoated rod	170
Cement-coated rod	465

It appeared from these tests that the adhesion between steel and concrete was materially increased by coating the steel with neat cement. However, the difference shown in the last tests between the uncoated and the cement-coated seemed too great. The concrete was, therefore, broken open and it was found that the uncoated rod did not have a good contact with the concrete, and that, therefore, the result obtained (170 lb.) is incorrect; but that the cement-coated rod was normal in every respect, and the result obtained (465 lb.) very probably correct.

The tests of the first four specimens had already shown that a coating of oil and one of red lead had very injurious effects upon the adhesion between the steel and concrete. In this experiment, however, the red lead paint had been allowed to dry for only one week, and it seemed possible that if it were allowed to dry for a longer period of time before being embedded in concrete better results might be obtained.

A second experiment was, therefore, commenced to determine:—

First, if, in the case of red lead, the adhesion could be increased by allowing a longer period of time for drying.

Second, if, in the case of neat cement, an injurious effect would result if the cement coating is applied while the steel is exposed to the sun, and if the newly coated specimen is allowed to remain exposed to the weather, as it would be if this method were used in actual building operations.

Accordingly, four rods were painted with red lead and allowed to dry for two months. About six weeks after eight rods were painted with neat cement. Four of these rods were placed in the shade to set and four were exposed to the weather. A week later these twelve rods and four which had not been treated were embedded in concrete, as described above. The red lead paint had been drying for two months and the cement paint had been hardening for one week.

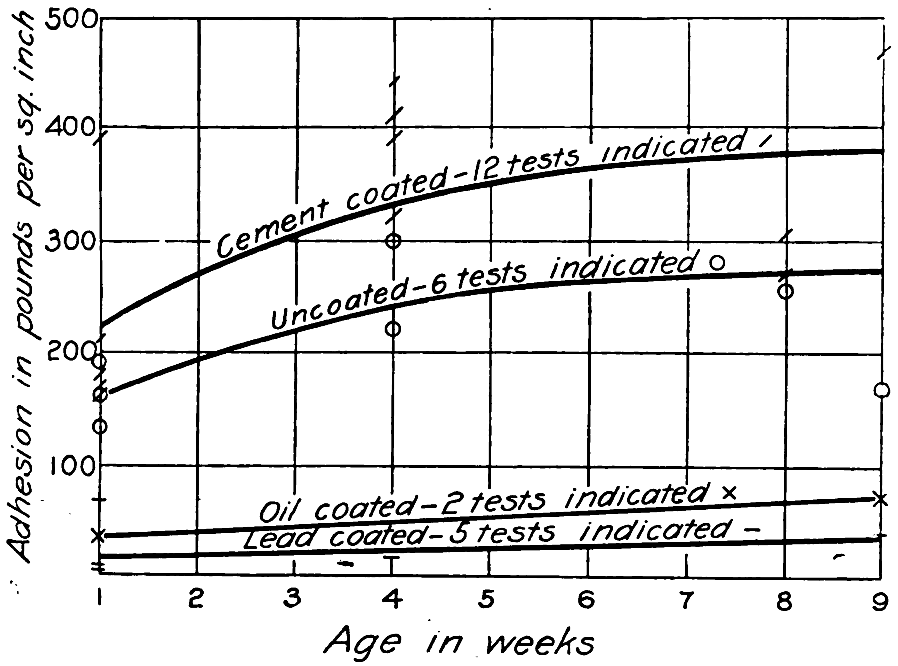
When the concrete was one week old eight of the specimens were tested and the adhesion found as follows:—

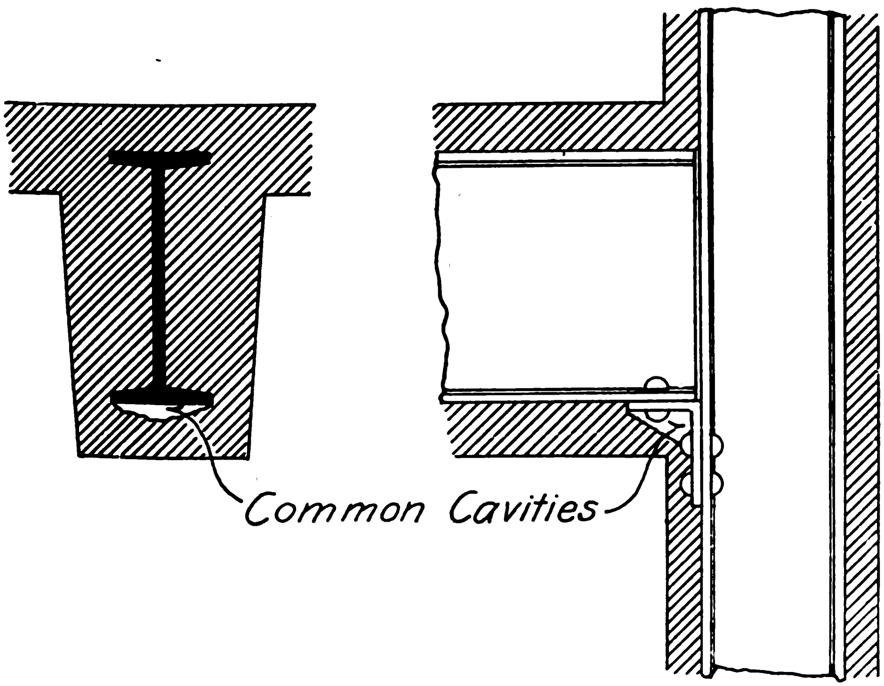
Red lead-coated rod	9 and 4
Uncoated rod	160 and 190
Cement-coated in shade	180 and 210
Cement-coated exposed to weather ...	160 and 390

The great difference between the two last values was probably due to the fact that two different cements were used. In the first case a slow-hardening cement was used and the rod was pulled out by shearing the concrete.

When the concrete was one month old four specimens were tested and the following adhesion found:—

Red lead-coated rod	17
Uncoated rod	220
Cement-coated rod in shade	410
Cement-coated exposed to weather ...	390





COVERING OF STEEL

When the concrete was two months old three specimens were tested and the following adhesions found:—

Uncoated rod	254
Cement-coated rod in shade	272
Cement-coated exposed to weather ...	305

The fourth rod, which had been painted with red lead, was injured, so that it could not be tested.

It follows from the experiments described:—

First, that the adhesion in the case of the red lead coating is not increased by allowing a greater period of time for the drying of the paint.

Second, that the adhesion in the case of cement coating is not affected injuriously by exposing the coated steel to the weather.

During the experiment it was found, however, that the best results can be obtained if the cement coating is moistened repeatedly for several days, either by rain, dew, or by an artificial spray of water. During the first few days the coating can be rubbed off easily, but after that it adheres firmly to the steel.

The results of the experiments are shown on the accompanying diagram accurately by points and approximately by lines which represent average values. If the adhesion between concrete and uncoated steel is taken as a basis, it is evident from the diagram:—

First, that the adhesion is reduced about 90 per cent. by a coating of red lead.

Second, that the adhesion is reduced about 80 per cent. by a coating of linseed oil.

Third, that the adhesion is increased about 35 per cent. by a coating of neat cement.

To determine the cost of applying a coating of cement to structural steel 1 lb. of Portland cement was mixed with ⅝ lb. of water. This quantity was sufficient to cover 70 sq. ft. one coat. Assuming the cost of the labour $3.00 per day, the cost per square is about 16 cents. On a larger scale, when the painting was done by common labourers, the cost was about 29 cents per square. This cost can probably be reduced if the cement is applied by means of a spray instead of with brushes.

Assuming the cost per square, for one coat, 22 cents, the cost per ton for those sizes and shapes commonly used, and which represent average values, would be about 63 cents, a little less than 1 per cent. of the cost of the structural steel erected in the building.

NEW WORKS IN CONCRETE.

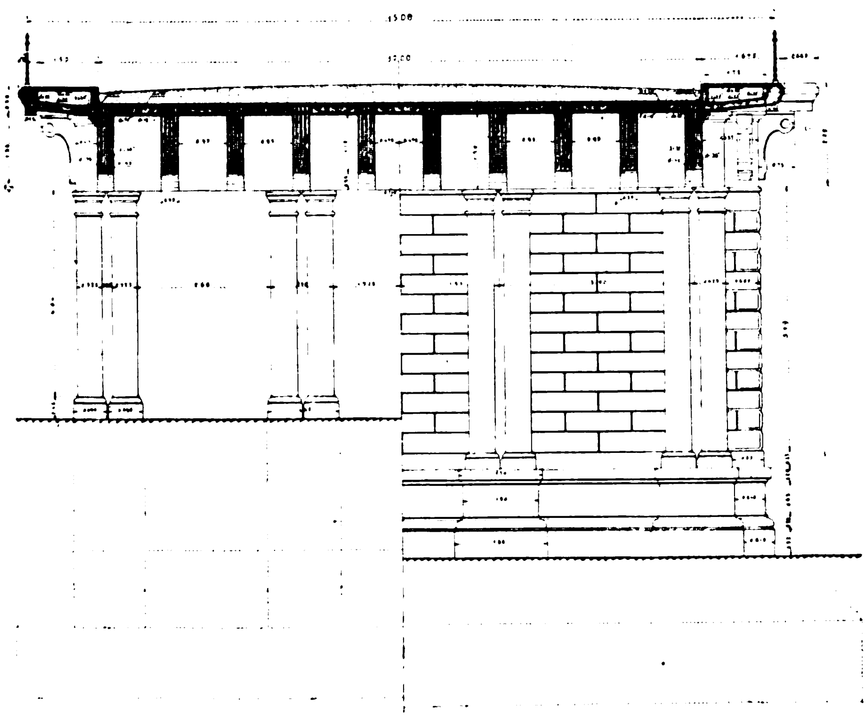
AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

A REINFORCED CONCRETE BRIDGE IN ITALY.
THE TERRALBA BRIDGE.

In the Italian periodical, *Il Cemento*, some interesting particulars and illustrations are given of the above bridge, and the following is a short abstract taken from the magazine in question:—

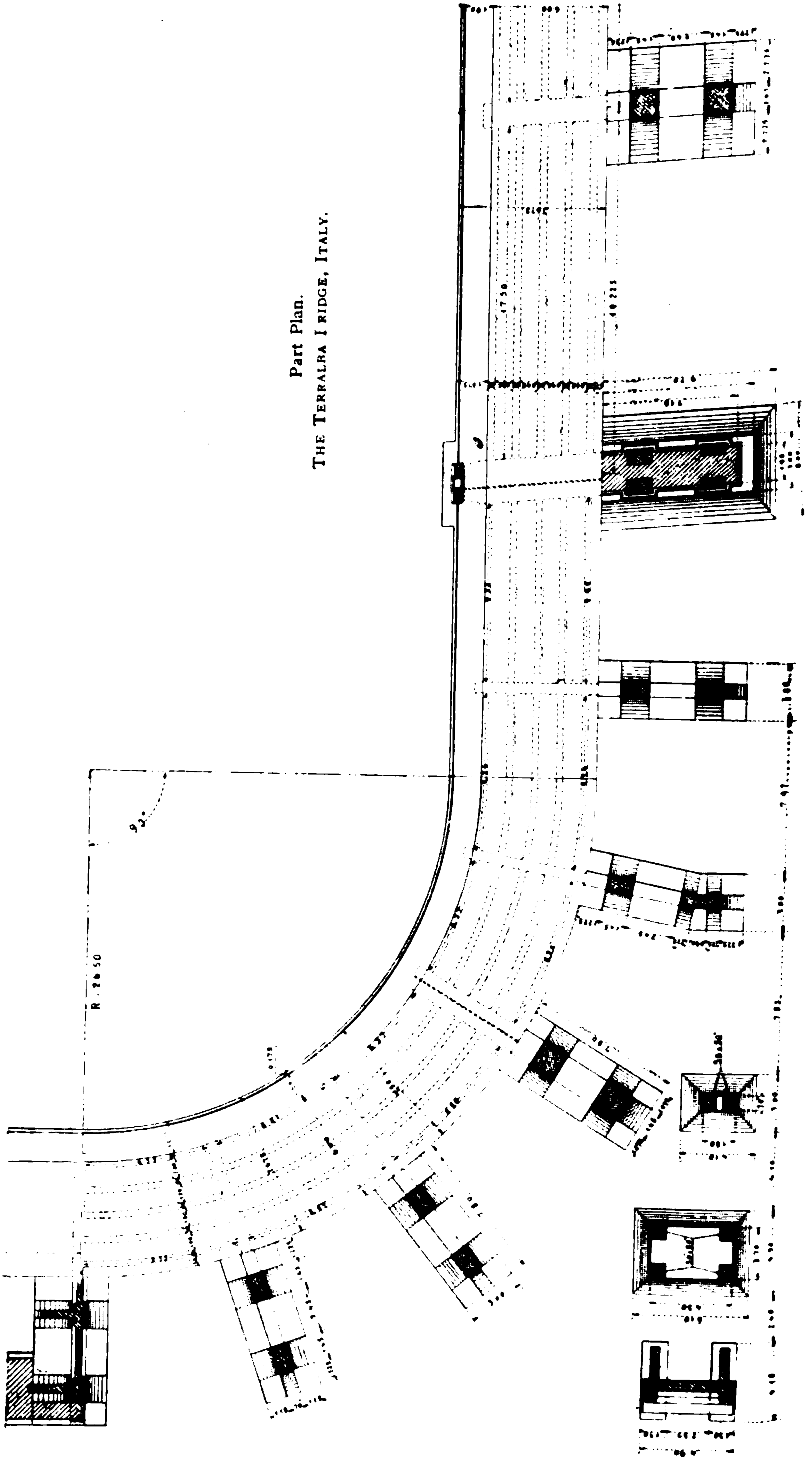
The Terralba Bridge is part of a scheme for the enlargement of the Genova Brignole Station. It replaces about 600 ft. of the Terralba highway connecting



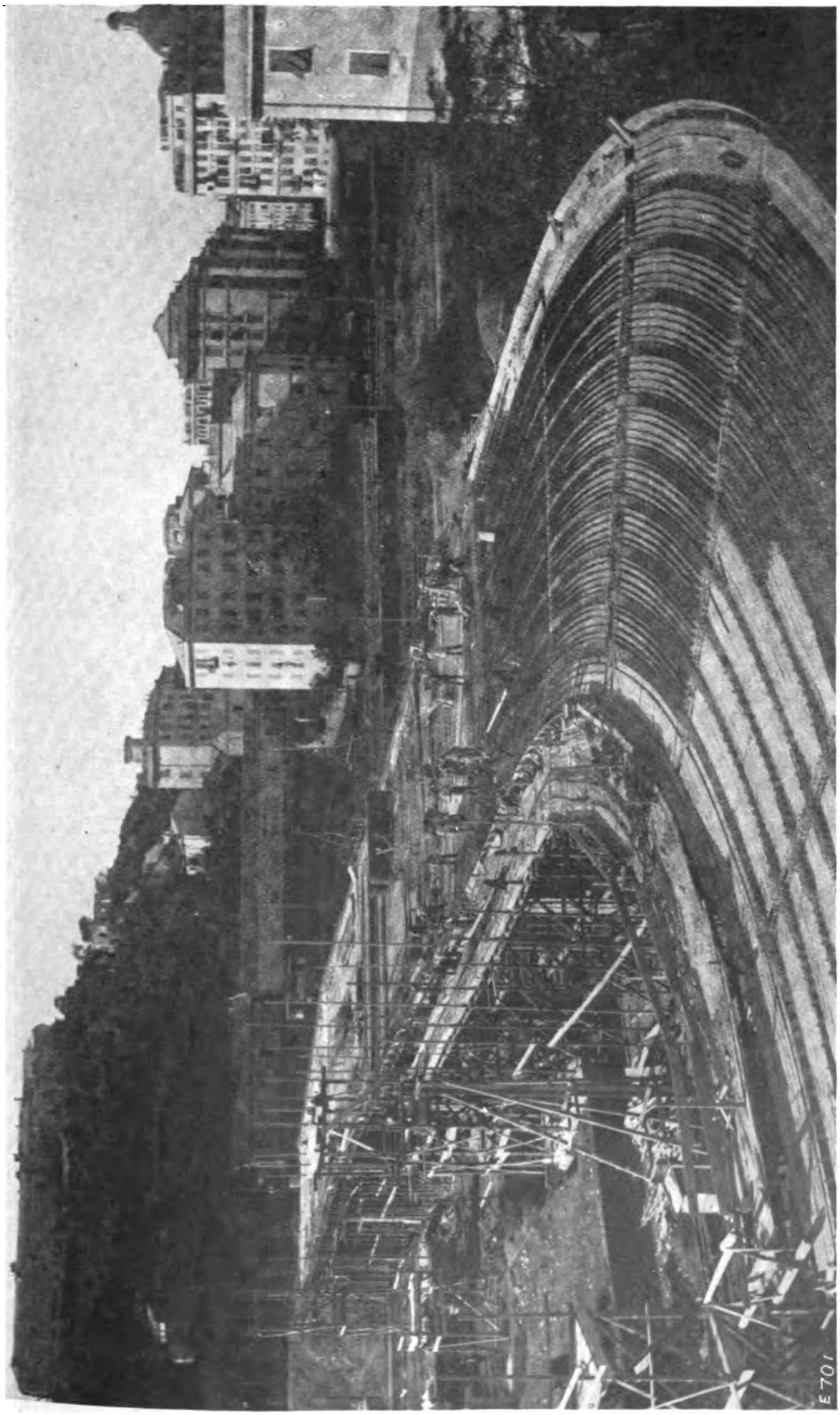
Half Transverse Sections of Two Bays.

THE TERRALBA BRIDGE, ITALY.

St. Martino with St. Fruttuoso. The total length of the bridge is 750 ft.; its width is 45 ft., including two footways each 5 ft. wide. It is constructed of reinforced concrete and has six spans, four of 61 ft. and two of 58 ft., each span being built in three bays. Part of the inclined approach is also built in six spans, each of 35 ft., and with three bays, the remainder of the approach plane is constructed of massed work between supporting walls.

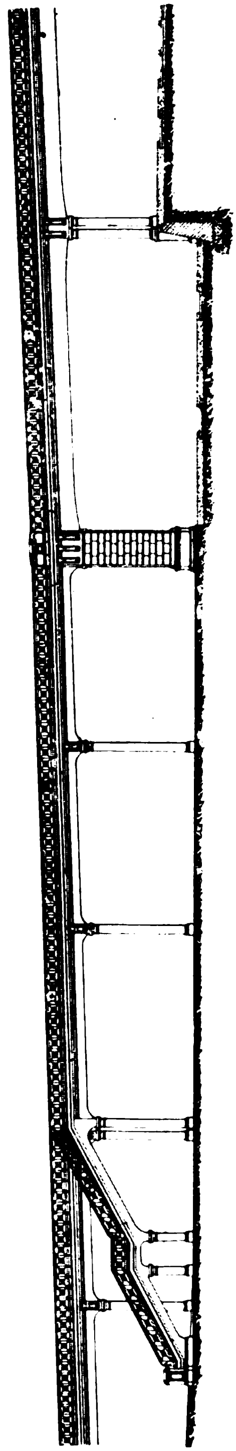


Part Plan.
THE TERRALBA BRIDGE, ITALY.

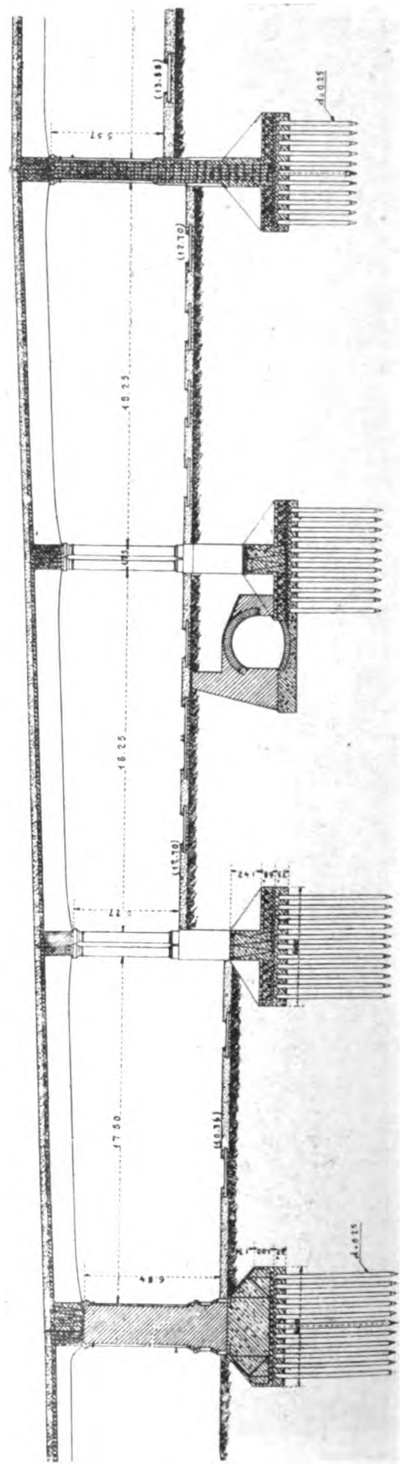


General View showing the Bridge in course of Construction.

THE TERRALBA BRIDGE, ITALY.

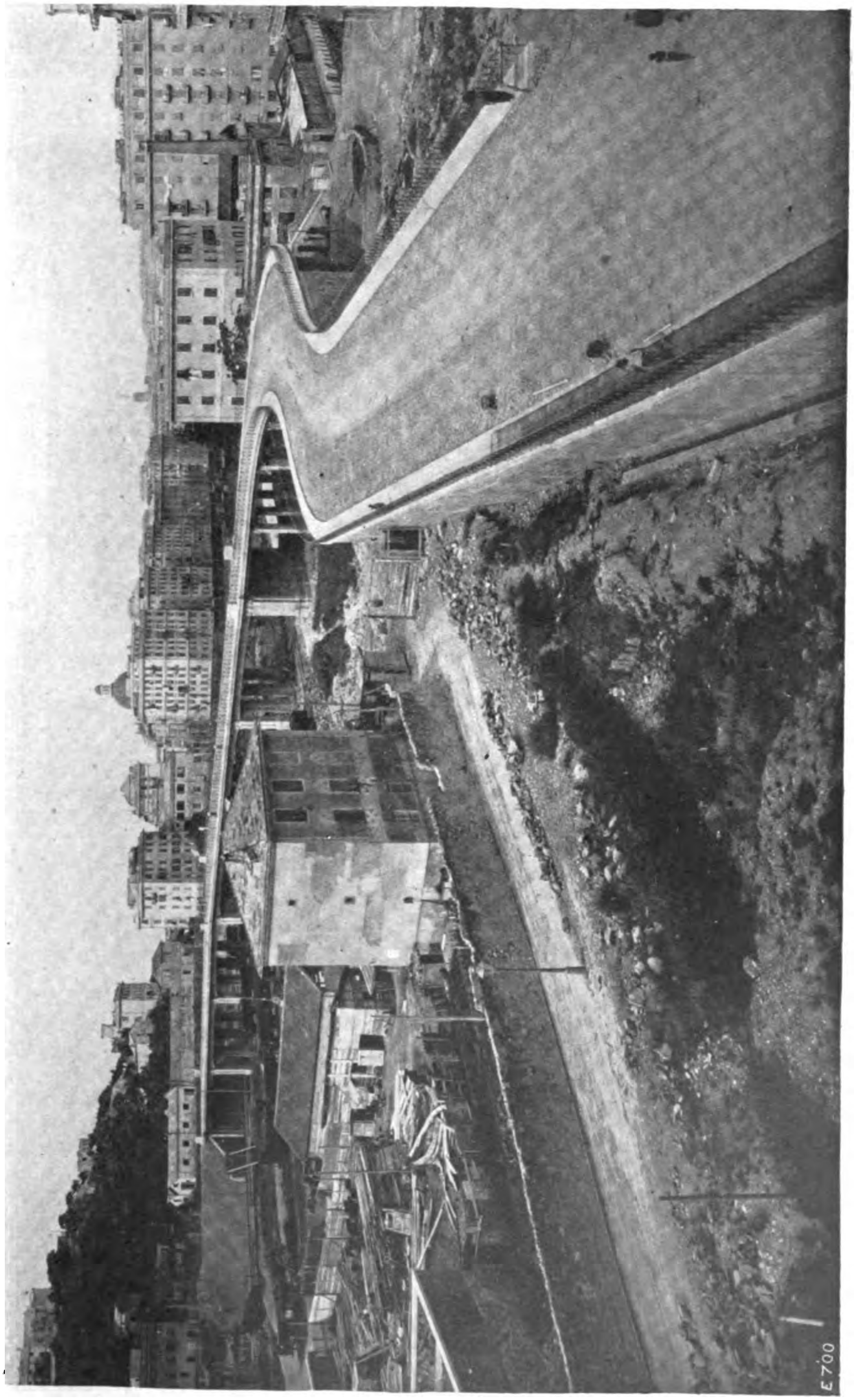


Part Elevation.



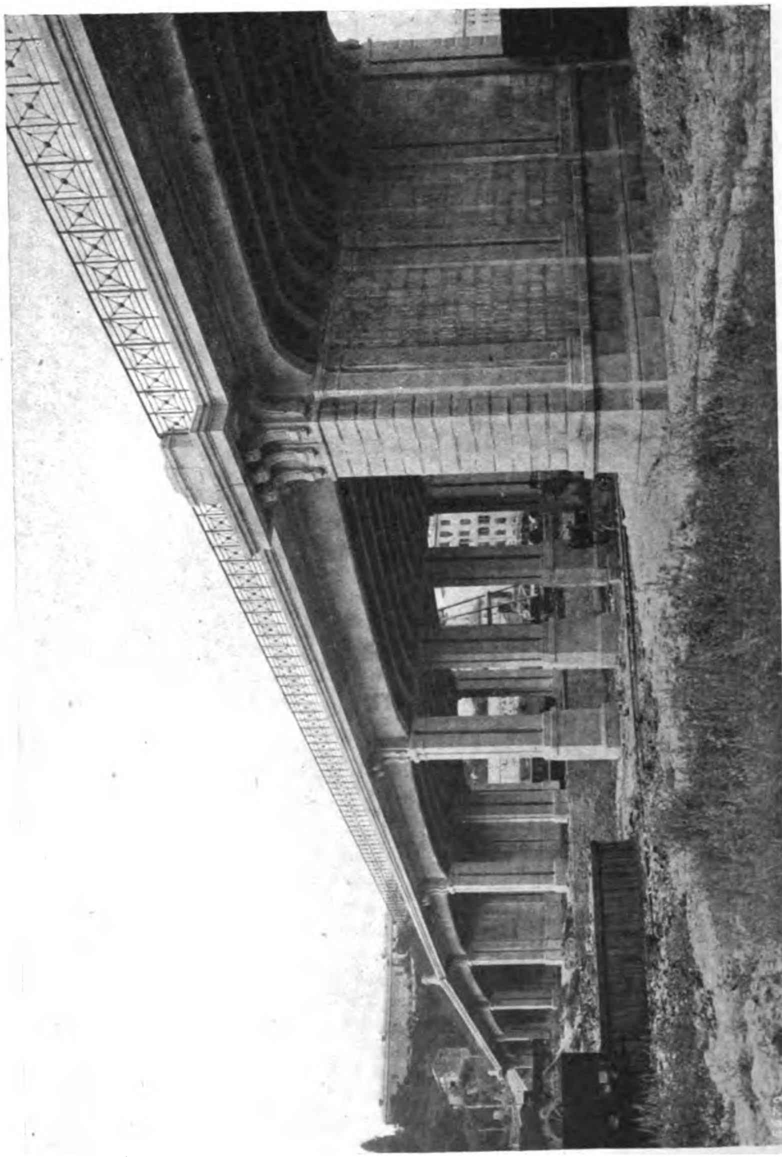
Part Section.

The Terralba Bridge, Italy.



View of finished Bridge.
THE TERRALBA BRIDGE, ITALY

The calculated strength of the structure was based on an accidental load, uniformly distributed, of 290 lb. per sq. ft., corresponding to a moving load of a row of 4-ton vehicles in the most unfavourable position and including the reaction of the wheels of a second row of vehicles near by. In the main truss the maximum positive bending



General View of Complete Bridge.
THE TERRALBA BRIDGE, ITALY.

moment on one bay is calculated at 700,000-ft. lb., the maximum negative at 880,000-ft. lb.

The subsoil consists of a deep bed of soft, marshy clay, which prohibited piling and requires a specially light foundation formed by a concrete raft, the reinforcement of which is carried up into the pillars of the bridge. The volume of the reinforcement of the raft is just under 1 per cent. of that of the concrete. The raft was supported on pine wood piles, each 20 ft. long and 10 in. wide, so spaced that two piles were placed in each sq. yd. of ground. The tops of the piles were covered with a coating of cement so that the raft might adhere to them and form a sound foundation.

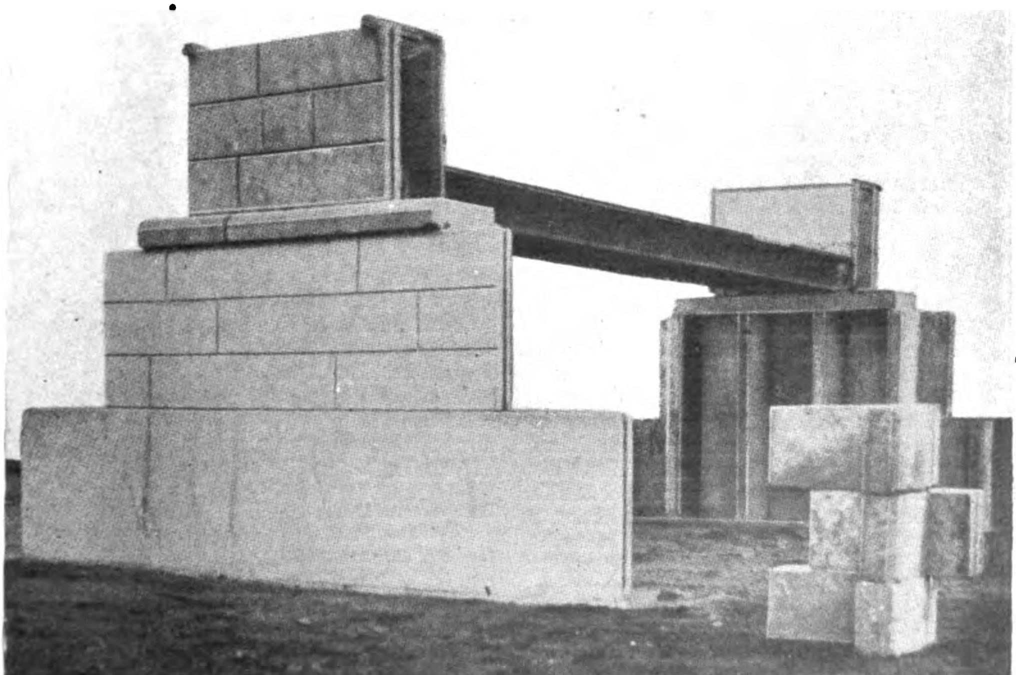
For the superstructure concrete mixers were used, having an output of about 80 c. yd. per day of 10 hours; these were mounted on a service bridge alongside the main structure. A good general view of the bridge is shown on page 461 of this issue.

The total volume of concrete used in the superstructure was 2,200 c. yd., rather more than 290 tons of reinforcement being used, so that the volume-ratio of reinforcement to concrete is 1·8 : 100. The concrete was made by mixing 0·5 c. yd. of sand, 0·8 c. yd. of small gravel, and sufficient cement to make 1 c. yd. when all were mixed together.

The effects of a static load were tested by spreading on top of the bridge a uniformly distributed load of 240 lb. per sq. ft. on the road and 100 lb. per sq. ft. on the footway.

The cost of the whole work was £18,000, which works out at £5 12s. per sq. yd. of concrete, including the foundation, and £3 per sq. yd. of road and footpath.

The work was designed and executed by the "Società Italiana Chini," of Milan.



New Form of Concrete Wall for Dwelling Houses.

(See p. 448 and p. 469.)

NEW BOOKS
AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

Experimental Building Science. Vol. I. By J. Leask Manson.

Cambridge Technical Series, Cambridge University Press, 1917. Price 6/- net.

In the class teaching of such a subject as building, which deals with practical matters without any clear scientific connection, it is always difficult to decide the limits of the course of instruction. The facts to be taught are connected only by their practical application, and a logical development of the subject, such as is possible in the teaching of chemistry or biology, is out of the question. A course of instruction in building has, therefore, a fatal tendency to become scrappy and disconnected. If the teacher could be certain that all his students had received a good grounding in the sciences of mechanics, physics and chemistry, his task would be comparatively easy, as he could then make clear the scientific principles underlying the concrete facts of the subject; but this condition is notoriously unfulfilled in the ordinary technical classes. It is to meet this difficulty that special courses have been devised, containing so much of mechanical, physical and chemical science as may make clear to the student the meaning of what he is learning in regard to building. Such courses are often very unsatisfactory, and merely give a smattering of knowledge, the effect of which may be to give a feeling of confidence which is quite unjustified, and fails its possessor in any actual difficulty.

The present book is a great advance on anything of the kind the writer has seen. It is essentially a course in elementary science, following the usual lines, but selecting the facts to illustrate scientific principles from those which are likely to be familiar to persons engaged in building. The meaning of weight and density, the facts of fluid and gaseous pressure, the structure of matter (including an excellent discussion of porosity and the calculation of voids), the measurement and combination of forces, the laws of heat, the nature of chemical change, are among the subjects dealt with in turn, the treatment being experimental throughout, with none but the simplest of mathematics. It is intended that the student should perform the experiments himself, and with this object each experiment is illustrated by a simple and clear line drawing. As far as the writer has checked the directions, they are simple and practical, and do not make heavy demands on the equipment of a technical school. A few details may be noted for revision in a future edition. In *Fig.* 149 turpentine vapour is issuing from the side arm of a flask very close to the flame of the burner, an arrangement which would almost certainly result in a blaze. A condenser should be used. In *Fig.* 151 the test tube should be nearly horizontal, otherwise the condensed mercury runs back and cracks the tube. Lastly, in *Fig.* 156 the quantity of mercury shown is insufficient to fill one leg of the tube, and air would be sucked in after the explosion.

The explanations are clear and accurate, and the whole book is thoroughly readable. Exercises are given at the end of each chapter, and a set of examination papers is printed at the end. As a course for students of building in a technical school it may be warmly recommended, and probably many persons engaged in the practice of building, but whose training was not based on definite scientific instruction, might read the book with advantage, even though they might have no opportunity of performing the experiments. At least so much of physical science as is here given should, however, form a part of all technical training in the subject in future.

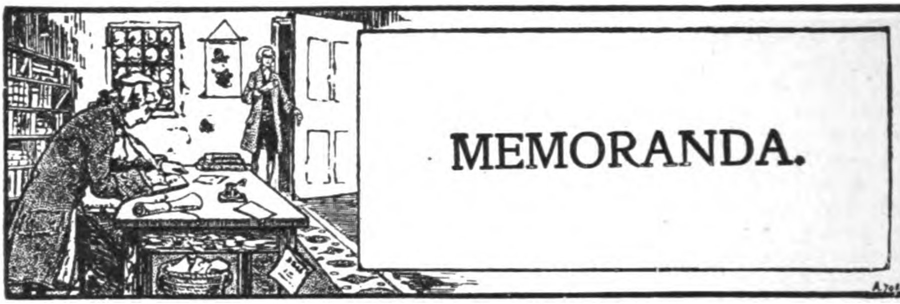
Documents Governing the Construction of a Bridge. By E. E. Howard, M.Am.Soc.C.E.

London: Chapman & Hall, Ltd. 113 pp. Price 5/- net

Contents.—The Function of Specifications—A Description of the Bridge—Advertisement—Specifications—Proposal—Contract—Bond—Index to Specifications.

This volume contains a reprint of the specifications, proposal, contract and bond of the Columbia River Interstate bridge, a description and drawing of the structure, and a discussion of the function of specifications; and the author, being associated with the work dealt with as engineer, has been able to compile the volume in a very thorough manner. Some very excellent notes are given in the section devoted to the function of specifications, and the writer wisely draws attention to the careless manner in which these are often prepared. He does not rest content, however, with urging the engineer to give proper time and consideration to the necessary document, but deals also with the eccentricities of many clients and the duties of the contractor. The bridge which is described is an important one, as it extends across the Columbia River Valley from the city limits of Vancouver, Washington, to the city limits of Portland, Oregon, a distance of about 3¼ miles, this including about 5,000 ft. of steel bridge structure. Provision is made for navigation on the river by a vertical lift span. A very good description of the bridge is given, and the specifications are very comprehensive; and no difficulty should be experienced by the contractor in pricing or executing work that is so clearly set out.

The volume is well arranged, and it should prove very useful both for reference and as an illustration of the right manner to deal with a scheme of this nature.



Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Concrete Shipbuilding—The following notes on what is being done in this direction may not be without interest to our readers:—

A Concrete Motor Launch (known as *Cementus I.*).—There has just been completed at the works of Messrs. Murïbloc, Ltd., a concrete motor launch, the dimensions of which are 21 ft. by 5 ft. 3 in. by 14 in. draught.

She is of the fast estuary type and has been built to the designs and under the direction of Mr John C. Snelling, for many years manager of that firm, and who also has had a considerable shipbuilding experience.

The method of construction has been a special one, the skin concrete being only ⅜ in. thick, and one of the special features being that these boats can be manufactured very quickly and cheaply.

It is proposed in the near future to lay down a large number of concrete vessels of considerable tonnage constructed on the same principle.

The launching of the boat will take place in a few days, and we hope to give a full description, with photograph, in our next issue.

A Coasting Vessel.—The following is taken from the *Shipping World*:—

Owing to the impossibility of being able to build steel or wood coasting vessels for their fleet of Miramar motor coasters, and to the fact that both vessels they have completed have been requisitioned by the Government, Messrs. James Pollock, Sons and Co., Ltd., London, the owners, have decided to construct reinforced concrete vessels. They have completed the plans and details, and, with the necessary sanction, will be able to start immediately. The first vessel to be laid down is practically a sister ship of the *Leelee*, with a length of 92 ft. 4 in., a breadth of 19 ft., and a depth of 10 ft. This concrete vessel will have a motor winch, the usual raised quarterdeck and forecastle, a large hold, hatchway and engine aft. The latter will consist of a Bolinder "M" type engine of 120 b.h.p., which does away entirely with water drip, and has an invisible exhaust, a feature of considerable advantage in these days when submarines can pick up steam vessels a long distance off when they are emitting smoke. The same firm have also completed designs, and are about to construct a swim barge of 130 tons capacity for the Thames. This will have new features, and will be entirely of reinforced concrete. By the materials used all these vessels will be perfectly tight in a few weeks after construction, and are calculated to be slightly stronger than a steel vessel six weeks after construction. Thereafter the strength of the reinforced concrete would gradually increase, the maximum strength not being attained until the vessels are fifteen years old. It is a little difficult to say at the present moment what the life of these barges will be, but, even allowing for a slight "fatigue" of the steel and concrete, there is no reason why each vessel should not be extremely useful when several hundred years old. They will be able to resist a local 20-ton blow by collision with another vessel, or otherwise, at one point, and the weakest point at that, without damage. The contract also provides extreme tests, such as when the vessel is light and without cargo, holding her up at each end whilst the centre is totally unsupported. When the vessel is uniformly loaded she will be left on a bank in the river or a camp-shed, with one-third of the stem or stern overhanging without any support whatever. A further test will be by supporting the whole of the vessel when light on a transverse block amidships, the ends being totally unsupported.

Concrete Shipbuilding in America. — The *Shipping World* also reports as follows:—

The Fore River Shipbuilding Corporation, Quincey, Mass., U.S.A., who are to build several vessels for the United States Navy in the near future, are making elaborate preparations for the construction of one of the large battle-cruisers. The keel will be laid on concrete foundations, while the supporting crib and launching ways will also be of the same material.

Concrete Shipbuilding at San Francisco. — A group of San Francisco capitalists have combined to finance a $200,000 venture for trying out a scheme for constructing ocean-going vessels of concrete. The plan has been developed by Alan MacDonald, of MacDonald and Kahn, construction engineers, of San Francisco, who will supervise the construction of the experimental vessel. Work is to start at once in a shipyard laid out for this purpose on San Francisco Bay near Redwood City.

The concrete vessel will be about 300 ft. long, with a cargo capacity of 4,500 tons. The shell of the hull is to be about 6 in. thick, made of the best concrete it is possible to mix, reinforced with steel rods welded together. The weight of the hull is to be less than the weight of a wooden hull for the same cargo capacity. In fact, it was a comparison of the weight and the efficiencies of joints in wooden vessels and in reinforced-concrete structures which first drew attention to the use of concrete in ship construction and resulted in the development of the scheme now being tried out. A study of modern wooden shipyard methods developed the fact that the weight of bolts used in the usual wooden vessel is more than the weight of reinforcing called for under the scheme proposed by Mr. MacDonald.

About ninety days will be required to build the first vessel. If the scheme is found to be successful, it is pointed out, any number of boats could be built without dependence upon Eastern steel mills; and at the rate of only 30 to 60 days' actual construction time on each hull, a large yard could turn out ships at an unprecedented rate.—(*Engineering News Record.*)

Cottages for Munition Workers. —The Clydebank Town Council have had under consideration a proposal from the Local Government Board to erect 100 cottage houses for the accommodation of munition workers. At a special meeting of the Council, Mr. Walter Smith, engineer to the Local Government Board, stated that the land could be acquired at £325 per acre, and the cost would be about £450 per house, including the price of the ground. The Council agreed to the proposal that the Ministry of Munitions should erect the houses. On the question of assuming ownership of the houses, however, the Council have agreed before proceeding further to await tenders, so that with the estimates before them they might suggest a percentage to be deducted from the actual cost, or, alternatively, they may prefer to assume ownership at a valuation to be made three years after the termination of the war.

Stone Bridges in French Battle Area Rapidly Rebuilt by the Use of Concrete without Falsework. —The exigencies of battle in the north of France have required the rapid and stable reconstruction of a number of masonry arch bridges that had been more or less completely destroyed by the German or by the Allied forces for military reasons. These bridges are generally in an area where timber and cut stone are scarce, and their reconstruction must be done rapidly without the aid of the needed quota of skilled artisans. To meet these conditions, concrete arches placed without the use of falsework have been successfully employed in a number of cases.

Cement, of course, can more readily be brought forward than any other structural material, and sand and gravel are local products, so that concrete, which can be made by unskilled labour, is doubly effective for such work. A novel feature of the reconstruction, however, is the use of old iron and a minimum of timber for arch centres, which can be readily erected, thus saving time and labour. As a rule, these centres are of old steel rails, curved to an arch immediately below the main arch rib and carrying the concrete of that rib on a supplementary thin concrete arch cast on a timber frame supported from the rail ribs.

The reconstruction of one such bridge in France according to this method is described in *Le Genie Civil* for April 7th, 1917. The bridge, shown in *Fig.* 1, originally comprised three 60-ft. masonry arches, of rather low rise. Two of these were completely destroyed, as shown in the drawing.

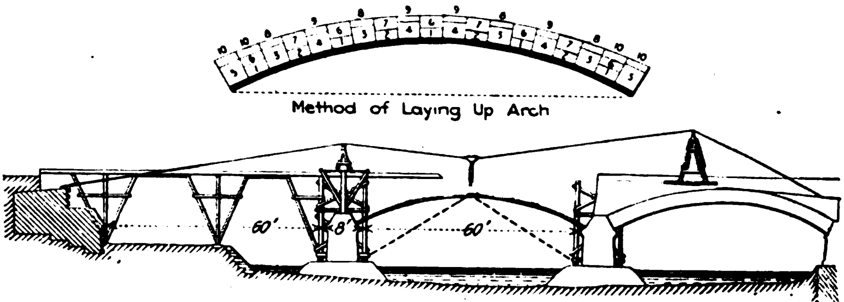


FIG. 1. RESTORING ARCHES IN DESTROYED STONE BRIDGES IN BATTLE AREA OF FRANCE.

The first operation was to build the light timber framework carrying the footway and erect thereon the towers for a construction cableway. From this cableway a series of centering ribs made up of old steel rails was placed. These rails, which were found in the neighbourhood, weighed 60 lb. to the yard. They were cold bent to the proper curve, in two sections, as shown, and spaced 20 in. c. to c. clear across the arch. At the abutment they were bolted to a bedplate that was held by a hook bolt driven into the masonry. These curved rails were used as the basis of a thin concrete arch that in itself served as the centre for the main arch. This procedure was adopted rather than placing the main arch immediately upon falsework hung from the steel ribs themselves, because the rails were not sufficiently strong to act as centres.

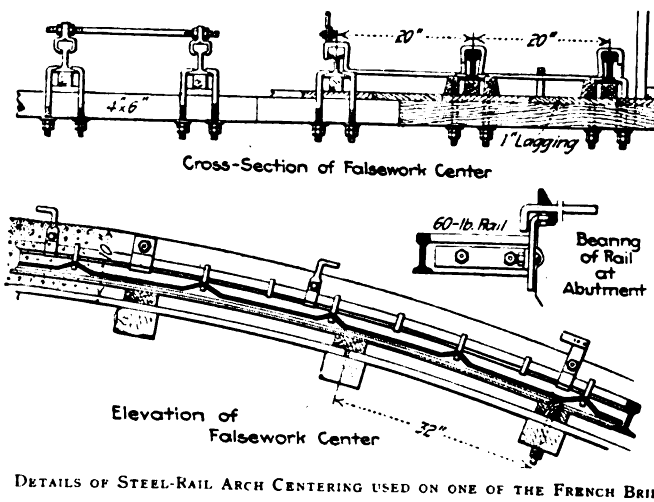


FIG. 2. DETAILS OF STEEL-RAIL ARCH CENTERING USED ON ONE OF THE FRENCH BRIDGES.

The details of the centering are shown in *Fig.* 2. It consisted merely of timber joists and a floor hung by steel of the arch. This concreting was done in two parts, a 1 : 2 : 4 concrete was placed for its uniform thickness of 10 in. from abutment to abutment, and for the full width rods from the old rails. On this a concrete arch rib of crown section and two abutment sections being first placed and the intermediate sections last. The whole concreting of this shallow section could be done in one morning. Ten days was allowed for this concrete to set. Meanwhile the top of the rib was laid off in 19 voussoirs, and a vertical dividing wall was erected across the arch at each voussoir division line. This dividing wall was made of a wire mesh, large enough to hold the aggregate, fastened to ¾-in. and ⅝-in. vertical rods tied in at the bottom to hook bolts that had been left emerging from the centering concrete. These frameworks having been placed during the 10 days allowed for the setting of the centres, concreting was carried on across the arch rib in the voussoirs so laid out, placing them across the bridge so as to impose the least eccentric loading on the centering arch. The progress of voussoir deposition is shown in *Fig.* 1. All this concreting for one 6-ft. arch could be done in two 10-hour days.

After the main arch rib has achieved a sufficient set, the centering arch can be removed, although this is not necessary. Meanwhile, the superstructure of the arch can be erected in a continuous process following the construction of the main arch rib, and the roadway put into service in a minimum of time.

American Output of Concrete Bars.—*The Iron and Coal Trades' Review* contains an abstract from two bulletins issued by the American Iron and Steel Institute, dealing with the output of steel in the United States during the last fifteen years. Almost every kind of steel product is referred to, and the figures for the last *four* years are given in the above-mentioned abstract. For concrete bars these figures are as follows:—

	Iron. Tons.	Steel. Tons.	Total. Tons.
1913	113	319,557	319,670
1914	—	288,571	288,571
1915	—	353,408	353,408
1916	2,683	458,717	461,400

A Concrete Road Oil-Tank.—A very large concrete oil-storage tank has been built at Nashville, Tenn., U.S.A., by the Davidson County Turnpike Board. The tank has eleven compartments, nine of which have a capacity of 5,000 gallons, and two, which take the place of one large one, each holding 2,500 gal. The dimensions of the larger compartments are 12 ft. by 9 ft. 6 in. by 6 ft. 10 in. high at the outside walls, with a 2 in. bottom slope to the middle of the tank, where there is a trough 2 ft. wide and varying from 10 to 14 in. in depth. In the middle of the trough is a longitudinal wall, which divides the tank into two rows of compartments. About one month was required for erection, the work being mostly done at odd times when road work was at a standstill. (*See illustration, p.* 471.)

Reinforced Concrete Gasholder Tank.—In connection with the new gasworks recently opened at Barrow-in-Furness, the gasholder is of the spiral guided type, in three lifts, and has a capacity of 750,000 c. ft. above ground. The tank is of reinforced concrete, 120 ft. in diameter and 25 ft. in height, and was constructed by Messrs. Gradwell and Co., of Barrow.

Concrete Cottage Building.—On p. 463 we show an illustration for a new form of concrete wall for dwelling houses, taken from a pamphlet recently issued by Mr. Peter Fyfe, Chief Sanitary Inspector of Glasgow. On p. 448 of this issue will be found a short description with diagrams as to the principle on which this form is constructed.

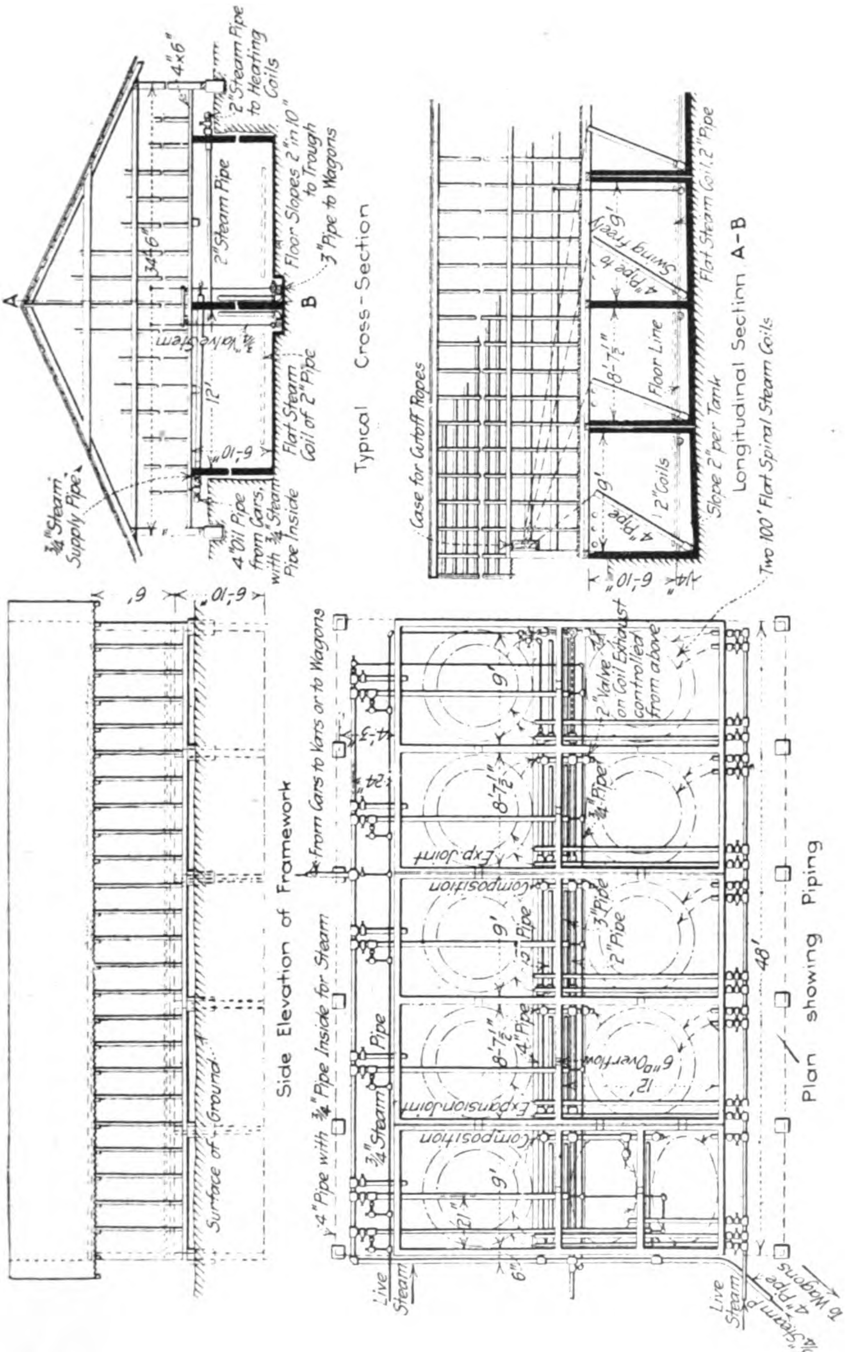
The pamphlet contains sixteen letters from well-known authorities testifying to the utility and advantages of concrete for small dwelling houses.

Concrete Paving.—The New York State Railways have in several instances had to install paving along tracks, the rails of which were not good enough to warrant the use of expensive paving, but which were too good to be torn up and scrapped. In these cases a concrete pavement was installed to solve the problem of providing a cheap material which would last throughout the remaining life of the rail. The first of this pavement was put down in 1915 at a location where it is subjected to heavy wear, and it has worn well. In fact, so far there have been no repairs.

PROPOSED WORKS.

Portsmouth.—The tender of Mr. F. J. Corke, amounting to £539, has been accepted by the Corporation for the extension of the concrete seat and wall along the Esplanade.


STEEL SHEET PILING AND PILE DRIVING EQUIPMENT.
Waistcoat Pocket Information Culled from General Catalogue
He's got his Copy
Have You!



Structural Details of Concrete Road Oil-Storage Tank at Nashville, Tenn., U.S.A.

Fulwell.—The Sunderland Rural District Council has decided, in connection with the carrying out of the sea wall at Fulwell, to erect a dwarf sea wall of reinforced concrete in place of the iron railings and standards originally intended to be placed on the coping.

ERRATUM.

In our February issue of this year we published an article entitled "Some Notes on the Construction of Curved Dams in New South Wales," by Mr. E. M. de Burgh, M.Inst.C.E. The following corrections are needed in regard to the titles to the illustrations :—

On page 84 : for "The Medlow and Bear Valley Dams" substitute "Plan of Upper Cordeaux Dam with Gravity Section on Right Bank of River," also "Section of Medlow Dam."

On page 86 : for "The Medlow Dam, New South Wales" substitute "The Upper Cordeaux Dam, New South Wales."

TRADE NOTES.

Messrs. Edward Le Bas Co., Dock House, Billiter Street, E.C., have recently issued a new catalogue of G.F. fittings. The catalogue comprises some 390 pages, dealing with over 7,500 varieties of malleable fittings for gas, steam, and water; all sizes, from ⅛ in. to 6 in.

PUBLISHER'S NOTICES.

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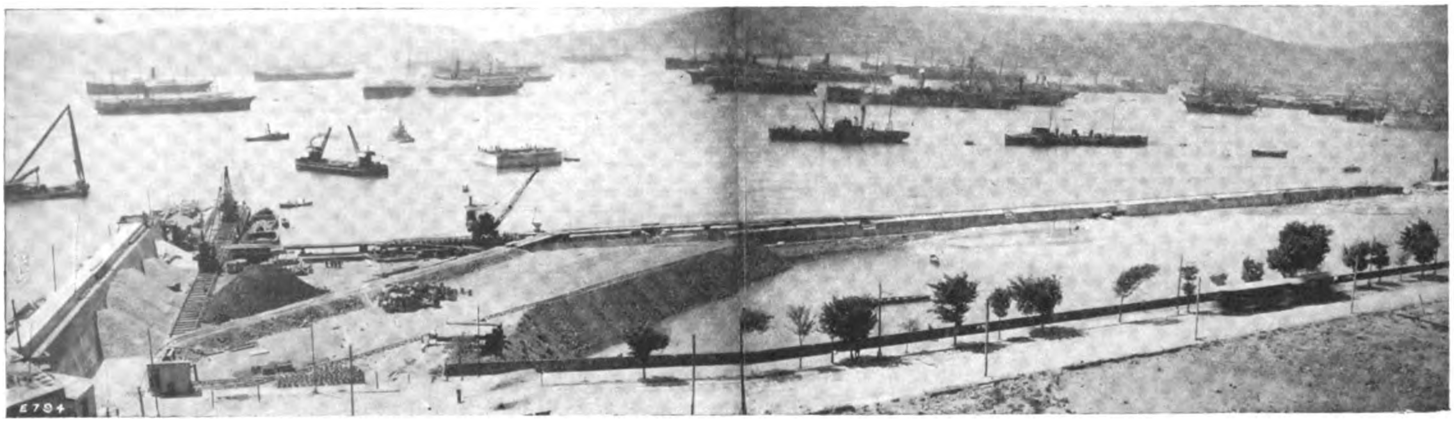


GENERAL VIEW—NEW PORT WORKS AT VALPARAISO.
(*For description see p. 479.*)

CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume XII., No. 9. LONDON, SEPTEMBER, 1917.

EDITORIAL NOTES.

COTTAGE BUILDING AFTER THE WAR.

GENERALLY.

It will have been seen from the daily Press that the Government have in contemplation the erection, by means of public funds, of a great deal of housing accommodation after the war. It is recognised that there will be a great dearth of small cottages required by the working classes both in manufacturing and agricultural centres. This lack of housing accommodation is not the direct outcome of the war, although it has been aggravated by the building trade having been switched on to factory construction and by the reduction of its activities. The trouble dates from further back, namely, when our present Prime Minister, Mr. Lloyd George, upset the foundations of building finance by his alteration in the basis of taxation of land and of buildings. The uncertainty that was thus produced made those financiers who were interested in building speculation in great part decide to wait and see how the cat jumped. We are in no wise criticising the measures that were taken. Looking back now, one sees that social conditions were bound to undergo a change and that there was instability in international affairs which was bound to react still further upon such social conditions. We cannot foresee now how the lives of the people will be changed by the result of this world-wide war. It is difficult, therefore, to formulate any definite mode of procedure and any settled basis upon which building finance can be made attractive; but meanwhile the Government has to make provision for the housing of the working classes. Certain of the manufacturing towns in the Midlands and North of England were growing at a great rate notwithstanding the difficulties of finance, because the increase of population in such centres of industry necessitated additional accommodation. The fact that private speculation was not able to keep up with the demand had led the municipalities to undertake housing schemes, and certain large industrial concerns had found it necessary to build townships for the housing of their own workpeople in the immediate vicinity of their works. The success of the Garden City movement had encouraged the municipalities and the industrial firms to erect model villages or towns, it being recognised that the presence of open surroundings made for the health of the workers, their contentment, and their greater efficiency as workers. The appreciation by capitalists of such facts is not peculiar to Great Britain, but is a noticeable feature of the growth of townships on the Continent and in the United States.

THE PROBLEMS TO BE FACED.

A great deal of attention was being directed to the problem before the war, and certainly there are already some definite rules to go upon in regard to town planning, though the change in social conditions may very well affect the size and type of house that will be required. It seems fairly certain that small houses will have to be built to a higher standard than the cottages that were considered good enough for the working classes before the war. Probably the better type of cottage, such as was erected in model towns, will fulfil the needs for a generation or two; but it is a great question whether something very much superior will not be needed after that time, because it looks almost as though the lower classes will become merged with the middle classes, and undoubtedly improved education will lead to an appreciation for, and insistence upon, better conditions. Whatever the Government does will therefore be somewhat in the nature of a temporary measure. Of course, temporary measures have been taken in the erection of houses for workers in centres where there has been a great extension of manufacturing, as, for instance, at Woolwich, where an estate of houses has been erected for the large number of employees engaged in munition making. A good deal of that housing accommodation, however, in other places has been provided by erecting buildings which are not durable, as, for example, timber huts.

TYPES OF HOUSES NEEDED.

The proposal as regards the erection of cottages when the war is over, upon which the expenditure of some millions of pounds is contemplated, is of a different order in that the buildings will have a greater durability; thus, in speaking of them as likely to be only a temporary solution, we do not mean to infer that they will be only temporary structures.

The problem has a good many aspects. There are two main sides to it in that the housing accommodation is required for (1) the agricultural labourer; (2) the town worker. It is evident that this will make a fundamental difference in the character of the buildings required. In the country one may expect small blocks of houses to be erected, while in the town whole estates of houses will require to be laid out. It is to be hoped that in the latter case the houses will not be crowded together as those in our older industrial towns have been. Such overcrowding was, no doubt, due to the exploitation by surrounding landlords. If the Government purchase the land and exercise the powers which have been given by legislation prior to the war to keep landowners in order, there should be no reason for packing houses so closely together. Plenty of open spaces are desirable, not only in the way of provision of recreation grounds, but with a view to the probability that different types of houses will be required in such centres to meet change and social conditions. Thus, it would be a good plan to reserve sites for the sandwiching in of such different types at a later date, so as to prevent the segregation of classes of workers that would only lead again to class distinctions, the creation of slums, and industrial unrest.

A far too common idea among those interested in the erection of housing accommodation out of public money is that it will be economical to build great blocks of dwellings either in the form of continuous rows of cottages or of blocks of flats. In the larger centres it may, of course, be desirable to erect a certain quantity of flats, because a great many persons prefer flats, but in most cases where cottages are desired it has been shown that there is no economy worth mentioning in erecting such cottages in long continuous lengths. It is cheaper, by reason of saving of roofing materials, to build cottages with two floors rather than the bungalow type, while to join a few together is economical in that a saving can be effected by the making of walls common to each—*i.e.*, party walls; but economy is practically finished when one builds four or six cottages together. It is true that if much space is put between such small blocks of cottages the town will cover a larger area of ground, and consequently require longer lengths of sewers, water mains, gas mains, and the like, but the general advantages of the arrangement more than offset the disadvantages. The very fact of splitting up the cottages into small blocks improves the appearance, especially if plenty of trees are interposed; but one still has to consider the point that variety of external appearance, and, indeed, of internal arrangement, is desirable if it can be obtained without great expenditure. This brings one back to the problem with which we are more immediately concerned, that of economy in the building of such cottages. The economy, as we have seen, depends not only upon the mode of construction, but upon the form of the structure. The problem involves, then, the planning as well as the nature of the materials and fittings and the proper organisation of labour and means of transport of material. A great deal has been done with regard to the planning of cottages, and certain general types have been arrived at as the result of considerable experience. The types are, after all, comparatively few in number, though a great many variations can be made and are made.

DESIGN AND CONSTRUCTION.

The most economical types are those which are compact and rectangular in plan rather than the straggling so-called picturesque types. It comes therefore to a case of dressing up standard types externally and internally, and of varying the disposition of windows and doors and other such features to suit the particular mode of construction that is considered appropriate and economical in each situation. So long as the building is efficient, the chief factor in securing official favour will be economy, no doubt, and there will not be a chance of expending much money on external treatment. The successful solution of the problem requires consideration of a number of elements, and it is not likely that either the architect or the borough engineer or contractor will have the whole say. It is a matter of adjusting their several interests. The architect and the borough surveyor must put their heads together so far as the town planning and the provision of sanitation is concerned, while the contractor must be allowed to interfere with the construction, in order to produce the cheapest building. The real difficulty as to the solution of the problem comes in the fact that so far the inventor has not been encouraged to give his attention to cottage buildings. There have been a few able men at work who have devoted some attention to the subject, but they have far too often approached it from an individual point of view and have been influenced by local conditions. It is no encouragement to an inventor to give time to the problem if he knows that he cannot obtain proper protection for his ideas or any adequate remuneration—that is to say, he cannot obtain protection for his plans either by way of patent, registration of design, or copyright. We really ought to have a sort of "design patent" such as they have abroad. Therefore it comes to this, that if a designer gives his attention to cottage building, he will put in as much thought and work as would be required for a large factory building, and possibly more through having so little margin to play with in respect of cost, whereas if he achieves any success he will be paid only a very small sum, entirely inadequate compared with what he would get for similar efforts in connection with larger buildings, while he runs the risk of having his ideas copied by other persons without any protection. It is not much use, in our opinion, to offer any further prizes in competition beyond what we did just before the war* because those who have had the most experience do not care to go in for public competition on the mere chance of publicity. If the Government decide to offer an opportunity for contractors to submit schemes and tenders for large numbers of houses, so that each contract will be for over £50,000, say, they may quite possibly attract the attention of inventive designers who may be able to make terms with the contractors which will serve as an adequate remuneration and encouragement of their efforts. The difficulty, however, in that respect is that such schemes would probably eliminate proper æsthetic treatment and result in far too much standardisation It would probably be better to engage persons of experience at really high fees to prepare designs, and offer them a small royalty on every building that is put up in accordance with their designs, and to protect the designs by legislation or, for the time being, under an Order in Council. The effect of this would be that designers would be encouraged to do their very utmost by the fact that their merits would be judged upon actual tenders received and the favour shown to the types of buildings erected from their designs by tenants and others after erection, so resulting in a demand for repeats.

In order to fit the æsthetic treatment economically to the construction, the architect should be associated with the detailer of the structure, because one cannot just put trimmings on the construction without its being noticeable and without its appearing to be an unnecessary extravagance.

MODES OF CONSTRUCTION.

This brings us to consider modes of construction and the possibilities of using methods that have not yet been exploited. Various attempts have been made to produce a pre-cast reinforced concrete cottage, for example, but the cost has been excessive, while concrete blocks and slabs have also been tried with marked success. The latter mode of building has considerable advantages, but the advocates have often spoilt their case by being rather too much "whole-hoggers." Perhaps the most economical and advantageous solution would be a combination of concrete blocks and reinforced concrete. Thus one might use a reinforced concrete framework that might be best erected *in situ* and then fix units to the framework consisting of, say, concrete blocks

* See Concrete Cottage Competition. Nos. 1, 7, 8, 9, 10, 11, 1914.

or slabs. Reinforced concrete offers an opportunity of economising with regard to the foundations, but the cost of centering is considerable and is the reason for the favour that has been shown to pre-cast work. If one uses moulds there is a danger of the work becoming too monotonous, in that they encourage the use over and over again, which turn out cottages like so many peas out of a pod. It is a case of hitting the happy mean. There are, of course, no limitations to the advantages of concrete for cottage building, but so far as the material has been used at present, one must recognise that there have often been limitations in the artistic effect obtained. Further, it does not do to use concrete without studying the experience of the past. Concrete blocks have often been badly made, which is nothing against the material, but shows that the concrete work should be done by persons of experience and care given to the supervision. Another point: concrete, if made properly, is dense and non-porous, with the result that if it be used without proper provision for either insulation against changes of temperature or the absorption of moisture condensed upon the walls there will be objection on the part of the tenants. There are many details which enter into the construction of a building besides just the walls. There are the windows, doors, partitions, roofs, ceilings, floors, and fittings. These have to be dealt with in conjunction with each other and their application in concrete cottages, and to get a really good result a lot of scheming will have to be done. The proper result might not be attained at once. It still requires a good deal of thought. The great thing is for the Government to devise some mode of encouragement to inventors, as we have said before, to induce them to give their attention to the problem.

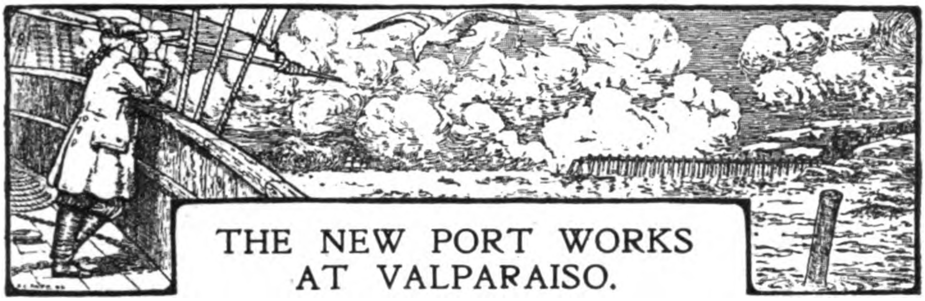
We in this journal are particularly interested in the application of concrete to cottage building, but this does not mean that we propose a house built of concrete *in toto,* like that suggested by Mr. Edison a few years ago. Concrete enters into the construction of cottages of all kinds at present, and it is very desirable to extend its use in cottage construction until the major portion of the constructional features are all of concrete, but there are so many aspects to be considered that one cannot assert that concrete as yet provides a solution for all and every difficulty. The total economy of cottage building is made up of many elements, and in particular the use of standardised fittings and organisation in the carrying out of the work of construction offer great possibilities of economy.

CONCLUSION.

We have indicated that the problem is not only one of design and construction, but also involves the consideration of the social habits and the requirements of the people who are to live in the cottages. It is evident that an agricultural labourer will require differences in accommodation from the town worker, and, moreover, one has to consider certain peculiarities of human nature. If the occupier of a cottage is to be encouraged to keep it in good order and to take an interest in it and its surroundings, nothing seems to serve better than to allow him to become the owner of the house, and it is to be hoped that the Government in any scheme for providing houses will enable them to be purchased outright, and not temporise with a leasehold or a co-operative scheme, this last, in some people's opinion, being worse than the leasehold system in giving no real security of tenure. If the small man is to be enabled to purchase the property the finance will need to be so arranged that building societies can operate. Whether it is desirable to encourage by legislation or otherwise the provision of housing accommodation by private effort is a matter of politics. It still seems, by adequate attention, the cost of cottage building could be reduced to make it worth the while of the speculative builder or of building companies to operate.

We would also call attention to another slight difficulty that arises out of human nature, that is with regard to securing proper technical advice. Those who undertake building schemes, and more especially the Government, will have to have technical guidance, and they will naturally go to architects, engineers, and possibly building contractors. It must be recognised that all these three are engaged in the business, and have their particular prejudices and personal interests, which incline them to give undue favour unless they are placed in a position of having no ties or of deriving no benefit from giving anything other than impartial consideration when a matter is brought before their notice. If professional men or contractors are to be placed in a position where they have to select between different schemes and advise upon details of construction, they should be prevented from competing at the same time for such work, and should be remunerated so well that, like judges, they can afford to be above influence.

It is to be hoped that when so great an opportunity is offered as is proposed by the Government with respect to the solution of the housing problem, which comes so close home to the majority of our population, the preliminaries will be gone into carefully, and that the mistakes which have been made in tackling the problem in the past will not be repeated. It comes to this, in short, that technical advisers should be chosen with care and rendered impartial, the finance and general conduct of the business should be properly organised, the designer and inventor encouraged, opportunity given for experiment, and prevision displayed in the selection of sites and the planning of townships, to allow of extension and modification in future years with the changing habits of the population.



THE NEW PORT WORKS AT VALPARAISO.

In the following article a short description is given of the concrete and reinforced concrete work in connection with the works being carried out at the above port.—ED.

THE new harbour works at the Port of Valparaiso form one of the most interesting contracts that are at present being carried out abroad, and the attention of engineers has been focussed on them from their inception on account of the difficulties involved.

A large amount of concrete, both plain and reinforced, is being used, and in spite of the war considerable progress has been and still continues to be made.

Fig. 1 shows the general layout of the harbour and the position of the new works included in the contract, which consist of:—

(*a*) A breakwater 288 metres long at Punta Duprat.

(*b*) Quay walls of a length of 1,210 metres, extending from the breakwater to the jetty.

(*c*) A jetty 250 metres long by 100 metres wide formed with surrounding quay walls.

(*d*) A monolith protection wall extending 745 metres.

(*e*) A rubble slope reaching from the monolith wall to the Coal Mole and from thence to Fort Andes.

(*f*) A coal mole 200 metres long by 30 metres wide.

(*g*) Filling between the new walls and the shore.

(*h*) Sheds, warehouses, railway tracks, etc., etc.

THE BREAKWATER.

The shore end consists of a wall of concrete blocks each weighing from 47½ to 60 tons, carried on a rubble foundation. On the sea side the wall is protected by 60-ton pell mell blocks and a parapet reaching to a height of + 10 metres. Most of this work has been completed and is shown in the panoramic view which serves as frontispiece to this issue.

The outer end of the breakwater is in very deep water, as much as 57 metres being reached at the head, and for this section the construction adopted consists of a mound of sand and quarry rubbish covered with a layer of rubble.

In the construction of this mound the work has been left to settle during the winter storms for two successive years, and thus ample time for consolidation and settlement has been allowed for.

This mound finishes at − 14 metres, and on it are to be set six reinforced concrete monoliths each 20 metres long by 16 metres wide by 15 metres high.

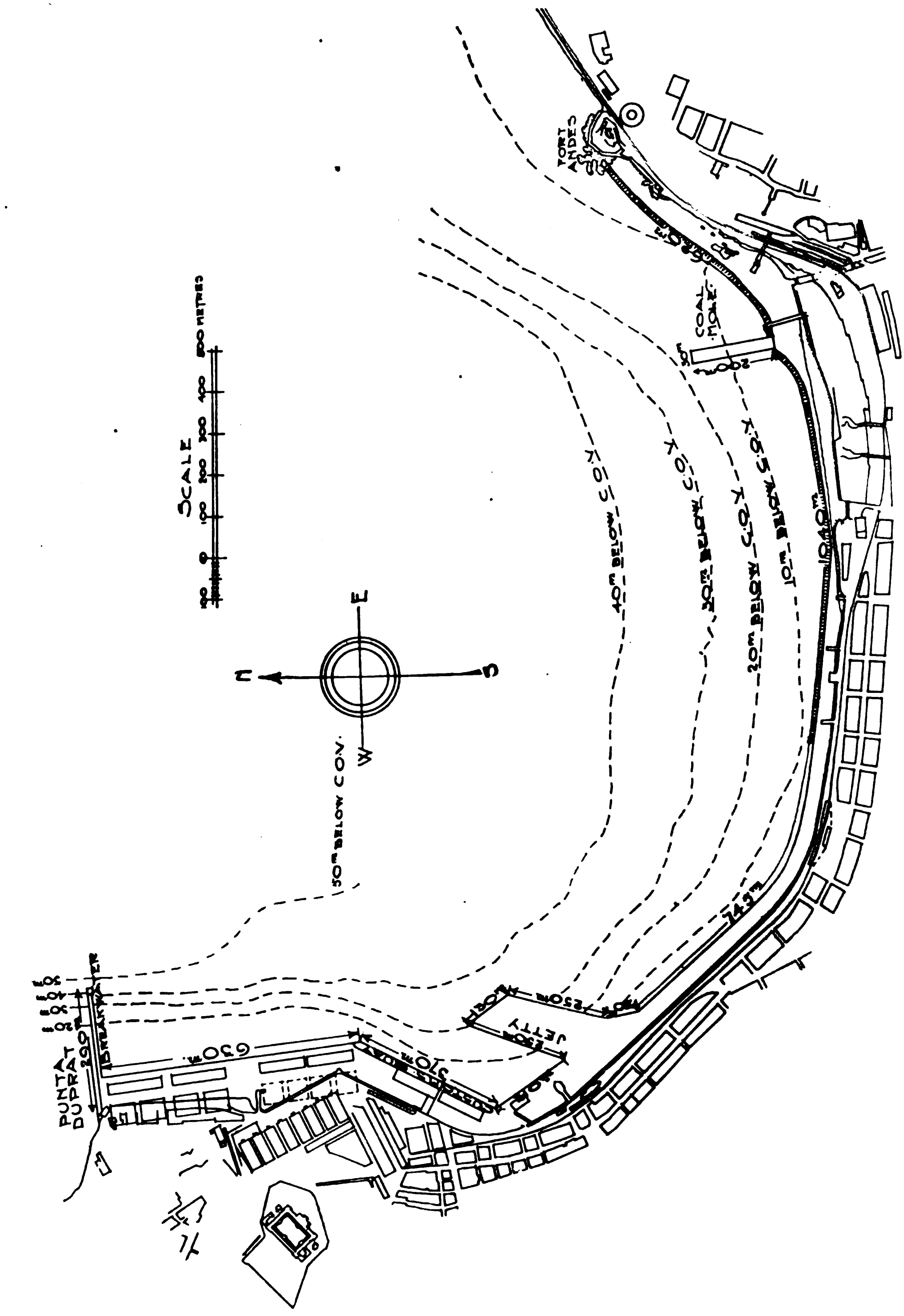


Fig. 1. General Plan.

Three of these monoliths have already been built, and one has been set and filled with concrete and can be seen in the Frontispiece and in *Fig.* 2 being towed to its destination. They were constructed in a temporary cofferdam behind the Customs Quay wall, which is shown in *Fig.* 3, the steel

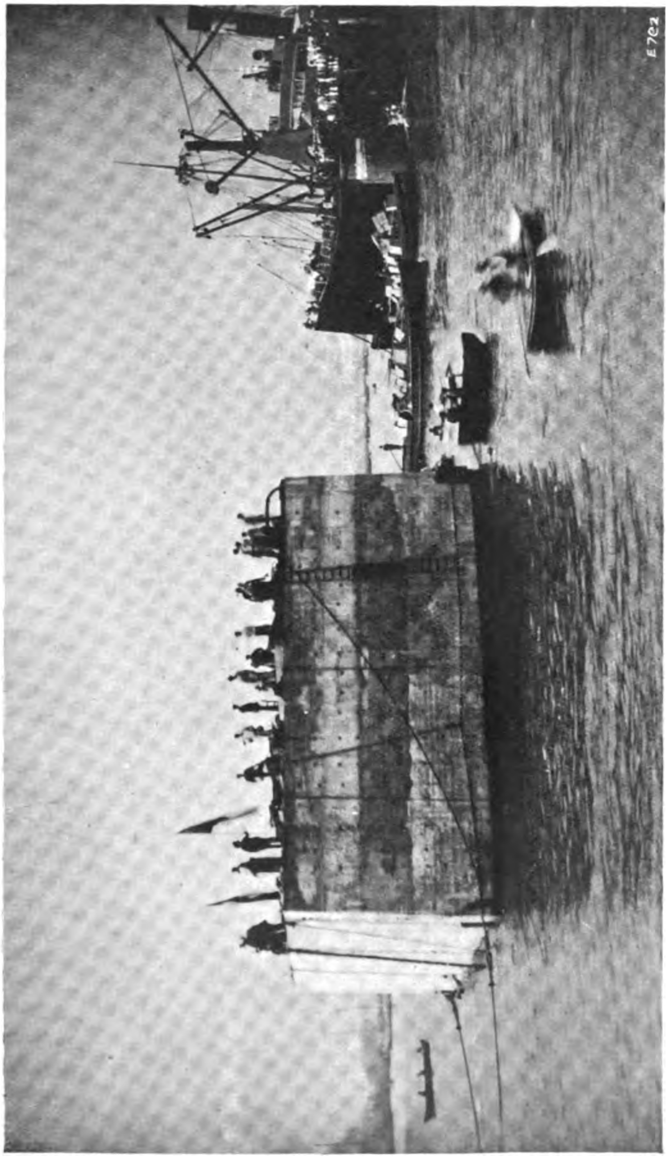


Fig. 2. Large Monoliths being Towed to Position.

piling across the entrance being removed for them to be towed out. The quantity of reinforced concrete in each shell is about 1,000 cu. metres and the draught 7·5 metres. On leaving the dock the monoliths are towed to the quay wall where concrete ballast is added till the draught was 11·80 metres, in which condition they are taken to the breakwater and sunk.

The weight of each monolith when launched is 2,300 tons, and when finished about 11,000 tons. The second three monoliths have been delayed owing to the difficulty of getting steel, but this has now been obtained and the work is proceeding.

Fig. 2 shows the first of the monoliths being towed to its site, and *Fig.* 3 gives a general view of the temporary cofferdam with the three monoliths.

When the breakwater is finished it is proposed to erect a reinforced concrete lighthouse 12 metres high on the last monolith.

THE QUAY WALLS.

Of the quay walls 830 metres have already been completed and a large amount of sand filling deposited behind the same. The walls are built of concrete blocks weighing from 40 to 60 tons each, on a rubble foundation laid in a trench dredged in the sea bottom; or in some cases on a deposited rubble mound. The blockwork is carried up to +0·5 metres and surmounted by a mass concrete wall faced with granite mosaic and finished with a granite coping.

The greater part of the quay walls have been built with a steam derrick crane travelling on bogies, the bogie under the mast running on the wall itself, the back bogies carrying the legs running on a staging 60 ft. behind the wall. With its load of 62 tons this crane has a radius of 60 ft.

THE JETTY.

The jetty occupies the space between the Custom House quay wall and the long monolith protection wall, and is 250 metres long on either side widths of 120 metres and 100 metres at shore and sea ends respectively, but owing to its end not being square to sides a mooring length of 130 metres is provided at end, as shown on the plan *Fig.* 1.

Its construction, like that of the breakwater, consists of a mound of sand and quarry rubbish with rubble finish up to the general foundation level of the walls.

MONOLITH PROTECTION WALL.

The reinforced concrete monoliths for this portion of the work are each 10 metres long by 7 metres wide at the base, 9·5 metres high, and weigh about 300 tons. They are being constructed in a yard behind the quay wall. These monoliths are built in rows with a gantry between each pair, on which travels a 5-ton crane. When the monoliths are completed trucks carrying hydraulic jacks are run underneath in prepared recesses, and by means of the jacks the monoliths are lifted from the building berths. They are then hauled forward to a traverser, which runs across the ends of the berths and brings the monolith in line with the "lift," by means of which it is lowered into the water.

This lift consists of a steel platform supported by four steel rods at the corners. Each rod is suspended from two hydraulic cylinders, by means of which it can be raised or lowered as desired.

Altogether there are seventy-four of these monoliths to be constructed, of which eleven are already made.

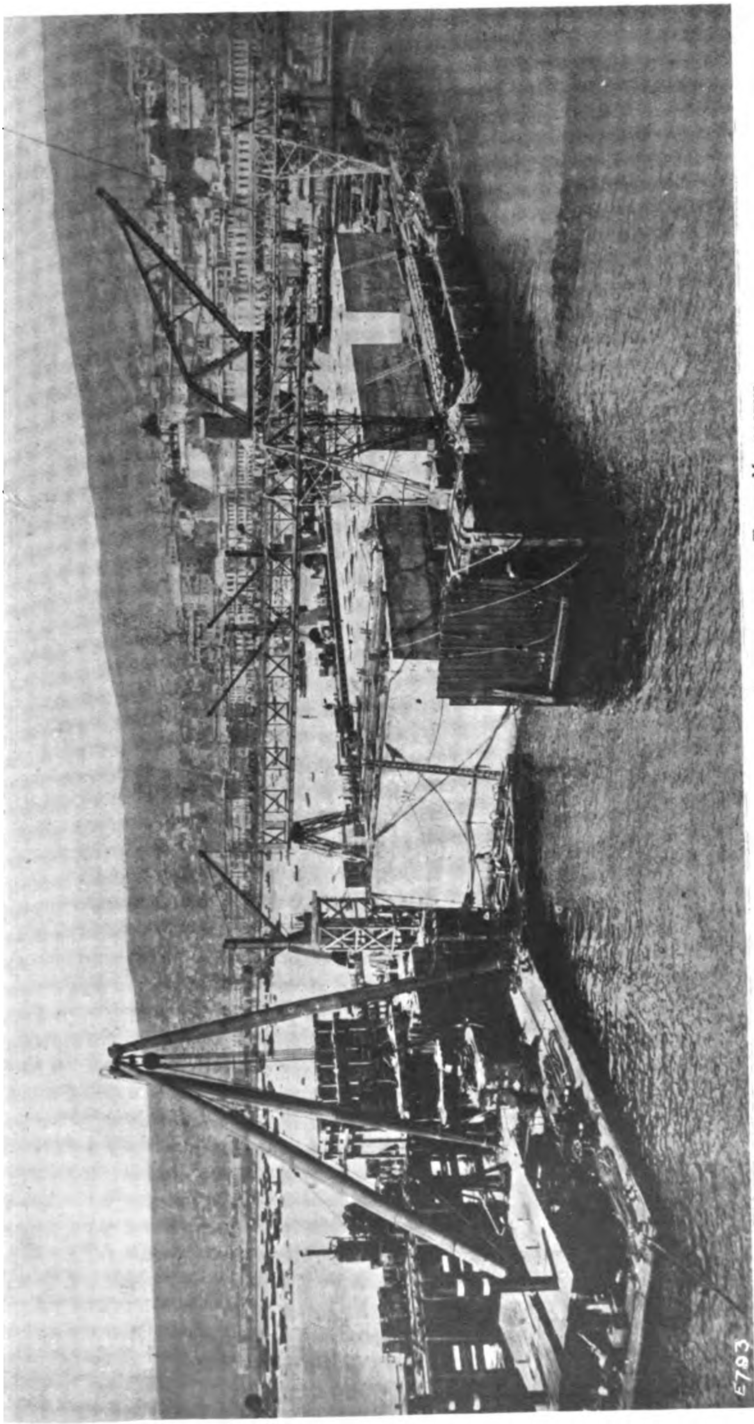


Fig. 3. General View of Temporary Cofferdam with Three Monoliths.

RUBBLE SLOPE.

This work, which hardly comes within the scope of our review, is well advanced.

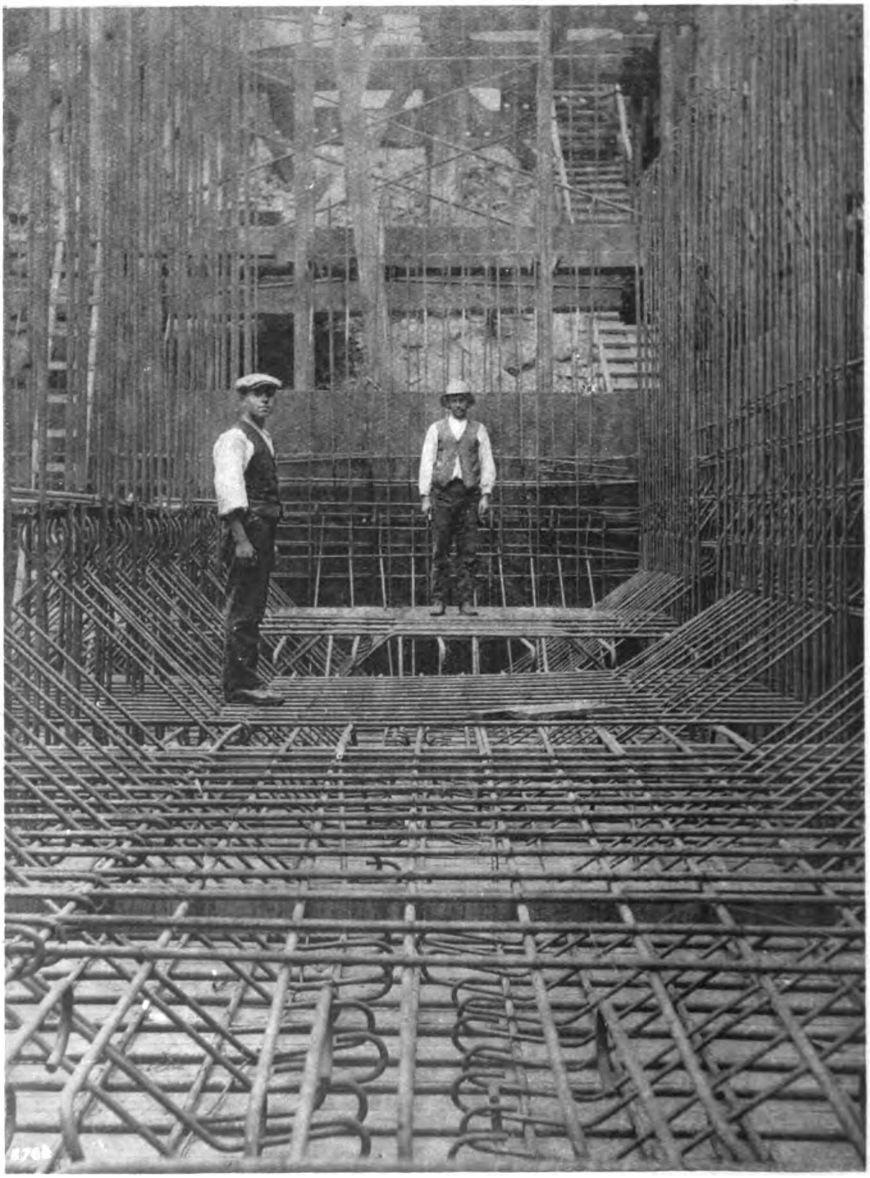


FIG. 4. LARGE MONOLITH IN COURSE OF CONSTRUCTION—SHOWING FLOOR REINFORCEMENT.

COAL MOLE.

This has now been completed for some months, but is not yet in use, the mechanical equipment being delayed by the war.

The mole (see *Fig.* 5) consists of reinforced concrete cylinders supporting a reinforced concrete deck. There are nineteen rows of these cylinders, each containing four, the depth to which they are sunk varying from 14 metres at

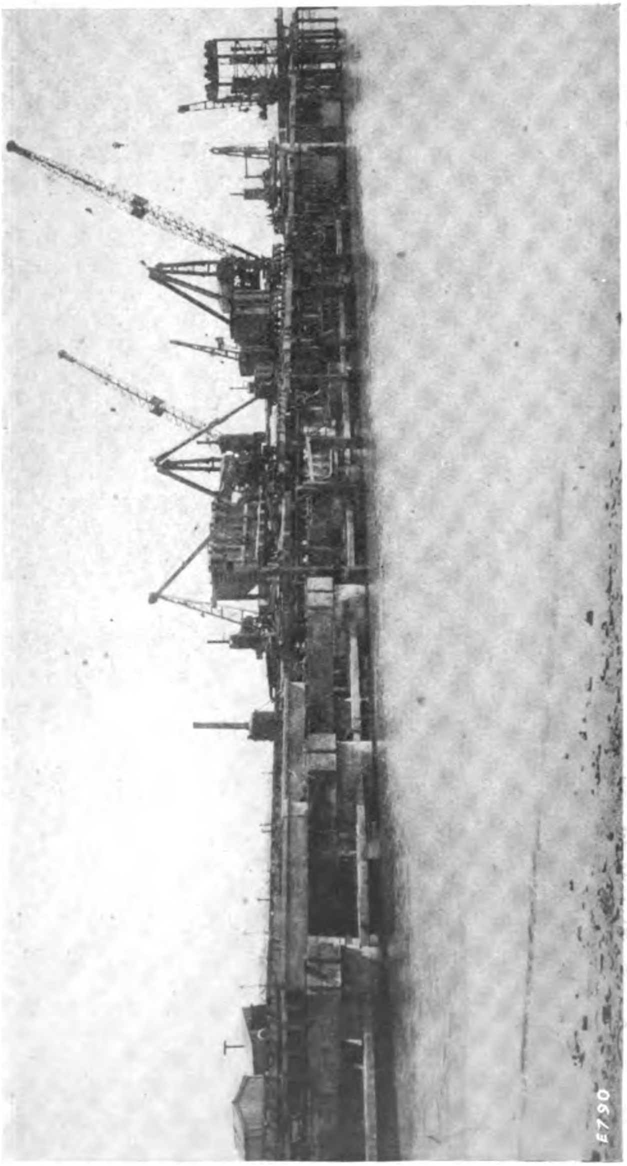


FIG. 5. COAL MOLE.

the shore end to 25 metres at the outer end. The shells of the cylinders are 4 metres in diameter and 0·20 metres thick, and were made in sections from 2 to 4 metres high at the yard at Las Salinas. The bottom section of each cylinder is provided with a cast iron cutting edge, and cast iron jointing rings.

are moulded in the concrete for the purpose of bolting the sections together. The cylinders were sunk from a pile staging the full width of the mole. The sections, when at least two months old, were built up and bolted together

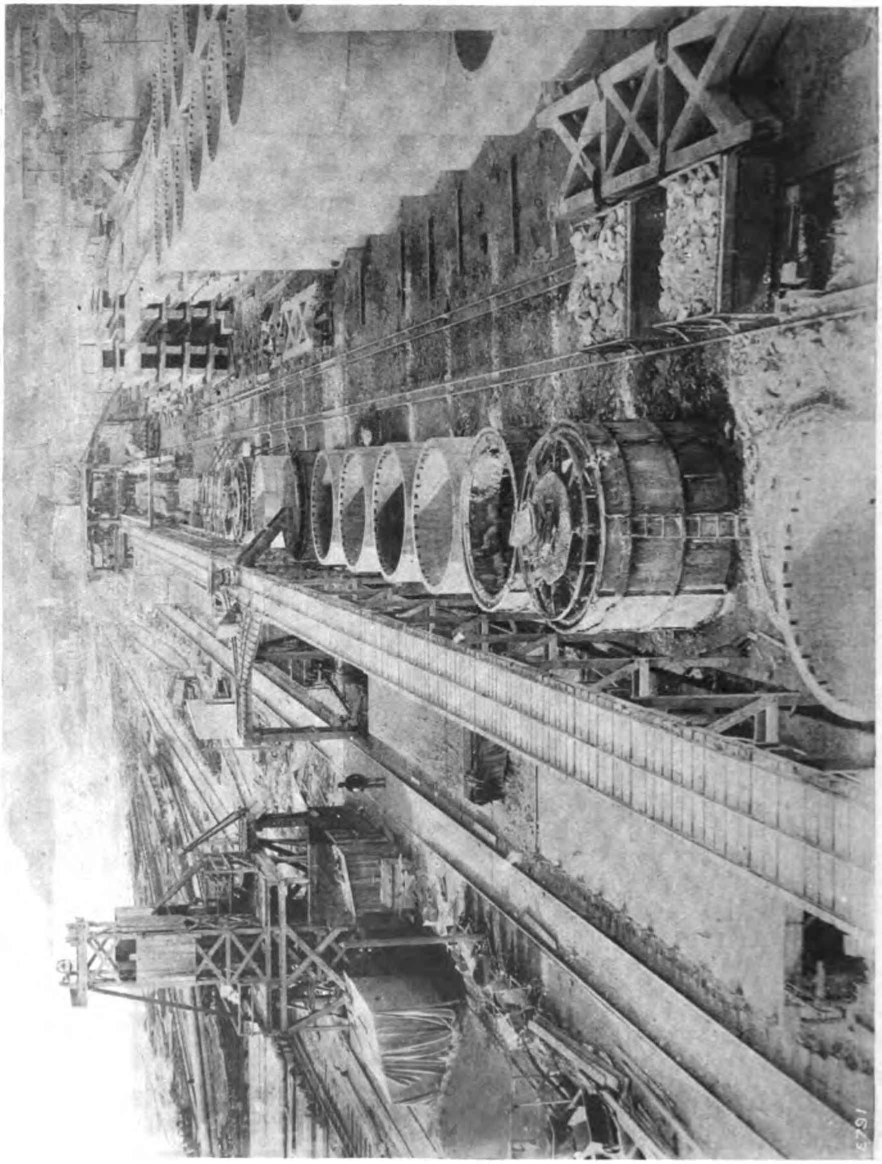


FIG. 6. CYLINDER-MAKING YARD.

on this stage till the complete cylinder was longer than the depth of water. On the stage the sections were assembled inside a steel tower fitted with hydraulic gear, so that when the length had been put together it could be lowered on to the sea bottom. The cylinder was then sunk by grabbing and weighing with kentledge in the usual way, further sections being added to the top as required until the full depth had been reached. Eight octagonal reinforced concrete piles, 20 metres long, were then driven inside the cylinder, these piles being driven in the water. The cylinder was then filled with mass concrete put in in the water until a sufficient seal was formed. The remaining portion of the cylinder was then pumped out and filled with mass concrete in the dry.

A reinforced concrete girder was then built on each of the nineteen rows of cylinders, and on this were placed the deck slabs, which were also constructed in the yard. Each slab weighed about 40 tons and was handled by floating sheerlegs. Each piece included two main girders, and with the slab gave the appearance of **T T** in cross section. The spaces at the sides and ends were concreted *in situ*.

SHEDS.

There are to be six quay sheds 25 metres wide, of which two are 130 metres long and the others 115 metres. These sheds will have concrete walls and corrugated steel roofs.

WAREHOUSES.

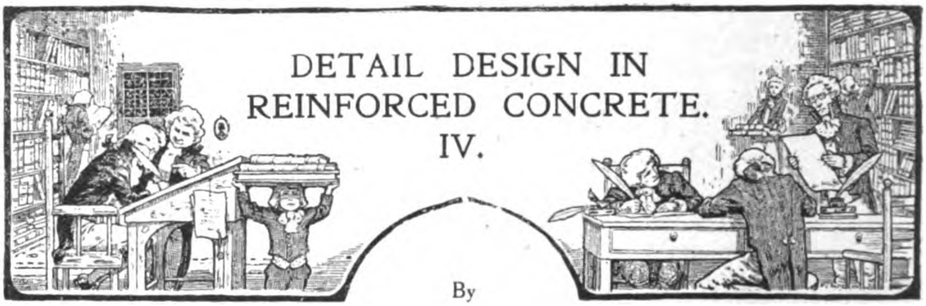
These are to be built of reinforced concrete, each of the four buildings being 60 metres by 35 metres by 4 storeys high. They are to be situated behind the sheds, and will communicate with the quay by bridges passing over the roofs of the sheds.

GENERALLY

Altogether about 300,000 cubic metres of concrete and 36,000 cubic metres of reinforced concrete will be required to complete these works. The concrete blocks, cylinders and slabs were made in the yard at Las Salinas, which is about four miles north of Valparaiso, and where the main quarry is situated. Besides this quarry, which supplies the major portion of the rubble for the foundation work, two smaller quarries at Conchas and Miraflores (which are situated a little distance inland) have been requisitioned, and these principally supply the broken stone for the concrete. Broken granite with sand is used with cement in various proportions, according to the class of work.

The improvements to the harbour are being built under contract with the Chilean Government, the contractors being Messrs. S. Pearson and Son, Ltd., of 10, Victoria Street, Westminster, to whom we are indebted for the information set forth herewith.

Señor J. Ramon Nieto is the Fiscal Director for the Chilean Government, and Mr. Arthur C. Walsh is the agent for Messrs. Pearson.



DETAIL DESIGN IN REINFORCED CONCRETE. IV.

By

EWART S. ANDREWS, B.Sc.Eng., M.C.I.

Continued from June issue.—ED.

DESIGN OF A PILLAR FOR A WORKSHOP BUILDING.

WE will next design one of the internal pillars, say *C, Fig.* 1 (see June issue, p. 315) of the same workshop building for which we have considered the detail design of the floor.

Before entering into the detail calculations we will point out some of the principal regulations that have to be observed, and will introduce the other regulations as they arise.

Cover.—By regulation **140** the minimum cover of vertical bars must be 1½ in. or the diameter of the vertical bars, whichever is greatest.

Effective Diameter.—By regulation **99** the effective diameter of the column is measured to the *outside* of the vertical reinforcement, so that if we adopt square pillars the effective breadth is at least 3 in. less than the total breadth.

Permissible Load.—Assuming 1 : 2 : 4 concrete with minimum hooping the permissive load P in kips is given in regulation **121** as

$$P = 0{\cdot}6\ (A + 14\ A_v),$$

where A = effective area of pillar (*i.e.*, core area).

A_v = area of vertical reinforcement.

We will take the building as having four floors, as shown in *Fig.* 15.

The area of floor carried by each column $= 18 \times 25 = 450$ sq. ft.

It is convenient to tabulate the loadings, etc., in some such form as the following; this greatly facilitates checking and the later preparation of detail drawings and estimates.

In arriving at the size of the column it is useful to assume that the vertical reinforcement will be about 1 per cent. (the minimum allowed by regulation **109**), giving an equivalent stress of 0·684 kips per sq. in.; if we first leave out of account the weight of the column itself (or estimate it at 2 per cent. of load carried) we can divide the load by 0·7 to get the approximate effective area of the pillar.

For Roof to Third Floor.—This gives effective area required $= \frac{49}{0{\cdot}7} = 70$ sq. in. Adopt 11 in. × 11 in. having core 8 in. × 8 in.—*i.e.*, area 64 sq. in.—and weight 1·2 kips.

We adopt the lower value here because by regulation **108** we cannot adopt vertical bars less than ½-in. in diameter, and even these are rather small for practice, so that we shall probably have a margin in the steel; later calculation will, however, show that on account of the ratio of length to breadth additional steel will be necessary.

$$\text{Then } A+14\,Av=\frac{50\cdot0}{\cdot6}=83\cdot3$$

$$\therefore\ 14\,Av=83\cdot3-64=19\cdot3$$

$$\therefore\ Av=\frac{19\cdot3}{14}=1\cdot38$$

Try $4-\frac{3}{4}\ \phi$ giving $Av=1\cdot77$.

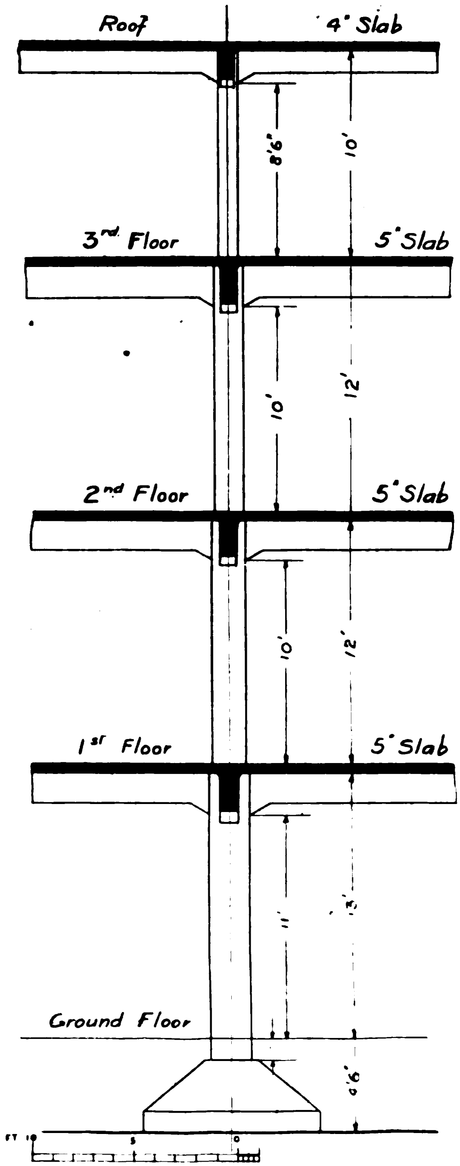


FIG. 15.
DETAIL DESIGN IN REINFORCED CONCRETE.

c

Portion of Column.	Loading in Kips.	Design Load (kips).	Size of Core (in.)	Reinforcement.	Permissive Load (kips).	Virtual length (in.)
R–3	Roof superload $= \frac{450 \times 56}{1000} = 25{\cdot}2$ Weight of slab $= \frac{450 \times 4 \times 144}{1000 \times 12} = 21{\cdot}6$ Weight of beams .. $= 2{\cdot}0$ $48{\cdot}8$ Weight of column $= \frac{11 \times 11 \times 10}{1000} = 1{\cdot}2$ Total $= 50{\cdot}0$	50·0	8 × 8 Area $= 64$ sq. in.	4—$\frac{7}{8}\phi$ vertical. $\frac{1}{4}\phi$ rectilinear binding at $2\frac{1}{4}$ in. pitch for $13\frac{1}{2}$ in. from each support and 3 in. pitch for remainder.	49·8	143
3–2	Load from floor above $= 50{\cdot}0$ Reactions from main beams $= \frac{2 \times 44{\cdot}9}{2} = 44{\cdot}9$ Reactions from secondary beams $= \frac{2 \times 41{\cdot}7}{2} = 41{\cdot}7$ $136{\cdot}6$ Weight of column $= \frac{14 \times 14 \times 12}{100} = 2{\cdot}3$ Total $= 139$	139	14 × 14 Area $= 196$ sq. in.	4—$\frac{7}{8}\phi$ vertical. $\frac{1}{4}\phi$ rectilinear binding at $2\frac{3}{4}$ in. pitch throughout.	149	120
2–1	Load from floor above $= 139$ Reactions as above $= 87$ 226 Weight of column $= \frac{17 \times 17 \times 12}{1000} = 3$ 229 Reduction allowed $= 2{\cdot}5$ Total $= 227$	227	17 × 17 Area $= 289$ sq. in.	8—$\frac{7}{8}\phi$ vertical. $\frac{5}{16}\phi$ rectilinear binding at $3\frac{1}{4}$ in. pitch throughout.	231	120
1–*G*	Load from floor above $= 227$ Reactions as above 87 314 Weight of column $= \frac{21 \times 21 \times 14}{1000} = 6$ 320 Reduction allowed $= 5$ Total $= 315$	315	21 × 21 Area $= 441$ sq. in.	8—$\frac{7}{8}\phi$ vertical. $\frac{5}{16}\phi$ rectilinear binding at 3 in. pitch throughout.	330	185

The following table facilitates the calculations for pillars; it gives the equivalent areas of steel—*i.e.* $(m-1)\ A_v$ for different sizes, and numbers of bars for various concretes.

TABLE II.

Giving equivalent areas of steel bars in columns—i.e. $(m - 1)\ A_v$ for various concrete mixes in accordance with the L.C.C. Regulations.

Concrete Mix.						Diameter of Bars.	Concrete Mix.					
1 : 2 : 4			1·2 : 2 : 4				1·5 : 2 : 4			2 : 2 : 4		
Number of Bars.			Number of Bars.				Number of Bars.			Number of Bars.		
4	6	8	4	6	8	inches.	4	6	8	4	6	8
11·0	16·5	21·9	10·1	15·1	20·2	½	9·33	13·9	18·7	8·63	13·0	17·2
17·2	25·8	34·3	15·8	23·6	31·5	⅝	14·6	21·8	29·1	13·5	20·3	26·9
24·7	37·1	49·4	22·7	34·0	45·4	¾	21·0	31·4	41·9	19·4	29·1	38·8
33·6	50·5	67·3	30·9	46·5	61·8	⅞	28·5	42·9	57·1	26·4	39·7	52·8
44·0	65·9	87·9	40·4	60·6	80·8	1	37·3	56·0	74·6	34·6	51·8	69·0
55·6	83·4	111	51·2	76·7	102	1⅛	47·2	70·8	94·2	43·7	65·5	87·1
68·6	103	137	63·0	94·5	126	1¼	58·2	87·2	116	53·9	80·9	108
83·0	125	166	76·2	115	153	1⅜	70·3	105	141	65·1	98·2	130
98·9	149	198	90·7	136	181	1½	83·7	126	167	77·6	117	156
116	174	232	107	160	213	1⅝	98·9	148	197	91·1	137	182
135	202	269	124	186	247	1¾	114	172	228	106	159	211
155	232	309	142	213	283	1⅞	131	197	261	122	182	243
176	264	351	161	241	323	2	149	223	298	138	207	276

Binding.—By regulations **101** and **103** we must use rectilinear binding, since we have only 4 vertical bars, and the least diameter of the binding must be $\frac{3}{16}$ in. We will adopt ¼ because it will do for the next length also.

To determine the pitch of the binding we have to consider jointly regulation **105**, which states that the maximum pitch shall be 0·6 of the effective diameter of the pillar (d) or 16 times the diameter of the least vertical bar, except at the ends for lengths equal to $1{\cdot}5d$ where the maximum pitch is $0{\cdot}3d$, and regulation **107**, which states that the volume of the binding shall not be less than ·5 per cent. of the volume of the core.

Taking the last requirement first we shall have

$$\text{Minimum Volume of Binding} = \frac{64 \times 102}{200} = 32{\cdot}7 \text{ cu. in.}$$

In estimating the volume of the core we take the length of the column by regulation **98** as the distance between the supports irrespective of any splayed work in excess of 30° with the horizontal.

The length of each ¼-in. binding $=4 \times 8 = 32$ in., and the area of each $=0{\cdot}0491$.

$\therefore$ Volume of each $=32 \times 0{\cdot}0491 = 1{\cdot}57$ cu. in.

$$\therefore \text{Minimum number required by } \mathbf{107} = \frac{32{\cdot}7}{1{\cdot}57} = 21$$

By regulation **105** for 12 in. each end the maximum pitch

$=0{\cdot}3 \times 8 = 2{\cdot}4$, this gives 5 each end,

and for the remaining 78 in. the maximum pitch $=4{\cdot}8$, which would give $\frac{78}{4{\cdot}8} = 16$ approximately, making altogether $16 + 10 = 26$, which is sufficient.

$\therefore$ We might adopt 2¼-in. pitch for 13½ in. from each end, and then 4½-in. pitch for the remainder, which will give 29 bindings.

Permissible Load.—To calculate the permissible load we must keep in mind the rather complicated regulations **118**, **122** and **124**.

We will consider first the last two.

The top and bottom lengths of a continuous pillar are usually considered to have one end fixed in position and direction and the other end fixed in position only, so that the virtual length $=1{\cdot}4l$.

$$\therefore \text{ In our case } v = 1{\cdot}4 \times 102 = 143 \text{ in.}$$

$$\therefore \frac{v}{d} = \frac{143}{8} = 17{\cdot}9$$

From *Fig.* 16, which expresses diagrammatically the values given in regulation **122**, we see that the permissible load is $0{\cdot}81\ P$.

Ratio of Virtual Length to Gyration Radius.

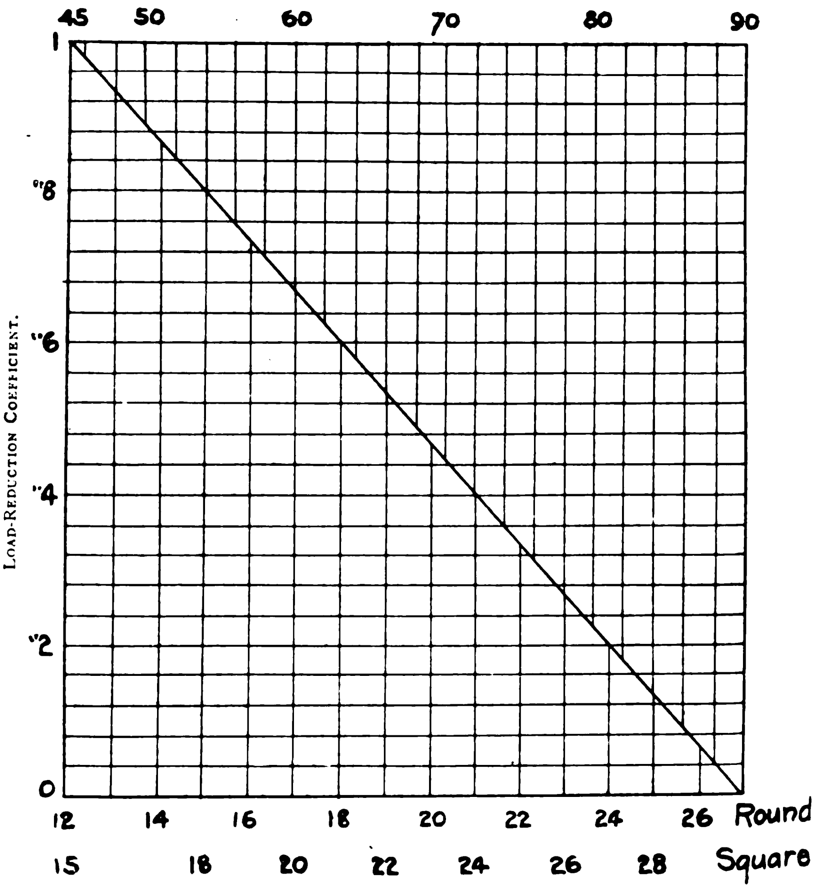


Fig. 16. Ratio of Virtual Length to Effective Diameter.

Detail Design in Reinforced Concrete.

It will be of interest to calculate the gyration radius for this case to see the difference in the results for the two cases.

The equivalent moment of inertia.

$$I_E = \frac{8 \times 8^3}{12} + 14 \times 1{\cdot}767 \times (4 - \tfrac{3}{8})^2$$
$$= 666$$

$A_E = 64 + 24{\cdot}7 = 88{\cdot}7$ (from Table II.).

$\therefore g = \sqrt{\dfrac{666}{88{\cdot}7}} = 2{\cdot}74.$

$\therefore \dfrac{v}{g} = \dfrac{143}{2{\cdot}74} = 52{\cdot}2.$

From *Fig.* 15 this gives permissible load $= 0{\cdot}84\ P$.

It may be taken that by working out the gyration radius a slightly greater permissible load may be allowed.

We will now calculate by regulation **118** the slightly increased stress that we may adopt in view of the fact that our binding pitch is less than the maximum $0{\cdot}6d$—*i.e.*, 4·8 in.

Our volume ratio $= \dfrac{\text{volume of binding}}{\text{volume of core}} = \dfrac{1{\cdot}57 \times 29}{64 \times 102} = 0{\cdot}007.$

and our pitch $= 4\frac{1}{2}$ in. $= \dfrac{9d}{16} = {\cdot}5625$

$\therefore$ spacing factor $= 3$.

$\therefore$ by regulation **115**, $i = c\ (1 + 0{\cdot}5 \times 3 \times 0{\cdot}007) = 1{\cdot}01c.$

$\therefore$ permissible stress $= 600 \times 1{\cdot}01 = 606$ lb. per sq. in.

$\therefore P = 0{\cdot}606 A_E = 0{\cdot}606 \times 88{\cdot}8 = 53{\cdot}2$ kips.

$\therefore$ permissible load $= 53{\cdot}2 \times 0{\cdot}84 = 44{\cdot}7$.

This is not enough; we can either increase our pillar to 12×12 overall or else use $\frac{7}{8}\phi$ verticals instead of $\frac{3}{4}\phi$; we will do the latter because we shall find that $\frac{7}{8}\phi$ bars will do well for the next length of pillar, and it is well to adopt as few sizes as possible.

This makes $A_E = 64 + 33{\cdot}6 = 97{\cdot}6$.

$\therefore$ permissible load $= 0{\cdot}606 \times 97{\cdot}6 \times 0{\cdot}84 = 49{\cdot}8$ kips.

Third Floor to Second Floor.—Approximate load (*see* tabular statement) $= 137 + 2$ per cent. $= 140$ kips.

Approximate core area required $= \dfrac{140}{0{\cdot}7} = 200$

Adopt core 14×14 giving area $= 196$.

Minimum area of vertical reinforcement allowed $= 1{\cdot}96$ sq. in.

Adopt $4 - \frac{7}{8}\phi$ giving 2·40 sq. in.

Equivalent area of column $= 196 + 33{\cdot}6 = 230$ sq. in.

Binding.—0·5 per cent. of core volume $= \dfrac{196 \times 120}{200} = 118$ cu. in.

Length of each binding $= 4 \times 14 = 56$ in.

If we adopt $\frac{1}{4}$-in. binding volume of each $= 56 \times 0{\cdot}0491$ in. $= 2{\cdot}75$ cu. in.

Minimum number required $= \dfrac{118}{2{\cdot}75} = 43$.

For 21 in. from top and bottom the maximum pitch is $0{\cdot}3 \times 14 = 4{\cdot}2$, say, 4 in.

Least pitch to give required volume $= \dfrac{120}{43} = 2{\cdot}79$ in.

$\therefore$ adopt $2\frac{3}{4}$ pitch throughout.

Permissible load.—$\dfrac{v}{d} = \dfrac{120}{14} = 8{\cdot}6,$

$\therefore$ permissible load $= P$, since this is less than 15.

In this case $\dfrac{p}{d} = \dfrac{2{\cdot}75}{14} = 0{\cdot}2d$ approx., $\therefore$ spacing factor $= 32$.

∴ by regulations **118** and **115**, since $V_1 = 0{\cdot}5$ per cent. $= \frac{1}{200}$

stress allowed $= 0{\cdot}6 \left(1 + \frac{32}{2 \times 200}\right) = 0{\cdot}6\ (1{\cdot}08)$

$= 0{\cdot}648$ kips per sq. in.

∴ permissible load $= 0{\cdot}648 \times 230 = 149$ kips.

Second Floor to First Floor.—In estimating the load carried by this portion we may avail ourselves of regulation **19**, according to which in calculating the loads to be carried on foundations, walls and pillars of buildings we must take the full load on the roof and on the floor of the topmost storey, but a reduction is allowed on other floors as follows :—

Floor of storey next below topmost .. 5 per cent. of superimposed load
Floor of next storey .. .. .. 10 per cent. superimposed load
Floor of next storey .. .. .. 15 per cent. of superimposed load

and so on, but the maximum reduction allowed is 50 per cent. This reduction is not allowed in buildings of the warehouse class.

∴ Reduction allowed on this floor $= \frac{450 \times 112}{1{,}000} \times \frac{5}{100} = 25$ kips approximate.

Approximate load $= 227$ kips.

Approximate core area required $= \frac{227}{0{\cdot}7} = 324$ sq. in.

18 in. × 18 in. core would do, but we will try 17 in. × 17 in. with 8 – $\frac{7}{8}\phi$ bars.
Then $A_E = 289 + 67 = 356$ sq. in.

∴ Increased compressive stress $= i = \frac{229}{356} = 0{\cdot}643$ kips per sq. in.

Our previous calculation shows that with a pitch of $0{\cdot}2d = 3\frac{1}{2}$ in. throughout and 0·5 per cent. binding reinforcement this stress will be allowable.

Adopting $\frac{5}{16}\phi$ binding we have volume per binding $= 0{\cdot}0767 \times 68 = 5{\cdot}21$ cu. in.
Core volume per foot $= 289 \times 12$ cu. in.

∴ 0·5 per cent. $= \frac{289 \times 12}{200} = 17{\cdot}3$.

∴ Maximum pitch required $= \frac{12 \times 5{\cdot}21}{17{\cdot}3} = 3{\cdot}61$.

Adopt $3\frac{1}{2}$ in. pitch throughout.

First Floor to Ground.—Approximate core area required $= \frac{322}{0{\cdot}7} = 460$.

Adopt 21 × 21 with 8 – $\frac{7}{8}\phi$ bars.
$A_E = 441 + 67 = 508$.

Stress $= \frac{322}{508} = 0{\cdot}633$ kips per sq. in.

Adopting $\frac{5}{16}\phi$ binding we have volume per binding $= 0{\cdot}0767 \times 84 = 6{\cdot}45$ cu. in.

0·5 per cent. core volume per foot $= \frac{441 \times 12}{200} = 26{\cdot}5$.

Maximum pitch required $= \frac{12 \times 6{\cdot}45}{26{\cdot}5} = 2{\cdot}92$.

Adopt 3-in. pitch throughout.

We are now in a position to make the detail drawing of the pillar shown in *Fig.* 17. By regulation **111** there must be an overlap in all joints of the vertical reinforcement at least equal to twenty-four times the diameter of the upper bar ;

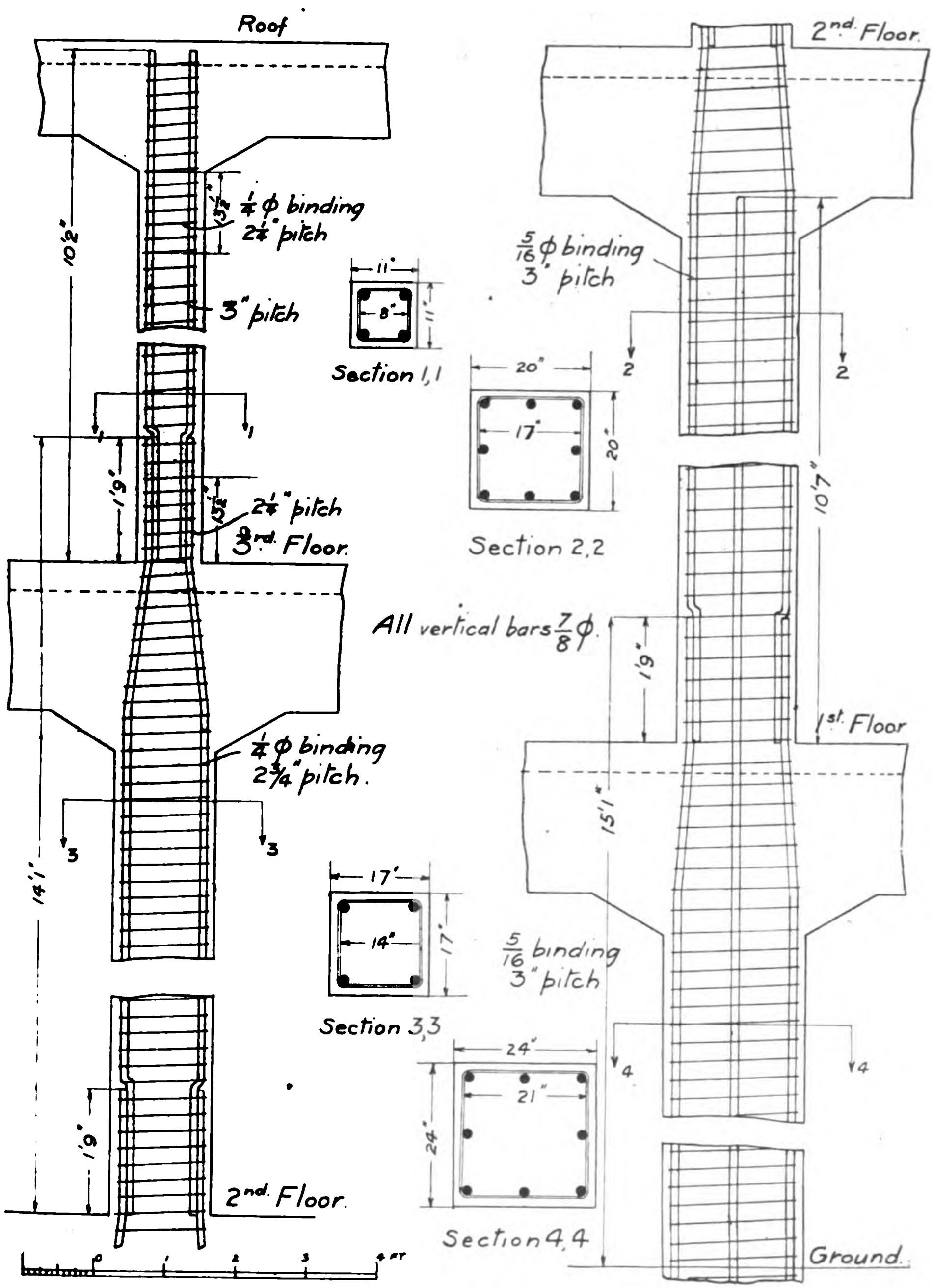


FIG. 17. PILLAR DETAILS.

DETAIL DESIGN IN REINFORCED CONCRETE.

and by regulation **110** such joints shall only be made at or adjacent to a floor level or other point of lateral support.

In most cases it is most convenient to make the joint just above the floor level, and we have followed a common practice in providing a joint in the reinforcement at each floor.

The overlap required in our case $= 24 \times \frac{7}{8}$ in.
$= 1$ ft. 9 in.

In the pillar that we have considered the loading is such that there will be no tension in the vertical bars due to eccentric loading or to wind stresses, etc.; in cases where such tension is likely the ends of the bars must be hooked or otherwise anchored as in the beam reinforcement.

We will consider next the design of footings.

(To be continued.)

A WATER TOWER AT VELSEN.

REINFORCED CONCRETE AND WATER TOWER CONSTRUCTION IN HOLLAND.

By

S. L. A. ORIE,
Civil Engineer.
Ginneken.

(*Revised and Abbreviated.—ED.*)

The following technical details of Water Towers erected in Holland will no doubt be of interest to many engineers. As indicated, we have somewhat revised and abbreviated Mr. Orie's original MSS.—ED.

FOR various reasons engineers in Holland were for a long time indisposed to adopt reinforced concrete for water towers, and, as in this country, it was only by degrees that this material was more generally applied. Some of the reasons put forward against its use were doubts as to its suitability for this form of structure, difficulty of architectural treatment, and the high first cost. But of late years architects and engineers in Holland have been led to a very general use of reinforced concrete for water towers, as will be seen from some of the illustrations given in this article.

The earliest examples in which the material was used consisted merely of four or more reinforced concrete columns stiffened by a few cross beams and braces, arranged to form a simple frame work for the support of the tank, and although the type is very suitable and economical for use in connection with low water towers for factories, it does not possess sufficient architectural merit to justify its use for important water towers which are of considerable height and which will be visible as landmarks over a large area of country. As the distinct advantages of the material became more generally known, however, architects and engineers realised the necessity of evolving designs which would permit of its use, while a satisfactory appearance was provided, and this generally consisted of a filling to the framework which partially or wholly disguises the latter, while a large mass presented by the tank at the top is apparently supported by a large mass below and thus a sense of stability is achieved.

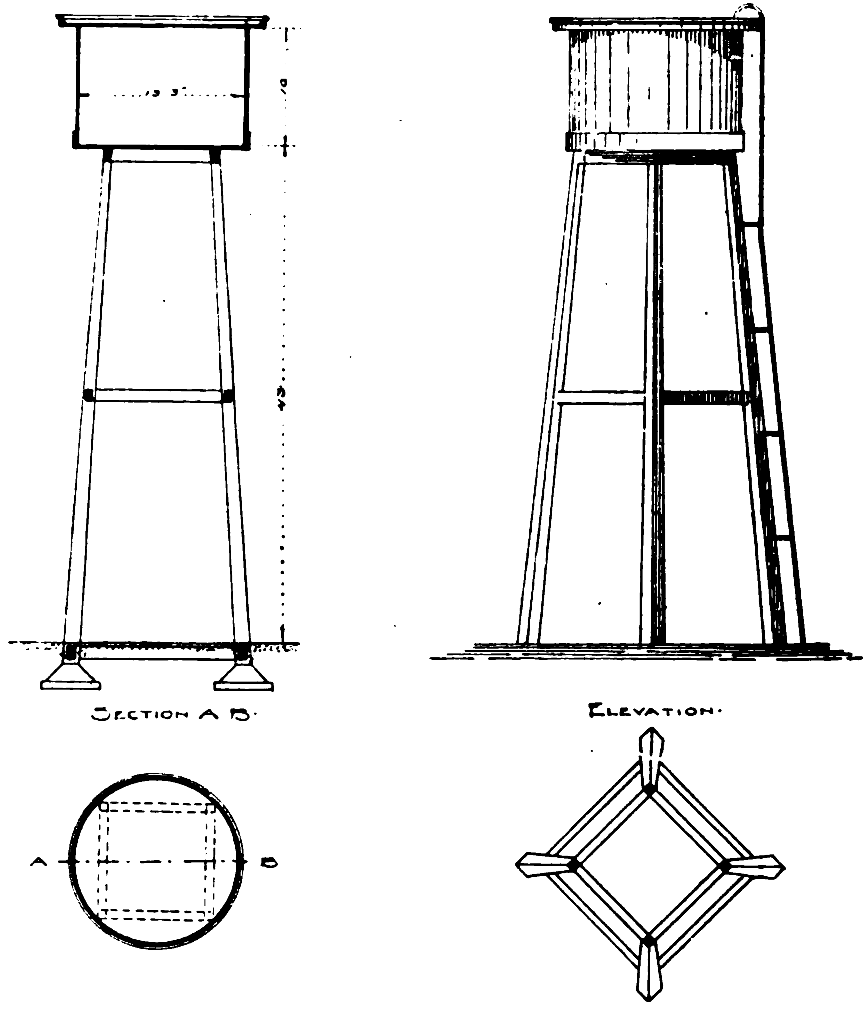


Fig. 1. An Elevated Tank at Breda.
REINFORCED CONCRETE WATER TOWERS IN HOLLAND.

Fig. 1 shows an elevated tank erected at Breda. It is a small tank for a sprinkler installation, and a large number of such tanks may be found throughout Holland; the only claim put forward for this design being that it is economical and light. A point of interest is the roof slab, which is constructed without beams. The slab is $2\frac{3}{4}$ in. thick and is reinforced with circumferential bars quarter inch diameter, spaced 5 in. apart, and radial bars quarter inch diameter, spaced 1 ft. apart. The calculation was based on the assumption that the slab would be fixed to the walls and not merely supported.

Fig. 2 is a tower at Vianen of similar construction as the one shown in

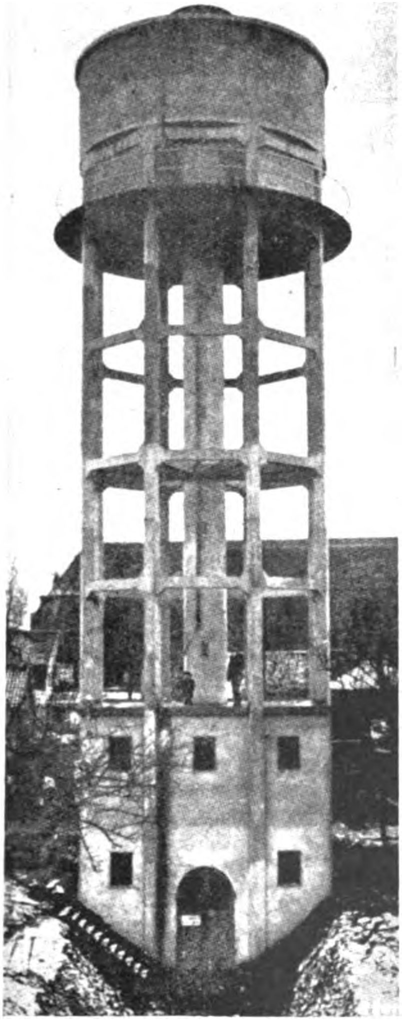


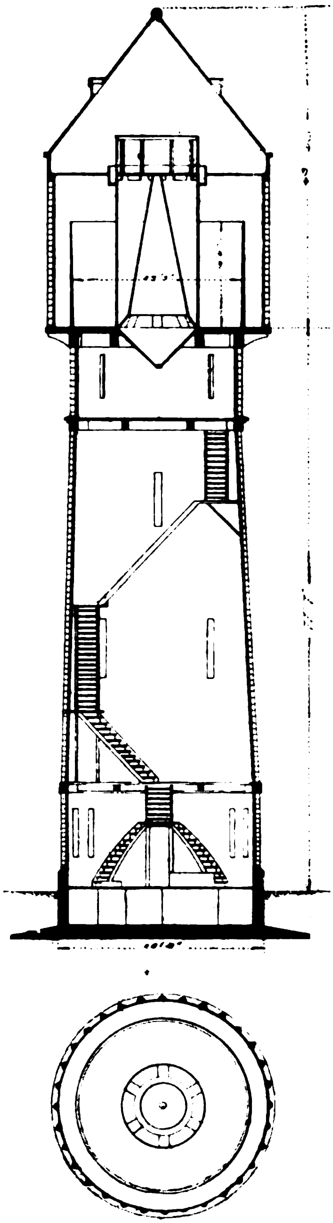
Fig. 2. A Water Tower at Vianen.

Fig. 3. Water Tower at Heemstede.

REINFORCED CONCRETE WATER TOWERS IN HOLLAND.

Fig. 1. The tank has a capacity of 22,000 gallons. The bottom of the tank is 84 ft. above foundation level and 72 ft. above ground level. This is one of the larger water towers constructed in Holland when reinforced concrete had not as yet been extensively used.

Fig. 3 shows a water tower at Heemstede, constructed on the same principle as that illustrated in *Fig* 2, only in this instance the openings



Figs. 4 & 5. A Tower at Oudewater.

Reinforced Concrete Water Towers in Holland.

between the concrete pillars and beams have been filled in with masonry, thus giving a more solid appearance to the building.

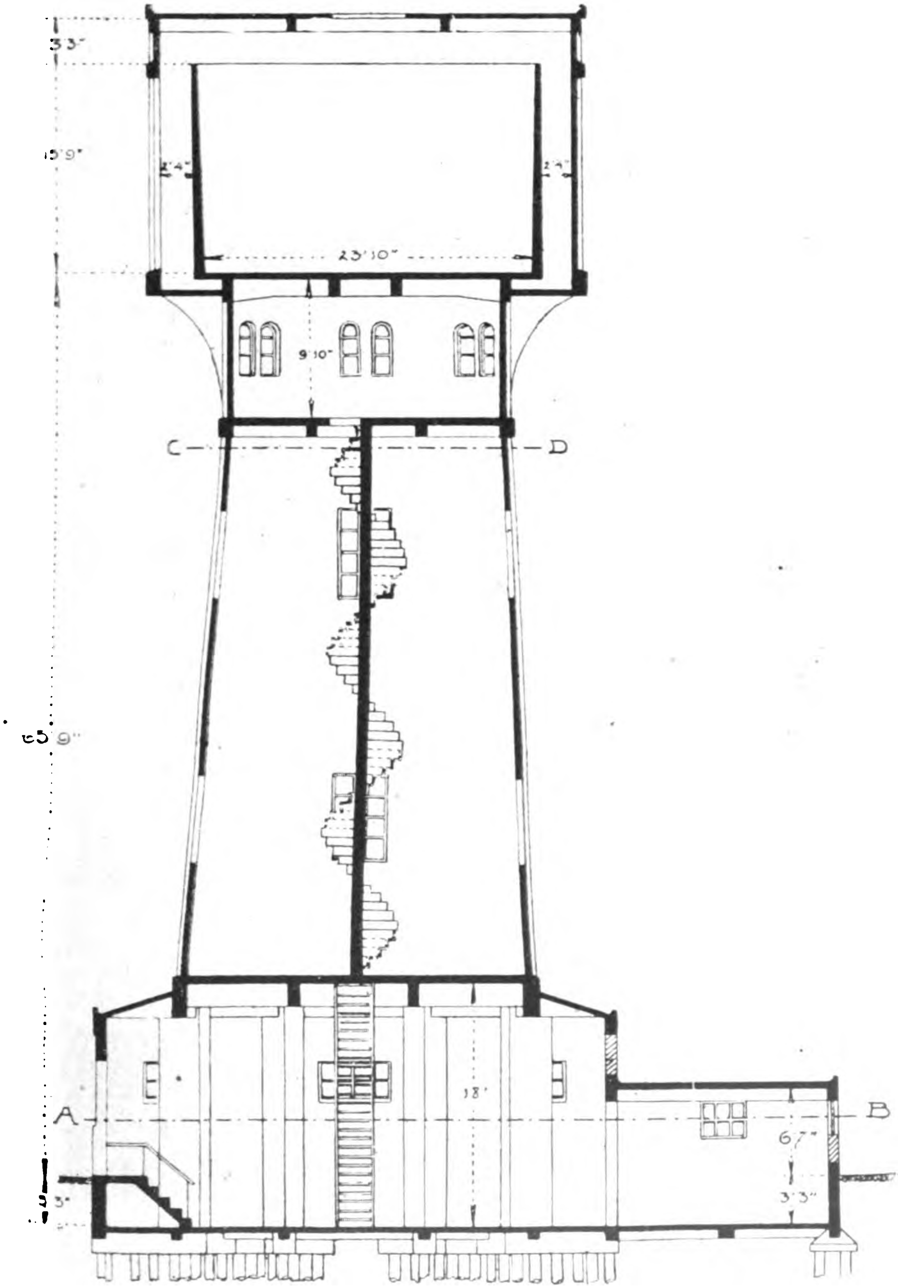


Fig. 6. Water Tower at Ysselstein.
Reinforced Concrete Water Towers in Holland.

This example affords an instance of desire on the part of the designer to introduce some architectural effect as distinct from the purely constructional aspect of the framework alone, and although it cannot be considered as a very fine conception it marks a step forward in the development of the later type of design.

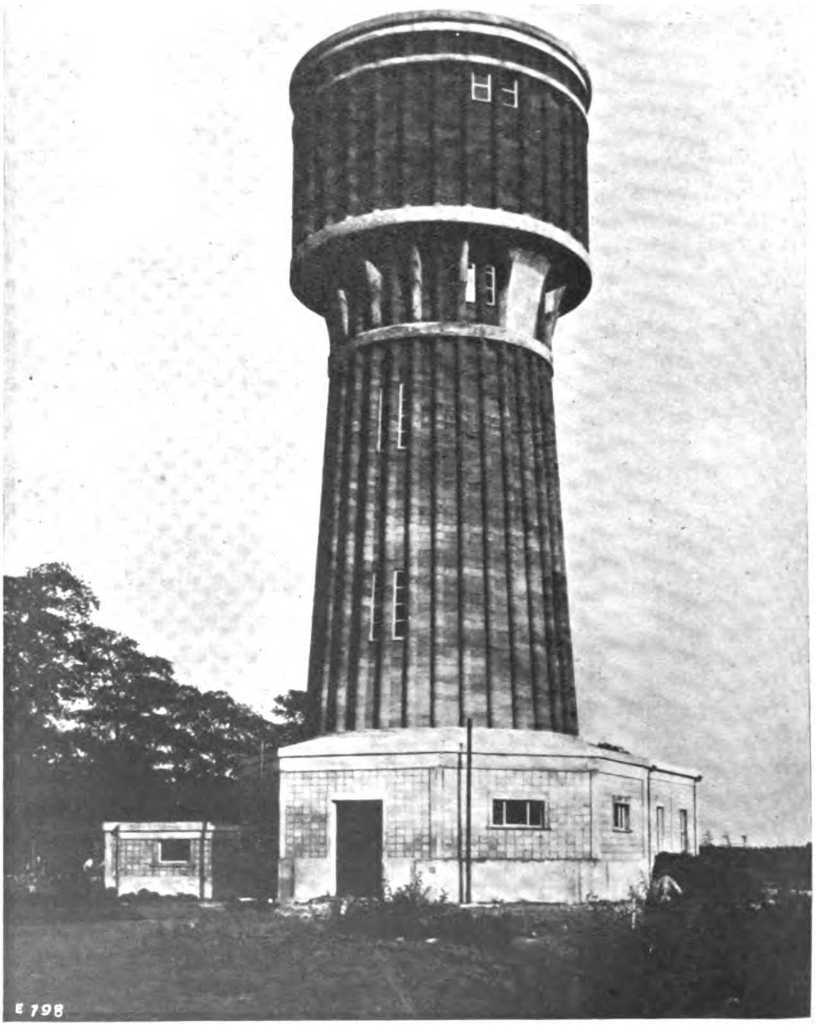


Fig. 7. Water Tower at Ysselstein.
REINFORCED CONCRETE WATER TOWERS IN HOLLAND.

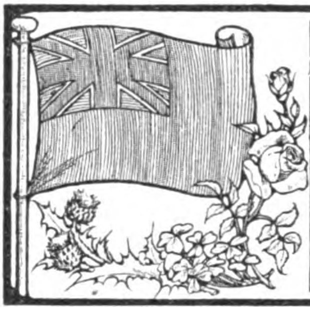
The only portion which is worthy of notice as regards the construction is the bottom of the tank, which is supported by radial beams, and these project as cantilevers beyond the face of the columns to support the overhanging tank at the top, as will be seen in the photograph.

The great depth of these is apparent, and as the beam portion is of similar depth the construction was not made quite as economical as it might have been.

Figs. 4 and 5 illustrate a tower at Oudewater, constructed on the Monnoyer system of reinforced concrete, the outer covering is entirely of reinforced concrete and is 4 in. thick. In this structure the filtering installation is at the top of the tower within the tank.

In *Figs.* 6 and 7 the system of construction is the same as for the Oudewater tower, only in this instance concrete blocks have been used as mentioned below. The capacity of the tank in this instance is 44,000 gallons. This water tower shows a distinct advance in the design and construction, because it retains all the features of a true concrete structure, while the appearance is effective. As will be seen in the detail (*see next issue for illustration Fig* 8), the walls are constructed with vertical reinforced rods, and the space between these is filled in with concrete blocks which are cast with projecting concrete of hook form alternately right and left hand, and these hooks are passed round the main vertical rods during the building up. The blocks are reinforced with light rods when they are large to facilitate handling without damage, and the spaces around the main vertical rods is filled with wet concrete. As no shuttering is required the method is economical, and the continuous circular wall so formed actually supports the tank. The floor of the tank is constructed with radial beams, and these are kept at the minimum depth by keeping them up to the top surface of the floor slab. The projecting portion of the tank and enclosure are supported by deep cantilever brackets, and the thrust from these is provided for by means of an intermediate floor, which is constructed at the bottom of them. The construction involves rather a large amount of steel in the beams and brackets, but it can be considered a good example.

(*To be concluded in next issue.*)



REINFORCED CONCRETE VESSELS.

THE POLLOCK IMPROVED DESIGN OF REINFORCED CONCRETE VESSEL.

In the accompanying article we give a short description and an illustration of an improved concrete vessel designed by Messrs. James Pollock & Sons, Ltd. The chief feature in this design is the use of straight shuttering and reinforcement in place of the curved work, whereby it is claimed one of the chief difficulties in reinforced concrete shipbuilding is overcome.—ED.

THE great difficulty experienced in obtaining steel, iron and timber, which has been caused by the war and the activity of the U-boats, is only too well known to those connected with any works requiring such materials, and has led to the introduction of many substitutes and methods of construction, prominent among which has been the extended use of reinforced concrete.

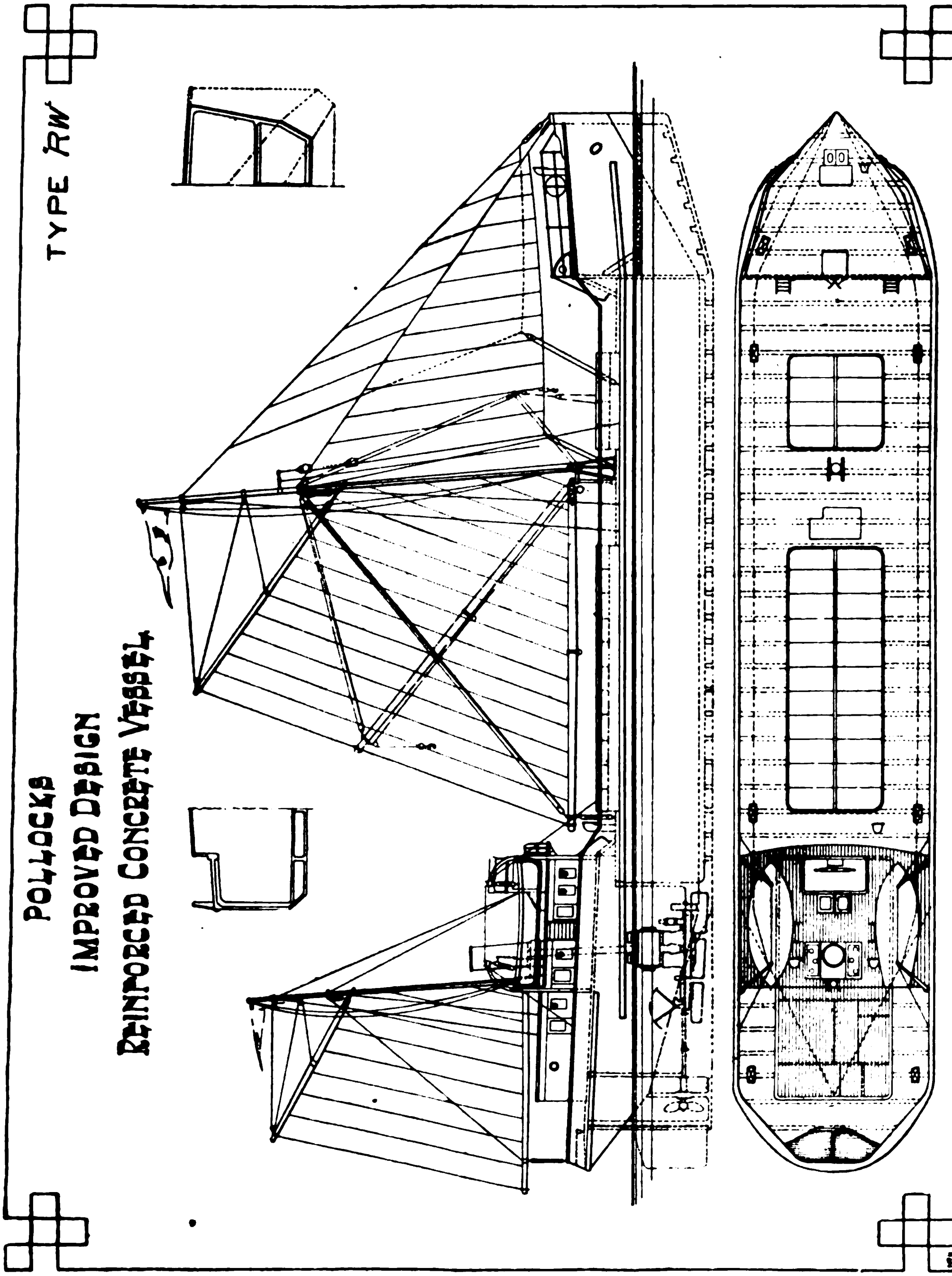
This shortage of steel and timber has applied very particularly to the construction of coasting vessels, barges and other craft; and although many have been built of necessity, the continual rise in price is, generally speaking, making their cost a matter for serious thought. These facts, together with the increasing shortage of tonnage, have led shipbuilders to give more consideration tc the possibilities of adopting reinforced concrete for the building of ships.

In itself the idea is not at all a new one, for during the past few years many experimental boats and barges have been built, especially on the Continent, and reinforced concrete pontoons are in use in many of the harbours of Europe.

Several brilliant Continental mathematicians have undertaken and carried out research work on this subject, and the bases of the calculations have already been published; whilst the results of the experimental vessels have so far been very satisfactory, provided that they were protected against chafing and impact, which difficulty can be obviated by building in heavy wooden fenders where such stresses are likely to occur.

There are, however, certain advantages in the use of this material for shipbuilding, for although the weight of the hull must of necessity be heavier than similar hulls of steel or timber (this weight being from 33⅓ per cent. to 50 per cent. greater), the cubic capacity of the reinforced concrete vessel is much greater than that of a vessel with a similar dead weight constructed in other materials.

Again, steel and wood are found to deteriorate immediately from the day they are built, unless very carefully protected by means of paint or other materials; but with regard to concrete, this takes about fifteen years to attain its maximum strength and hardness, and this increase also decreases the



Reinforced Concrete Vessels. Pollock's Improved Design. Type "R.W."

stresses of the steel. Concrete has been proved to be an absolute preservative of steel, more especially when it is surrounded by water and not subjected to the influence of air.

The whole external surface of the concrete can be made perfectly smooth, and in cases of sea-going vessels the surface would be coated with the ordinary anti-fouling compositions as are employed on steel and wooden vessels; but with regard to barges for river work this is not necessary.

The design illustrated on p. 505 is that of a vessel 125 ft. by 25 ft. by 11 ft. 6 in., designed with a normal co-efficient of ·72, and will carry 300 tons of cargo on 9 ft. 9 in. draft.

The raised quarterdeck and the raised forecastle increases the surplus buoyancy and will enable the vessel to work well and safely on a freeboard of 1 ft. 9 in.

It is found that where the ordinary lines of a vessel are adhered to there is a very great expense in constructing the necessary shuttering or false work, so as to get all the correct curves both longitudinally, diagonally, and transversely, and it is owing to this difficulty, and also the curvature of the rods, that Messrs. James Pollock, Sons, and Co., Ltd., of London, have decided to adopt another method of construction in order to get over this difficulty.

All curved work is dispensed with in the reinforced concrete work, the form work becomes of the simplest possible nature, and the rods are practically straight throughout, so that no great expense is incurred either in bending or fixing in place. The sharp corners are rounded off. The curves shown are of the wooden fenders, and there are no other curves on the ship.

The deck work and the internal construction become very simple, especially as regards the ballast tanks, either at one or at both ends of the vessel.

At a first glance shipowners and naval architects will stand aghast at such a drastic alteration from the accepted and preconceived ideas of design; but when one considers the speed of 7 to 8 knots, which is usual for coasting vessels of this size fitted with sails and auxiliary power, or for vessels up to 9 knots with full power and without sails, they will agree that the straight-lined hull will cause very little if any greater resistance, always assuming that the co-efficient of fineness is the same and that the lines are slightly fuller forward than aft—*i.e.*, the centre of buoyancy slightly forward of amidships.

The designers are, therefore, of opinion that if reinforced concrete vessels were built on these lines, especially for experimental vessels, it would considerably reduce the cost and add to their strength and efficiency.

It is hoped that the first vessel of this design will be completed in four months.

The advantages of reinforced concrete vessels are:—(*a*) They cannot corrode or rust; (*b*) the life of a concrete vessel is, of course, considerably longer than that of an ordinary steel or wooden ship; (*c*) are fire resisting and vermin proof; (*d*) are easily repaired and at a very low cost; (*e*) do not require trained shipwrights, platers, angle smiths, riveters, etc. (owing to Admiralty requirements, these are very scarce now); (*f*) no expense for upkeep and depreciation nil; (*g*) can be constructed in half or one-third the time of steel or wooden vessels; (*h*) cost very much less than steel or wood vessels, especially if standardised and a number are constructed from the same shuttering.

RESEARCHES ON REINFORCED CONCRETE BEAMS.

With New Formulæ for Resistance to Shear.

By OSCAR FABER, D.Sc., A.M.Inst.C.E., etc.

Continued from August, 1917, p. 431.—ED.

PART V.

SHEAR TESTS ON CONTINUOUS BEAMS (1911 SERIES)

(*Continued.*)

Beam 5a.

For beams 5 to 8 the load was applied at two-thirds points, and hence the l_1 used in the calculation of shear by inclined compression is to be taken as two-thirds of the span, or 30 in. (see Part III., Section 17).

This gives $S = \frac{225 \times 4 \times 36}{30} = 1{,}080$.

Beam 5b.

The effect of the haunch is to increase considerably the obliquity of the inclined compression, and may be taken into account by taking the rise of $h/2$ in the distance from the load to the beginning of the haunch.

This gives $l_1 = 30 - 2 \times 6 = 18$ in. and $S = \frac{225 \times 4 \times 36}{18} = 1{,}800$.

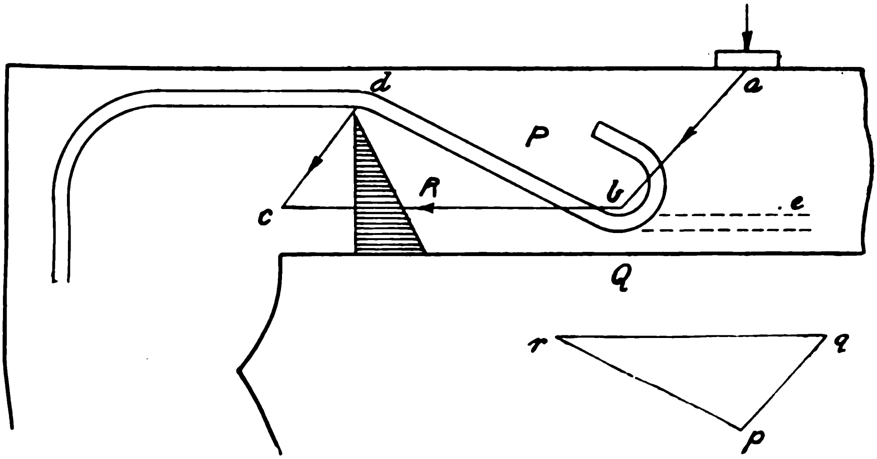


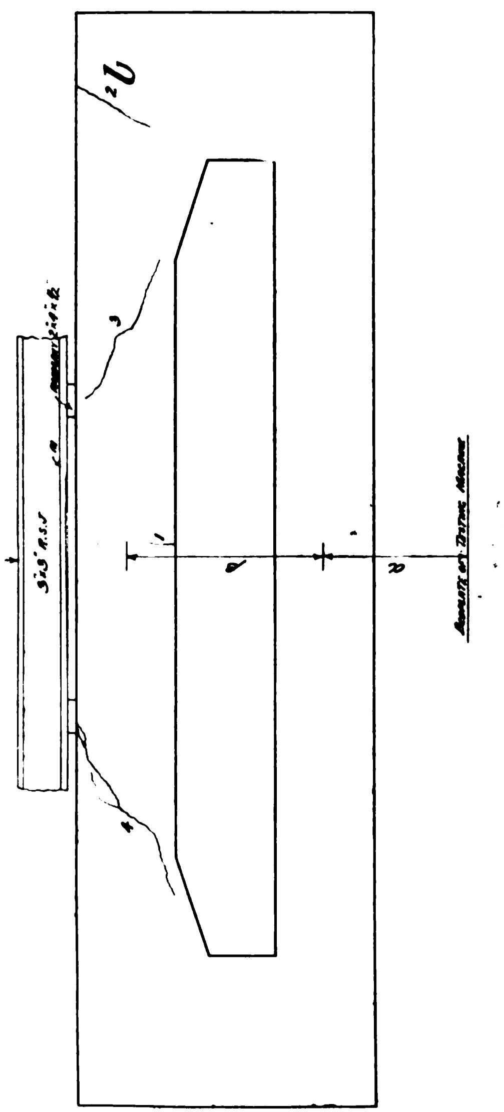
FIG. 102. INCLINED COMPRESS IN BEAM NO. 7*a*.

Beam 6a.

Shear due to stirrups 1,170

This causes $C = 146$, leaving shear due to inclined compression $1{,}080 \times \frac{454}{600} =$ 818

1,988



LOAD	LOAD CORRECTED	a (inches)	B (inches)	Deflection at a *	Deflection at b †	REMARKS
390	-	9.932	11.70	-	-	
3000	2610	9.932	11.70	-	-	
6000	5610	9.915	11.687	.017	.013	
9000	8610	9.900	11.675	.032	.025	
10000	9610	9.900	11.668	.032	.032	
11000	10610	9.900	11.660	.032	.040	
12000	11610	9.897	11.651	.035	.049	
13000	12610	9.897	11.635	.035	.065	
14000	13610	9.895	11.600	.037	.100	

LOADS	REMARKS
6000	1. Hair crack [illegible]
9000 to 10000	II. Small; 3
10000	4
11000	[illegible]

FIG 76

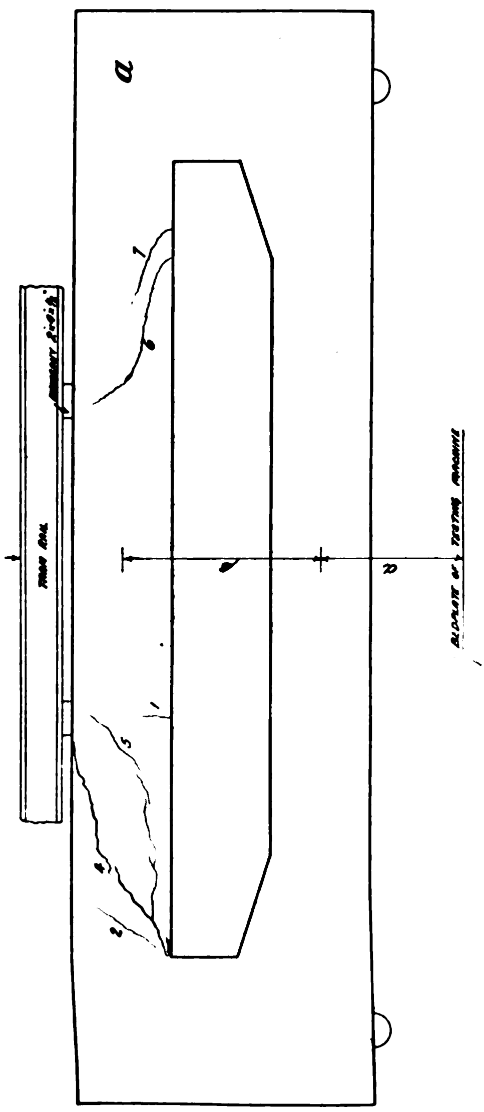
BEAM 5b

Beam 6b.

Shear due to stirrups	1,170
Inclined compression $1{,}800 \times \frac{454}{600} =$	1,360
	2,530

Beam 7a.

If the inclined bar had been a continuous one throughout the span, as in 7*b* and 8*b*, the only compressions would be two inclined ones from load to one bend and the other bend to the support.



LOADS	REMARKS
6000	1 FAINT HAIR CRACK
7.000	2 " " " ALSO 3 "
8000	2 CLOSED UP AND 4 OPENED INSTEAD 5 FAINT HAIR CRACK
9000	6 AND 7 IT WAS NOTICED THAT CRACK 4 (CAUSING FAILURE) OPENED VERTICALLY AND NOT DIAGONALLY THUS

LOAD	LOAD CORRECTED	a (INCHES)	B (INCHES)	DEFLECTION OF b *	DEFLECTION OF a †	REMARKS
520	153	8·385	11·770	—	-	NOTE. LOAD WAS APPLIED RATHER ON ONE SIDE OF BEAM
3000	2480	8·379	11·770	·016	-	
6000	5480	8·368	11·750	·027	·020	ZERO 365
7000	6480	8·362	11·73	·033	·040	" WITH WT OF TRAMRAIL = 520
8000	7480	8·360	11·719	·035	·051	
9000	8480	8 360	11·65	·035	·120	[illegible]

* MEASURED RELATIVE TO BASE
† " " " b

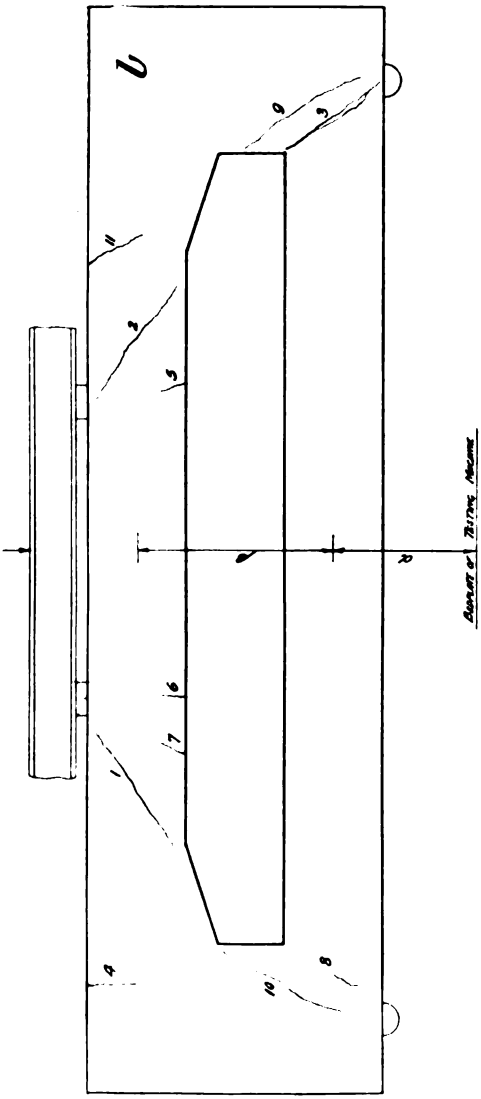
FIG 77

BEAM 5*a*.

Tested	5/5/11
Made	2/3/11
Age	64 Days

As it is, however, a little consideration will show that the inclined bar is only effective if held in equilibrium by the forces *ab* and *bc* in *Fig.* 102.

Unless prevented by the force *bc*, the effect of *ab* would simply be to lower the point *b*, which would not be so if the bar had continued to *e*.



LOADS	REMARKS
9000	1 and 2 — Note b side was tested before a.
10000	3
11000	4
12000	5 6 and 7
13000	8
15000	It was observed at this load that the beam was touching side of testing machine. This may have accounted for irregularities but was not considered to be of importance. The cracks were bigger on the back side of beam
18000	9
19000	10
21000	11 Failed by 1 and 2 simultaneously

LOAD	LOAD CORRECTED	α (inches)	β (inches)	Deflection of a *	Deflection of b †	REMARKS
270	-	10·432	10·738			
3000	2730	10·432	10·732		·006	
6000	5730	10·415	10·714	·017	·024	
9000	8730	10·404	10·684	·028	·054	
11000	10730	10·403	10·681	·029	·057	
12000	11730	10·413	10·672	·022	·066	
13000	12730	10·400	10·673	·023	·065	
14000	13730	10·399	10·652	·033	·086	
15000	14730	10·406	10·636	·026	·102	
16000	15730	10·398	10·618	·034	·120	
17000	16730	10·396	10·606	·036	·132	
18000	17730	10·397	10·597	·035	·141	
19000	18730	10·396	10·576	·036	·162	
20000	19730	10·391	10·525	·041	·213	
21000	20730					

* Measured relative to base
† „ „ „ „ a

BEAM 6b

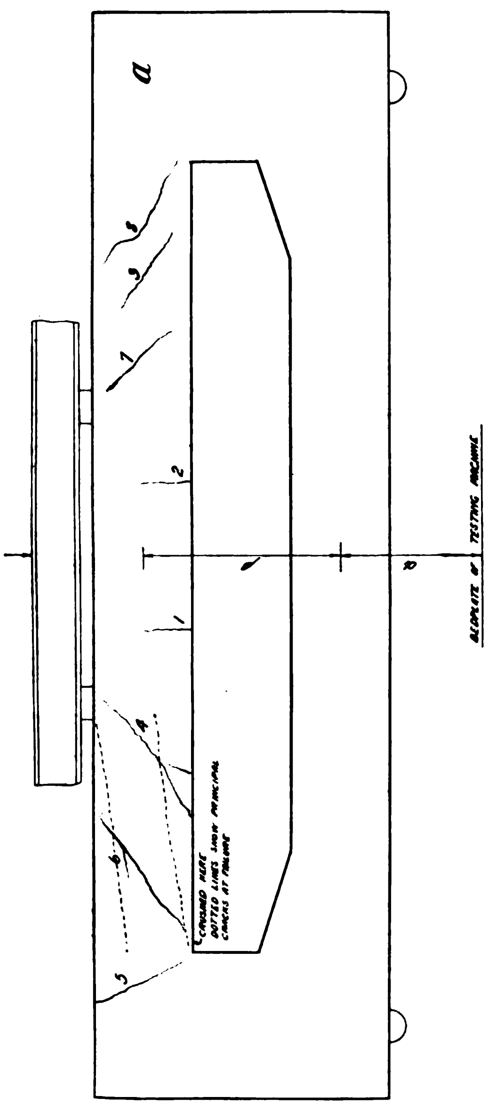
FIG 78

We must allow for these compressions as follows :—

Resistance of bar $= 0{\cdot}2 \times 16{,}000 \times \frac{4}{10} = 1{,}280$

Lettering the spaces *P*, *Q*, and *R*, and drawing the triangle *p*, *q*, *r*. of the forces acting about *b* in *Fig.* 96, we see that the force *cb* is equal to the sum of the horizontal components of *bd* and *ab*,

$$\text{or } 0{\cdot}2 \times 16{,}000 \times \tfrac{9}{10} + 1{,}280 = 4{,}180$$



LOAD	LOAD CORRECTED	α (INCHES)	β (INCHES)	DEFLECTION OF b *	DEFLECTION OF a †	REMARKS
270	-	9.044	10.612			
3000	2730	9.02	10.598	-.006	.014	
6000	5730	8.981	10.565	+.039	.047	
9000	8730	8.981	10.541	.029	.071	
11000	10730	8.986	10.496	.028	.116	
12000	11730	8.982	10.478	.032	.130	
13000	12730	8.987	10.446	.027	.166	
14000	13730	8.985	10.381	.029	.231	
15000	14730					

* MEASURED RELATIVE TO BARS
† " " " " b

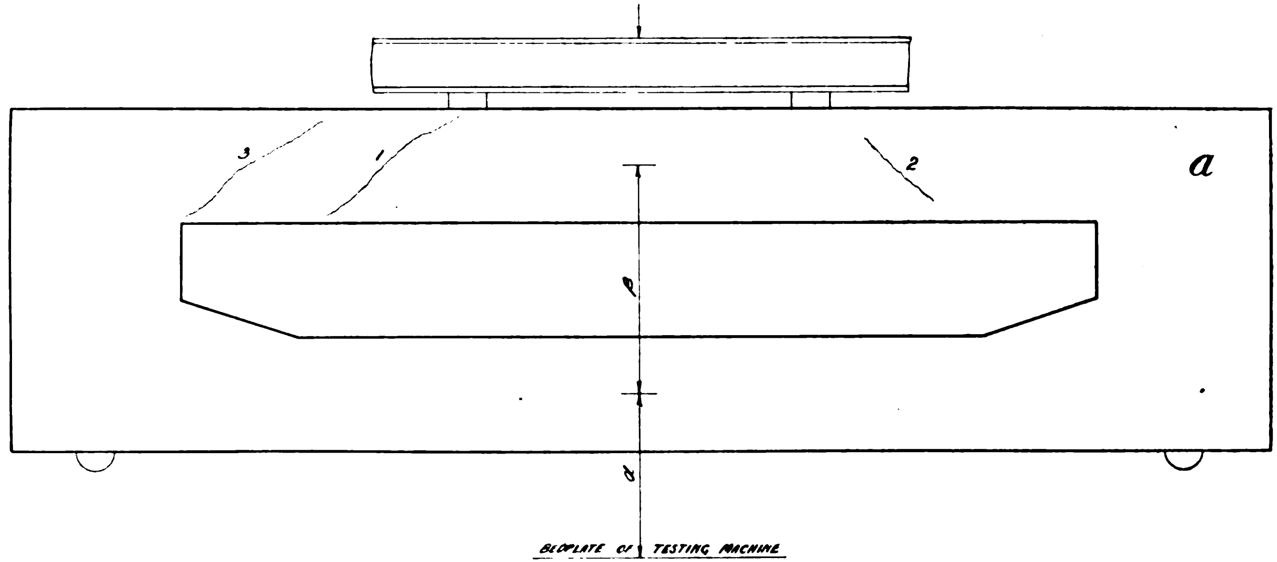
FIG 79

LOADS	REMARKS
6000	1 2 AND 3
8000	4 5. 6 AND 7
12000	*SEVERAL [illegible] PROMINENT CRACKS. ALL CRACKS SMALL
13000	8
14000	SHEAR CRACKS OPENING
15000	FAILED

BEAM 6a.

Tested 11/5/11
Made 2/3/11
Age ... ... 70 Days

CONCRETE



LOADS	REMARKS
6000	1 AND 2
9000	3
10300	BEAM FAILED AT 1 AND 2
	NOTE 'a' TESTED AFTER 'b'

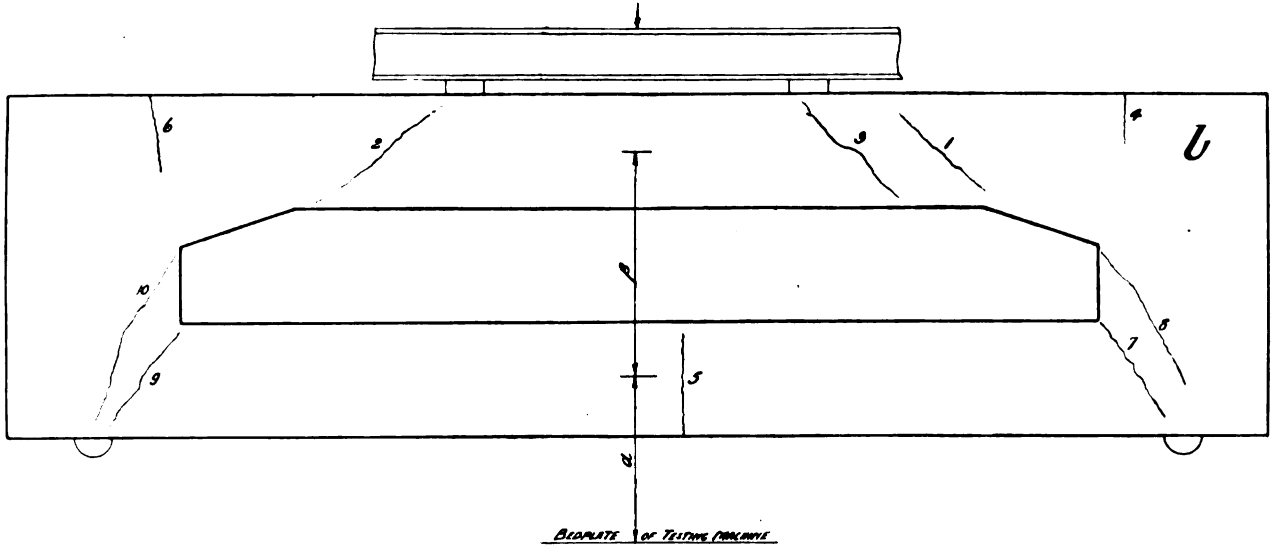
LOAD	LOAD CORRECTED	α (INCHES)	β (INCHES)	DEFLECTION OF b *	DEFLECTION OF a †	REMARKS
270		9·392	10·373			
3000	2730	9·378	10·364	014	·009	
6000	5730	9·361	10·339	031	·034	
9000	8730	9·356	10·279	·036	094	
10300	10030					BEAM FAILED

* MEASURED RELATIVE TO BASE
† " " " b

FIG 81

BEAM 7a.

Tested 11/5/11
Made 6/3/11
Age ... ... 66 Days



LOADS	REMARKS
9000	CRACKS 1 2 AND 3
12000	4 AND 5 AND ALSO SEVERAL SMALL +VE B M CRACKS ALSO 6 APPEARED
	CRACK 5 WAS OF EVEN THICKNESS THROUGH BEAM
17000	7 AND 8
18000	9
21000	10 BEAM FAILED SLOWLY

LOAD	LOAD CORRECTED	a (INCHES)	β (INCHES)	DEFLECTION OF a *	DEFLECTION OF U †	REMARKS
270		10·305	10·489			
3000	2730	10·309	10·475	−·004	+·014	
6000	5730	10·293	10·466	+·012	·023	
9000	8730	10·278	10·452	·027	·037	
12000	11730	10·285	10·444	·020	·045	
15000	14730	10·278	10·429	·027	·060	
18000	17730	10·269	10·400	·036	·089	
21000	20730	10·254	10·358	·051	·131	

* MEASURED RELATIVE TO BASE

† " " " a

BEAM 7U

FIG 80

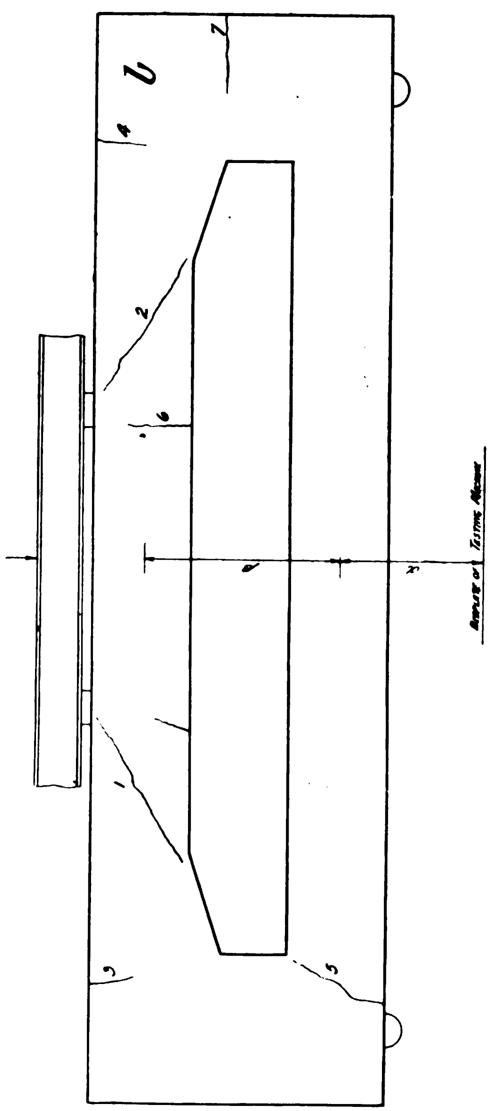
Assuming the stress diagram for this varies from a maximum at the lower edge to zero at three-fourths from the edge (as for the direct inclined compression), the fibre stress due to this is

$$\frac{4,180 \times 2}{4\frac{1}{2} \times 4} = 475;$$

to this has to be added the stress due to the force *cd*, which is

$$\frac{1,280 \times 2}{5 \times 4} = 128.$$

Hence the horizontal stress at *c* is $475 + 128 = 603$.



LOADS	REMARKS
9000	1 and 2
12000	3, 4 and 5 — Note "b" side was tested after "a"
15000	6
20000	7

LOAD	LOAD CORRECTED (+10% − 935)	α (inches)	β (inches)	DEFLECTION OF a *	DEFLECTION OF b †	REMARKS
935	–	9.503	10.188			
6000	5665	9.500	10.168	.003	.020	
9000	8965	9.476	10.146	.024	.042	
12000	12265	9.472	10.130	.031	.049	
15000	15565	9.468	10.122	.035	.066	
18000	18865	9.451	10.101	.052	.087	
20000	21065	9.442	10.078	.061	.110	
22500	23815					Beam failed shortly

* Measured relative to base
† " " " a

BEAM 8b

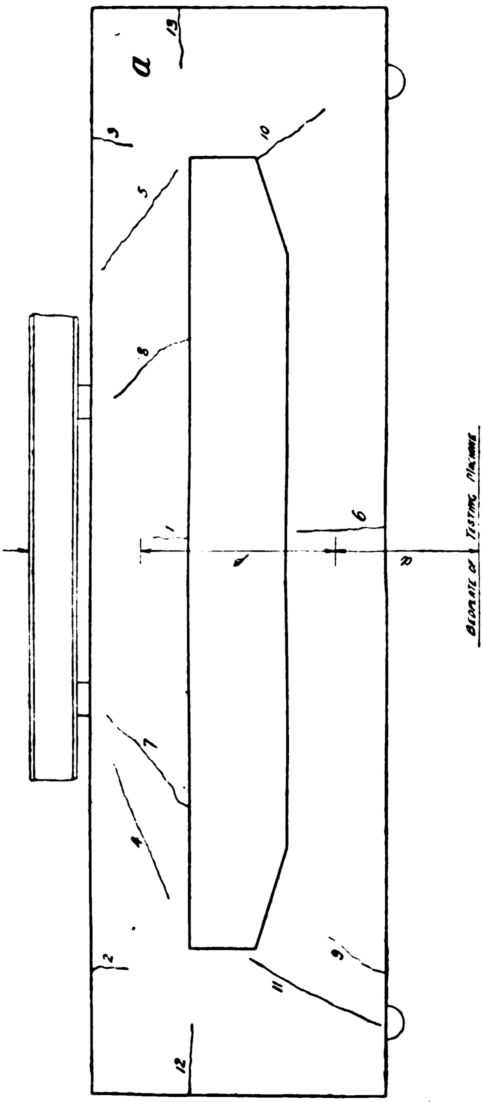
FIG 82

We must therefore in this case neglect the direct compression, since the concrete is already fully stressed.

Note that an alternative calculation would be to neglect the resistance of the inclined bar and take the direct compression in full, which would give us $S = 1{,}080$.

Beam 7b.

In this beam the inclined bar is carried along the beam, and is therefore held in equilibrium without calling into play the horizontal compression, as in *7a*.



LOADS	REMARKS
6000	Crack 1
9000	2, 3, 4 and 5
12000	6, 7, 8, 9, 10 Crack 6 quite free round beam
15000	11
17000	12
17000	13 Beam failed very slowly

LOAD	LOAD CORRECTED	a (mean)	b (mean)	Deflection of b •	Deflection of a +	REMARKS
270		10.278	10.346			
3000	2730	10.276	10.332	.002	.014	
6000	5730	10.276	10.318	.002	.032	
9000	8730	10.268	10.299	.010	.047	
12000	11730	10.262	10.278	.016	.068	
15000	14730	10.253	10.223	.025	.123	
17000	16730					[illegible]

FIG 83

BEAM 8a.

Tested 11/5/11
Made 6/3/11
Age ... ... 66 Days

We have

Resistance of inclined bar	1,280
This causes a concrete stress of $\frac{1,280 \times 2}{5 \times 4} = 128$, leaving $C = 472$ for the inclined compression.	
Resistance of inclined compression $= 1,800 \times \frac{472}{600} =$	1,420
	2,700

***Beam* 8*a*.**

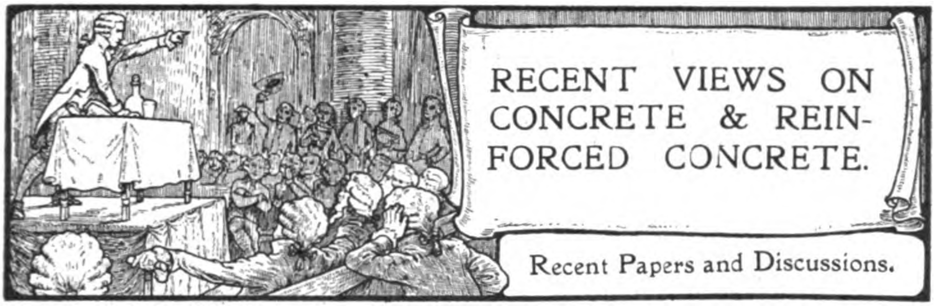
Resistance of stirrups	1,170
This causes a concrete stress of 146, leaving 454.	
It has been shown for beam 7*a* that the inclined bar acting in full causes a stress of 603, so we must confine the safe resistance of the bar to $1,280 \times \frac{454}{603} =$	960
	2,130

and neglect that due to direct inclined compression.

Beam 8*b*.

Resistance of stirrups	1,170
,, ,, bent-up bar	1,280
These cause a concrete stress of $146 + 128 = 274$, leaving 326 for inclined compression. Hence resistance of inclined compression $= 1,800 \times \frac{326}{600} =$	980
	3,430

(*To be continued.*)



It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.—ED.

REINFORCED CONCRETE: ITS APPLICATION TO PIT PROPS.

At a meeting of the Midland Branch of the National Association of Colliery Managers, held at the University College, Nottingham, on July 28th, Mr. W. A. Machin, of Birmingham, Assoc.M.I.Min.E., member of the Association, read the following paper on "The Use of Reinforced Concrete in Buildings and Mines, and its Application to Pit Props." We are able to reprint this paper and some of the illustrations by the courtesy of the National Association of Colliery Managers.

THE use and application of reinforced concrete to colliery and other work has developed very considerably during the last few years. It is owing to the fact that the co-efficient of expansion of concrete and steel are practically the same, being for concrete 0·000006 and for steel 0·0000065, that has made the introduction of this material (for it resembles an alloy) a practical proposition. The introduction of steel into concrete in proper form gives to the concrete a ductility scarcely to be credited, and forms a material unsurpassed for all classes of building purposes. This ductility was well demonstrated on observation of a beam under test, which gave a deflection of 0·2 in. under a load of 15 tons without the slightest sign of a crack on the tension or other side of the concrete, and even when the concrete had commenced to show fine cracks, due to overload, it was far from yielding.

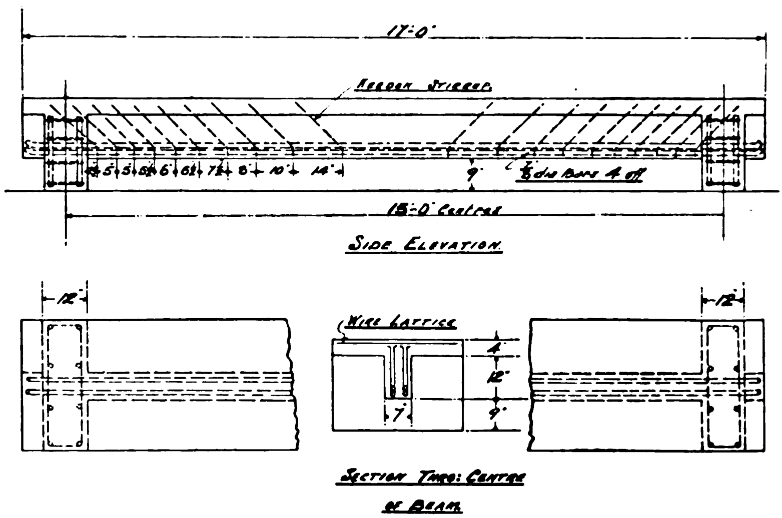
The many advantages to be gained by reinforced concrete have begun to be realised by architects, engineers, and others, which accounts for its rapid growth during the last few years. Its principal advantages over steel construction and brickwork are its everlasting qualities, fireproofness, and simplicity of construction, while in many instances it is economical.

Referring to its application to colliery work, which is the object of this paper, there are the surface buildings, such as engine house, pump house, headgears (these call for special attention), and other buildings which are familiar. It is now universally accepted as the best form of building construction, and a few instances of its application will give some idea of its possibilities:—New transit sheds for the Manchester Ship Canal Co.; coke bunkers, Dalmarnock, for the Glasgow Corporation Works; water tower, Knutsford; underground reservoir for water storage; open surface reservoir; staircase to Manchester Unity offices; cotton warehouse, Liverpool; railway station, San Domingo; car sheds, Fleetwood.

Considering that reinforced concrete has been used so successfully for all classes of construction, there is no reason to doubt that its application to pit props will be attended with success. They have been used on several occasions, and, so far as the writer knows, have given satisfaction. There are many advantages in the use of reinforced concrete for pit props; for instance, they are not subject to dry or wet rot, they are fire-resisting, and have a greater strength than the same sizes of wooden prop; they can be made from material around the surface of the pit, and do not require any special skill

A brief description of the Keedon ordinary reinforced-concrete prop will enable us to see how it is built up. The reinforcement consists of four steel bars of suitable diameter, which are linked at definite intervals with Keedon hoops. These hoops are wedged firmly to the bars with a small wedge at the corner of each hoop. When the bars, hoops and wedges are assembled, they form a complete unit in themselves, and a structure which is capable of supporting a considerable weight. The concrete is made of ballast 3 parts, sand 1½ parts, cement 1 part. It is mixed three times dry and three times wet. The water should be applied through a rose. This wet concrete is placed in wooden moulds (which have been previously prepared) to a depth of 1½ in. This should be well rammed and upon it placed the complete reinforcing unit, pressing the unit down until it is about 1 in. from the casing. The remainder of the concrete is now filled in and well rammed to eliminate all air spaces. The whole prop will set in two or three days, when it can be turned out of the mould and put by to mature.

The weight of these ordinary props is about 18 lb. per foot for props up to 7 ft. long. They are very little heavier and much more durable than the timber at present used in mines. A Keedon prop 6 ft. long by 4½ in. square has an ultimate breaking strain of 50 tons



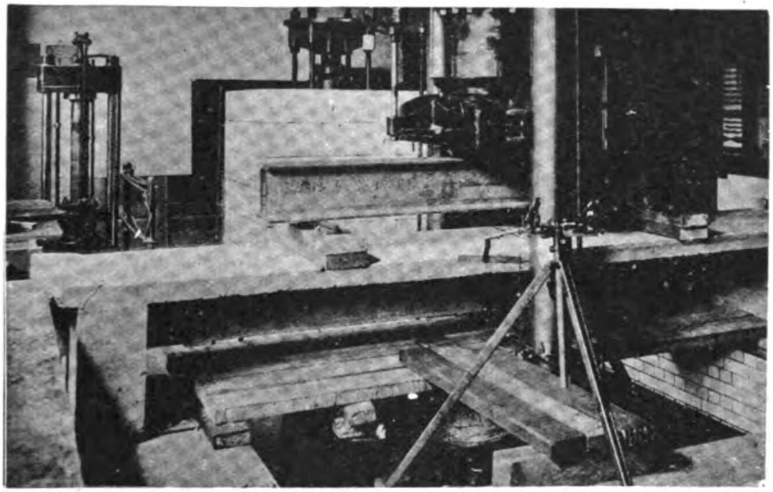
The writer has designed a special prop for the purposes of supporting the roof by means of the system known as "cockering" and "herring-boning." Every colliery manager who has had any experience in setting this type of timbering knows that it is only the very skilled workmen that he can entrust with the task of erecting them, and also how useful they are when they are in position. Therefore, to make the erecting a little easier, the "cockering" prop has been designed. It is a reinforced-concrete prop with a ledge at the position where the prop which supports the centre longitudinal bar is placed. It is made much stronger than the ordinary prop about the position of the ledge and below it. It does away with a small prop entirely, and the whole structure is more stable.

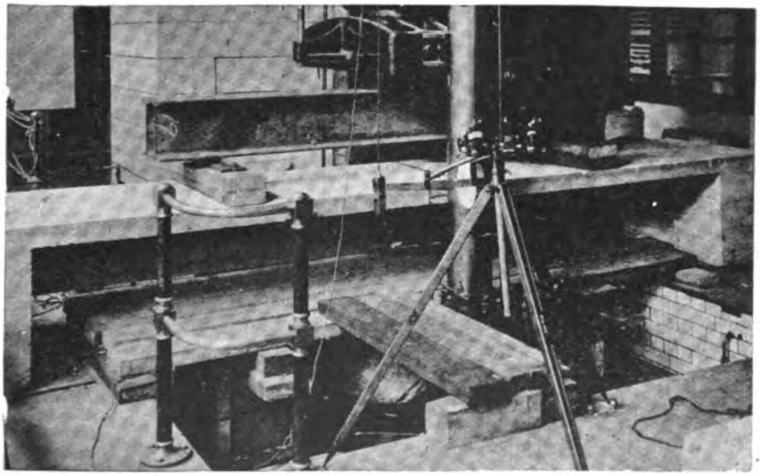
Another prop which has proved very satisfactory in lengths up to 6 ft. consists of three steel bars, fastened together in a similar manner to the Keedon prop. Tests have been made with two of these props and two Norwegian larch wooden props. The wooden props were of very good quality and well seasoned.

Concrete is composed of 1 part best Portland cement, 3 parts selected coal blast-furnace slag, and 1 part of clean coke breeze. The latter is used to reduce weight.

The advantages of concrete props over the usual timber prop may be summarised thus:—(1) They can be made much stronger; (2) they are fireproof; (3) they are not subject to dry or wet rot; (4) they have not to be renewed so often; (5) at the present moment, if a large quantity of props were used, it would release a quantity of shipping for other work.

Discussing the advantages in the order tabulated, we note that the first relates to strength. A few experiments, results of which are shown in the following table, have been conducted to prove this.





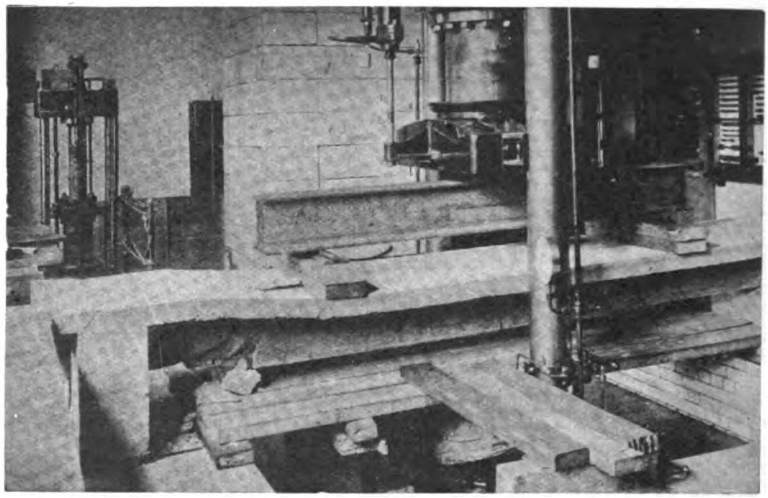
TESTS OF REINFORCED-CONCRETE PIT PROPS.

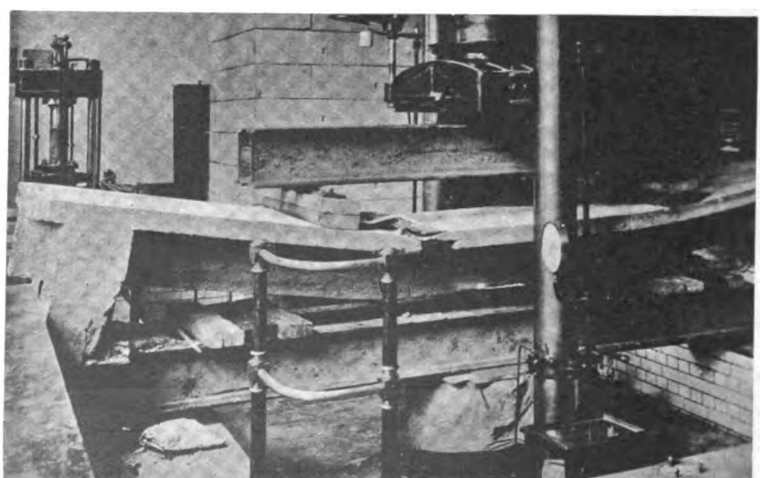
Test No.	Description.	Length.		Shape and dimensions.	Base area (approx.)	Ult. load. Per sq. in.		Remarks.
		ft.	in.		sq. in.	Lbs.	Tons.	
1402	Wooden pit prop (Norwegian larch)	5	10¾	Round, 6¼ in. mean dia.	30·7	2,670	1·19	Failed at mid length.
1403	Do.	5	11¾	Round, 5¾ in. mean dia	26·0	4,080	1·82	Failed at one end.
1404	Reinforced concrete. A pit prop (3 vertical rods, ¾ in. dia.).	6	0	Square, 4½ × 4½ in., with corners chamfered to 1¼ in. flats.	18·5	3,840	1·71	Failed at mid length.
1405	Do. B.	6	0¼	Hexagon, 4¼ in.	17·5	3,540	1·58	Failed at one end.

NOTE.—Load applied at 10 tons per minute. Ends of props only roughly squared. Tested against 9-in. × 3-in. deal walings.

(1) From the experimental results, it will be seen that concrete props can be made much stronger than wooden ones. It goes without saying that this is a great point in their favour, because the cost of renewals will be proportionately less. It is common knowledge that a prop or bar costs more to renew it than it is worth, without taking into consideration the possibility of the roads being stopped through dirt having to be removed in the wake of broken timber.

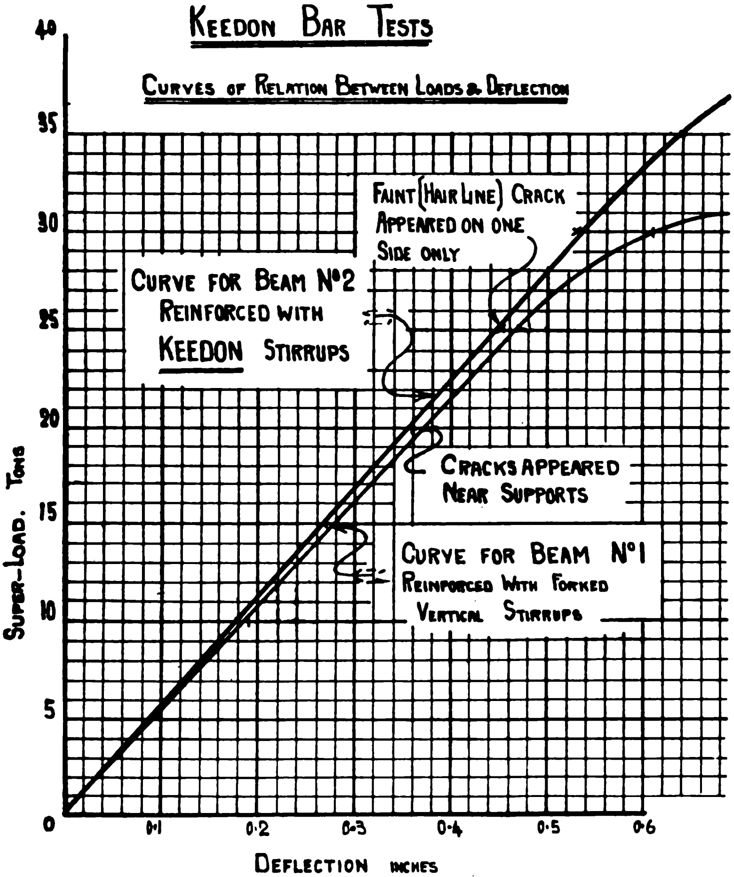
(2) They are fire-resisting. This factor is of great importance, in view of the liability of mines to gob-fires. Timber props on the side of roadways, after a fire has once broken out, feed it, and make it very difficult to successfully combat. The writer





has known a fire caused by the fusing of an electric cable to burn for weeks with only the timber props and combustible material in the shales to feed it. Had the roadways been supported with concrete props and girders the fire would nave been immediately overcome, and in all probability would never have started. The heavy expense of reopening a road which has been on fire is well known; practically a new road has to be made, whereas if the supports had been "fireproof" they would still be performing their usual functions, even if they had not stopped the fire beginning. In mines liable to spontaneous combustion these props would be useful, and the writer believes some such support will become compulsory on the roadways in the near future. Some collieries are considering this question, and are not only using concrete props, but lining the whole of the main roads with concrete, making it fire-resisting and incidentally permanent. In attacking a gob-fire it is absolutely necessary that concrete or other fire-resisting props should be used.

(3) They are not subject to dry or wet rot. Mine timber is specially subject to this defect. The troubles which it causes are:—(*a*) Constant renewals; (*b*) falls of roof, with their usual evils. Reinforced-concrete props would eliminate this trouble. In one particular case known to the writer timber props rotted away at the foot



every six months, and had to be renewed. Eventually reinforced-concrete props were substituted, with the result that for two and a half years not a single prop has been renewed.

(4) They have not to be renewed so often. Owing to their greater strength and other qualities these props have a much longer life than timber props; therefore, less labour is required to renew them.

Weight, etc.—This is not such a great disadvantage for roadway support as for face work. The writer does not advise their use on the face, only at the gate ends, where they can be easily recovered. Reinforced-concrete props cannot be hammered in the same way as a wood prop, and any such necessity would not present itself after the workmen had become accustomed to their use. Finally, the cost of these props compares favourably with the wood props; in fact, to-day they are much cheaper.

While discussing the application of reinforced concrete for use underground, it may be of interest to learn of some other uses to which it is being put. Its use makes an excellent roadway; it can be used chiefly in cruts and drifts, and is applicable also to main roads. In some cases girders are bent to suit the size of the proposed roadway, and concrete is placed between the girders; this method is practically out of the question at present on account of the difficulty and expense in obtaining the girders, but it may be done by a much cheaper method. The materials required are bars of steel, about 2-in square, bent to suit the shape of the proposed roadway, old ropes, and concrete. A few ordinary railway rails are bent to the shape of the roadway. Around these is built a covering of wood to form a bed for the concrete, and two or three inches away bars of iron are placed at a distance apart of 18 in. to 2 ft. Old ropes are placed 1 ft. to 18 in. apart on these bars and fastened with some thin wire at the points where they touch the bars. This forms a fairly strong structure at very little cost. The concrete can now be placed over the bars and properly filled in, other ropes being fixed in loosely as required, and the main supports being left in until the concrete sets. The concrete becomes stronger with age.

THE EFFECTS OF GRADING OF SANDS AND CONSISTENCY OF MIX UPON THE STRENGTH OF PLAIN & REINFORCED CONCRETE.

By L. N. EDWARDS,

Supervising Engineer of Bridges for the City of Toronto.

THE following is a short abstract of a paper read by Mr. Edwards at the recent convention of the American Society for Testing Materials, held in Atlantic City, June 26th to 29th. The paper presented the results of three series of tests made by the Department of Works of the City of Toronto, under the direct supervision of the author. These tests were undertaken with the object of securing information relating to (1) the influence of the grading of sand; (2) the effect of the consistency of mix upon the strength and physical characteristics of the concrete properties; and (3) the effect of varying the time of mix. The author drew the following conclusions:—

COMMON PRACTICES UNRELIABLE.

1. The commonly practised "visual examination" test of sand aggregate for concrete is generally unreliable, since it gives at best only a superficial knowledge of the cleanliness of a given sand.

2. The generally accepted practice of proportioning a concrete mix by volume, as, for example, 1 part cement, 2 parts sand, and 4 parts broken stone, is impracticable and unscientific, since it does not take into account the adaptability of the grading of a given sand to the production of a dense, strong, and reliable concrete. Proportioning by volume, as commonly used, gives no guarantee of the production of a concrete having a desired strength, hardness, or other physical properties.

3. The strength, toughness, and durability of the concrete to be secured from the use of a given sand can be determined only by an actual test of that sand in a properly prepared concrete.

4. In field operations incident to spading, slicing, or otherwise compacting the concrete, the movement of the water content of the mass is intensified whenever the sand aggregate contains insufficient fine material to hold the cement in suspension by the formation of an adequate amount of sandy paste. The free movement of the water tends to produce an improper distribution of the cement.

AMOUNT OF WATER.

5. The use of a quantity of water sufficient to produce a concrete, the mortar component of which is of a saturated, sticky, semi-plastic consistency, is for most practical purposes required in order to facilitate economical and efficient placing. This quantity of water is ample for the development of the proper functions of the cement. An increase in the quantity of water used results in a proportionate decrease in the strength of the concrete. This decrease is in no sense a function of the proportions of the mix.

6. The excess water in an over-saturated concrete necessarily occupies space and thereby bulks-up the mass. By reason of its high surface tension, it forms water globules which, although somewhat affected by the weight of the concrete, are, nevertheless, distributed throughout the mortar component, and are accumulated underneath the particles of the sand and stone aggregates and the reinforcing steel. By evaporation, this excess water ultimately disappears, leaving a considerable volume of water voids and cavities, which constitute an extremely important factor in the strength and reliablity of the concrete.

BOND BETWEEN CONCRETE AND REINFORCING.

7. The critical failure of reinforced concrete depends upon the intensity of the bond existing between the concrete and the steel reinforcement. Concrete containing an excess of water not only develops less surface contact with the steel on account of the resulting increase in the volume of water voids and cavities, but, in addition, the excesive laitance produced by the water tends to accumulate around the reinforcement, thus contributing materially to a decrease in strength. This condition becomes further aggravated by reason of the tendency of the laitance to become less resistant with age.

8. For the various grades of concrete, the minimum ultimate strengths assumed in the modern practice of plain and reinforced concrete design are not assured by the commonly specified requirements for sand and stone aggregates, and by the present lack of uniformity and of efficiency in field methods and operations.

9. The results obtained show no definite relation between the compressive strengths of 1 : 3 mortar cubes and the compressive strengths of the concrete produced from the same sands.

In the course of the paper the author took occasion to submit the following specifications for a cement to be used for general concrete purposes :—

Sand shall be of hard, preferably silicious, material, clean, rough, free from dust, soft particles, vegetable loam, or other deleterious matter. It shall consist of particles graded from course to fine, of sizes that will pass, when dry, a sieve having four meshes per linear inch. The grading of particles shall otherwise conform to the following :—

Not more than 80 per cent. shall pass a sieve having 10 meshes per linear inch, not more than 55 per cent. shall pass a sieve having 20 meshes per linear inch, not more than 15 per cent. shall pass a sieve having 50 meshes per linear inch, and not more than 5 per cent. shall pass a sieve having 100 meshes per linear inch. Upon the 10, 20, and 50-mesh sieves an allowable variation of 5 per cent. will be permitted.

Sand, when combined with a normal Portland cement and 1-in. broken granite, limestone, or trap of good quality, in the proportions 10 lb. of cement, 21 lb. of dry sand, and 35 lb. of dry broken stone, thoroughly mixed with 4¼ lb. of water for not less than one minute, and moulded into cylinders 6 in. in diameter by 12 in. long, shall develop a compressive strength of 1,300 lb. per sq. in. when tested at the age of seven days and a strength of 2,200 lb. per sq. in. at the age of thirty days. Strength shall be determined from an average of five cylinders tested at each age. The cylinder shall be removed from the form 24 hours after moulding, and shall be stored in a moist closet or in damp sand until tested.

Sand failing to develop the above strengths may, at the option of the engineer, be accepted for use, provided that the proportion of cement be increased by an amount sufficient to fulfil the strength test requirements.

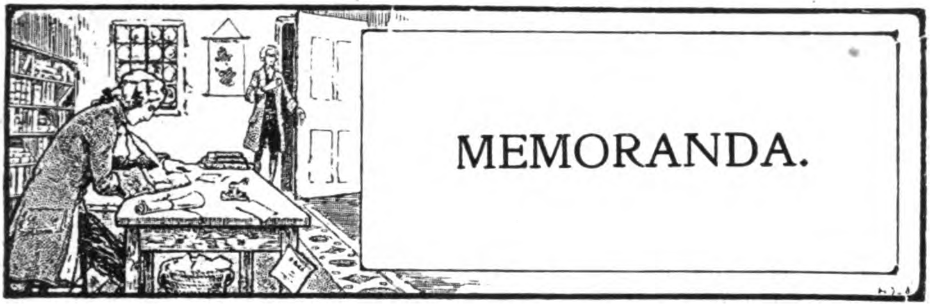
A REINFORCED CONCRETE TAR AND LIQUOR TANK AT BLANDFORD.

At a recent meeting of the South-West of England Association of Gas Engineers Mr. G. F. Dunn, engineer and manager of the Blandford Gas Company, Ltd., gave some interesting particulars regarding the construction of a tar and liquor tank in reinforced concrete. The provision of the tank was a war-time requirement, made necessary by the repeated failure in the supplies of sulphuric acid for the production of sulphate of ammonia. The following is an abstract from the paper:—

THE site chosen for the tank was under an existing oxide shed; the nature of the subsoil being known to consist of chalk. It was also fairly certain that water would not have to be contended with. It was proposed to excavate to a depth of 12 ft. by 30 ft. in length by 15 ft. 6 in. wide; and the author hoped to be able to dispense with the use of timber for shoring purposes. This hope was fully realised; and never for a moment was there any suggestion of a fall of the subsoil. For the concrete, the aggregate selected consisted of ½ in. granite chippings, coarse grey Sitcheth sand, and slow-setting Portland cement. It was decided to form the concrete of 3 parts aggregate, 3 parts sand, and 1½ parts cement. The reinforcement was to consist of six 1-in. vertical tubes, one being placed at each of the four corners, and an additional tube placed 14 ft. 7 in. from either of the corner verticals at both sides. The vertical tubes were connected by two tubes fixed horizontally; one being connected 3 in. from the point where the walls would meet the roof of the tank, and the other connected 5 ft. below. Solid drawn No. 8 gauge steel wire, secured to the vertical tubes, was stretched from tube to tube. The wires were placed 12 in. apart; the whole forming a skeleton frame. The corners were further strengthened by means of steel wire secured in the form of triangles placed horizontally. The vertical and horizontal tubes were all filled with neat cement, to exclude all air and increase their efficiency. The rolled steel joists forming part of the roof were of British steel, each having a safe permanent carrying capacity of 10 tons for a span of 14 ft. These were connected with No. 6 gauge steel wire, placed 12 in. apart, under and over alternately; provision being made for the whole of the iron and steel work to be covered or buried in the concrete.

After the bottom of the excavation had been carefully levelled and pounded, further chalk was taken out to receive the footings of the side walls. The thickness of the side and end walls of the tank, owing to the dressing necessitated by the removal of flints, was increased from 8 in. to an average thickness of 10 in.; the footings protruding some 6 in. on either side. Granite, sand, and cement alike were sifted; the two former being in addition washed. A wooden frame, capable of holding exactly 1 cubic yard of material, was used to measure the parts required to be mixed. To guard against the possibility of error in quantities, two pieces of lath were secured to the interior sides at the required height. Granite was placed in first, followed by sand, and finally cement on the top. The frame was then removed, and the contents thoroughly mixed in the dry state while another quantity was being measured. Frame plates borrowed for the purpose were then placed in position and bolted together. The lengths of the plates was in such variety as to make it comparatively easy to form a complete frame, enabling the walls to be taken up continuously to a height of 2 ft. all round. Everything being in readiness, the concrete was lowered to the man responsible for tipping the contents into the recess forming the walls. A layer of concrete 3 in. in thickness was laid around the entire walls of the tank. The foreman meanwhile using a wooden rammer, the concrete laid was well pummelled until the air-bubbles had been excluded and the voids filled in. It was found possible to raise the walls 2 ft. each course of the plates, until a height of 6 ft. had been reached. The bottom plates were then removed and fixed above the others.

After the height fixed for the roof had been reached, we excavated an additional foot of subsoil, and filled the trench with concrete formed as before. The purpose in view was to ease the walls of a portion of the weight of the roof and the material that might afterwards be stored above it. Needless to say, the concrete was well rammed round the whole of the iron forming the reinforcement. The steel joists were next placed in position. They were put 3 ft. apart; provision being made for two manholes, one formed at either end. The average thickness of the roof was 12 in. The steel joists were so placed as to be submerged in concrete on all sides. To avoid damaging the bottom of the tank while constructing the sides and roof, the floor was left to the last; the material being lowered through the manholes. After the plates had been removed, all irregular parts were carefully pointed with neat cement, and the whole of the walls, top, and bottom were washed down twice with cement wash. To facilitate the examination of the suction and delivery pipes, safeguard against a possible nuisance, and prevent loss of ammonia, four 6 in. flanged sockets were fixed in the concrete, with flanges to the top, to receive blank flanges. Arrangements were made for a 1½ in. pipe to carry off the displaced air to a small purifier to be fixed for the purpose. The capacity of the tank is 25,703 gallons.



Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

The Government and the Housing Question.— According to information which has appeared in the daily Press and elsewhere, the Government have decided to afford financial assistance for the building of the large number of houses which will be required after the war. The *Daily Telegraph* reports that the President of the Local Government Board has appointed a committee to consider the question of building construction in connection with the provision of dwellings for the working classes. "The principal tasks of the Committee," says the *Daily Telegraph,* "will be to consider some means of building the class of houses required at less cost, if possible, than at present, without making them less convenient, less comfortable, and less attractive. The Committee will inquire how far standardisation is possible, and also how far new materials are available as compared with those utilised in pre-war structures. For instance, ferro-concrete has not as yet been used in the building of working-men's houses. These and other practical and technical questions will be considered in the light of modern knowledge and experience. It is probable that the question of design or designs will be dealt with separately. The Committee, whose chairman has taken a great interest in this vital question of housing, is determined, without undue delay, to explore the whole problem thoroughly, and, it is understood, will not confine itself merely to receiving statements and hearing evidence, but will also make experiments."

The Committee is composed of :– Sir John Tudor Walters, M.P. (chairman); Sir Charles Allom; Mr. F. Pains, M.V.O.; Mr. James Boyton, M.P.; Mr. William Fairley, M.I.C.E.; Mr. G. Marlow Reed; Mr. J. Walker-Smith, A.M.I.C.E.; Mr. J. Squires; Mr Raymond Unwin, F.R.I.B.A.; and Sir Aston Webb, K.C.V.O., C.B. Mr. E. Leonard, of the Local Government Board, will be secretary to the Committee.

Iron and Steel Institute.—The autumn meeting of the Institute will be held, by kind permission, at the Institution of Civil Engineers, Great George Street, Westminster, on Thursday and Friday, September 20th and 21st, 1917, commencing at 10.30 a.m. on the 20th and at 10 a.m. on the 21st.

University of Manchester (Courses of Technology).—The session 1917-18 commences on Thursday, October 4th. Classes will be held in every branch of technology, special attention also being paid to research work.

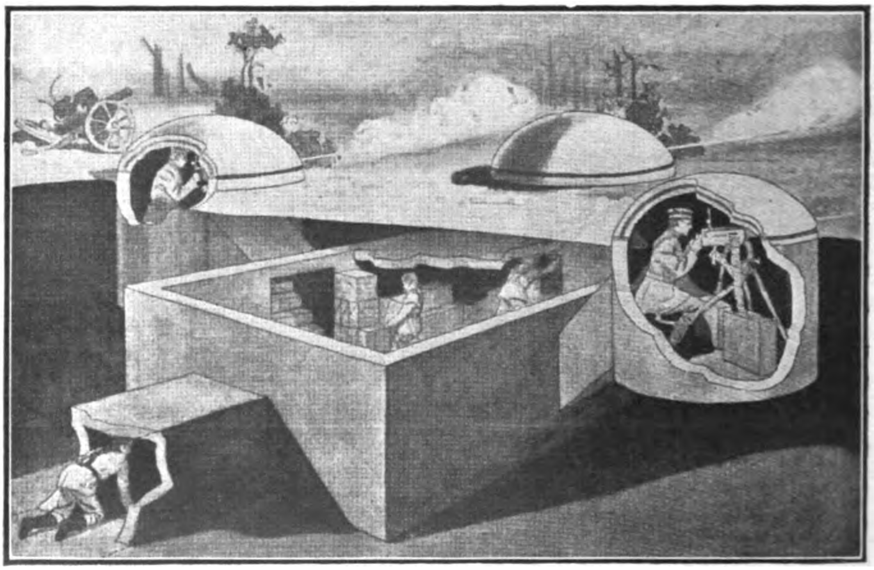
The City and Guilds of London Institute (Department of Technology).— The programme for the session 1917-18 has been issued. Applications for the registration of classes in technology, etc., or for the renewal of the registration of such classes previously registered, must be received at the offices of the Department of Technology, Exhibition Road, London, S.W.7, not later than October 27th. Copies of the programme, price ninepence net (postage extra), may be obtained from any bookseller, or from Messrs. Lamley and Co., 1-5, Exhibition Road.

British Prisoners of War and their Studies.—In connection with the book scheme inaugurated by Mr. A. T. Davies, at the Board of Education, to supply British prisoners of war with books for study, contributions in aid of the scheme are urgently needed. In the technical and scientific sections the prisoners' demand for books is very large, but the works asked for are rarely obtainable as gifts, as the owners generally need them for their own use, while second-hand copies sufficiently up-to-date are proving increasingly difficult to procure. In these circumstances the Committee are compelled to make large purchases of new copies of up-to-date books of the above character, and for this ample funds are essential. Donors to the scheme will recognise that their gifts do not merely help to save the prisoners from mental starvation, but also increase their value as a commercial and professional asset after the war. Offers of books (which should always be accompanied by a detailed list) are also invited, and should be addressed to Mr. A. T. Davies, C.B., "Prisoners of War," Board of Education, Victoria and Albert Museum, South Kensington, S.W.7.

Reinforced Concrete Railway Sleepers.—In continuation of the review which appeared in our July issue it is proposed to publish details of further information which has come to hand on this important subject in our October issue.

Concrete in the Italian War Zone.—The *Times* reports that theatres of concrete and wood have been erected in the Italian war zone for performances for soldiers.

Concrete Fortresses at the Front.—In our June issue we made reference to the field fortress known as the "Mebu," constructed by the enemy. By the courtesy of the editor of *Popular Science Siftings*, we are able to reproduce the accompanying illustration and additional details of a Mebu Fortress. It consists of three independent machine-gun pits connected with a central subterranean store chamber, which in turn is reached by an underground passage-way from the rear. Each machine-gun pit is sufficiently large to accommodate a machine-gun and gunner.



A Reinforced Concrete "Mebu" Fortress.

Concrete in Spain.—In connection with one of the large hydro-electric plants recently erected in Spain it is stated that a concrete dam has been built, 330 ft. high and 700 ft. long.

A Large Reinforced Concrete Factory.—H.M. Consul-General at Chicago, Mr. H. D. Nugent, C.M.G., reports that a company has acquired a site of twenty acres for the establishment of a large can manufactory. The erection of a four-storey reinforced-concrete building, containing approximately 1,000,000 sq. ft. of floor space, is to be commenced immediately. It is claimed that the plant when complete will be one of the largest and most up-to-date can factories in the United States, employing 3,000 hands; every facility will be provided for the rapid and economic handling of a very large volume of business. A striking feature of the plans for the building and plant is the receiving platforms, 300 ft. long, with twenty-seven parallel sidings, each with capacity for eight cars, connecting up eventually with one of Chicago's railway systems.

Some Further Notes on Concrete Shipbuilding.—We learn from the daily Press that the first Norwegian reinforced concrete ship was launched at the end of August. To quote the Christiania correspondent of the *Times*:—"The ship is built on an entirely new system, with the bottom upwards, in which extraordinary position the launching took place on a sort of underlying sledge, which glided out with the ship. When the water was reached the hull became detached from the sledge, and gradually sank up to a certain point, then subsequently slowly righted itself." This particular ship, which is of 200 tons burden, was built in three weeks.

Canada. — In the course of an article which appeared in *The Canadian Engineer* on reinforced concrete ships, Mr. J. L. Weller, M.Can.Soc.C.E., consulting engineer, St. Catharines, Ont., says:—

"The construction of ships of reinforced concrete has been advocated by quite a number of engineers who have had more or less experience in somewhat similar work, but, like most new ideas of a revolutionary character, it is extremely hard to convince capital that they should be adopted.

"The scow *Pioneer*, built in 1910 by the writer (see *The Canadian Engineer*, December 15th, 1910), is still in excellent condition, although there have been no maintenance charges. The length over all of this vessel is 80 ft.; beam, 24 ft.; sides, 7 ft. high. She is divided into eight compartments by a longitudinal bulkhead and three cross bulkheads. The deck, bottom, sides, and bulkheads are 2½ in. thick reinforced with ¼-in. steel wire running longitudinally and transversely. In addition to the bulkheads the steel is supported by beams and posts, generally 6 by 8 in.

"The concrete was placed in the usual manner in reinforced concrete work. A platform was first laid on blocking about three feet above the level of the canal bank, upon which the bottom of the scow was constructed; the bottom beams were next built, the interior forms erected, and the posts, sides and bulkheads completed, after which, for convenience, the interior forms were removed and the forms for deck and deck beams erected, and both completed. The scow was then stripped, given a coat of grout, and launched on five ways in the usual manner.

"The interior forms were built as far as possible in uniform sections, and can be used again in similar work.

"To-day much more is known about the properties of reinforced concrete than when the scow was built, and engineers are now able to calculate with extreme accuracy the strength of reinforced concrete structures. Cement is more reliable than it used to be, and concrete of remarkable strength and homogeneity can now be made without any question as to its reliability.

"The building of reinforced concrete ships thus becomes a matter of sound theory, good judgment in design, and practical knowledge of construction.

"Concrete ships may not be quite as economical of operation as steel ships on account of their extra weight, but when capital and repair accounts are taken into consideration it is not so certain that they will be at any great disadvantage. They require no painting, no renewals of rivets, and repairs to the hull, when required, can be made at a fraction of the cost of the repairs to a steel hull. The first cost of a concrete hull will be considerably less than half the cost of a corresponding steel hull.

"The writer has of late been engaged on reinforced concrete steamship design, and hopes to be able to build a 3,000-ton ship this summer, as it is extremely advisable that one ship at least should be tried out as soon as possible in order to be ready to cover the seas with them next summer, should it be necessary to do so.

"The financial problem is, however, a severe one, as insurance companies are slow in taking up such a new and radical departure from established precedent.

"There is also the unfortunate fact that some attempts to build concrete scows have not been entirely successful, owing to poor design or to poor workmanship. One very unfortunate thing about concrete is that it is so willing to do its share of everything it is put at and succeeds so well, where it gets any chance at all, that, like the willing horse, it is very much abused, and parties with a very perfunctory


STEEL SHEET PILING AND PILE DRIVING EQUIPMENT.
Waistcoat Pocket Information Culled from General Catalogue
He's got his Copy Have You!

knowledge of its real merits and capabilities often try to make it do things without giving it the support of the technical knowledge and experience which are necessary to success.'

Repairing Softened Concrete Lining to Tunnel.—It is proposed to adopt the following method of repair for the concrete lining to the Cascade Tunnel, Great Northern Railway, U.S.A., which had softened, due to the formation of sulphur compounds formed from sulphur in the locomotive gases and the cement. As the lining was put in principally to protect the rock face against disintegration, and not for strength, and as the steam locomotives are now superseded by electric traction, it is thought that repairs made will be permanent:—

(1) Clean the entire area of sidewalls and arch, removing all disintegrated portions. (2) Drilling 2-in. holes where necessary to provide additional drainage. (3) Drill 4-in. holes in the arch where necessary and fill cavities existing back of the concrete lining with sand filling or grouting. (4) Replace all disintegrated portions of the lining with a coating of concrete by a cement gun. The specifications provide that where the coating is over 3 in. deep it shall be supported by a triangular wire mesh—American Steel and Wire Co.'s No. 28 A—cut to fit and fastened to the old concrete by spikes driven into holes drilled in the concrete, 24 in. apart. The mixture for use in the cement gun will be 1 part Portland cement and 3½ parts sand, mixed dry. After cleaning, the surface of the concrete is to be sprayed with an alkaline solution for neutralising the acid in the concrete. The plans will be carried out under the supervision of A. H. Hogeland, Chief Engineer of the Great Northern Railway Company, U.S.A. (*Engineering News-Record.*)

Concrete Roads.—New specifications for roads, issued by the Highway Department in the State of Ohio, under the direction of Clinton Cowen, State Highway Commissioner, have some interesting provisions regarding the specifications for concrete pavement.

In proportioning, for instance, the specification reads as follows: "The ingredients of concrete shall be mixed in the proportion of one sack of cement to 1½ cu. ft. of fine aggregate and not more than 3 cu. ft. of coarse aggregate. The mortar shall always be more than enough to fill the voids in the coarse aggregate. If necessary to secure this result, the proportion of coarse aggregate shall be reduced. In general, this will require from seven to eight sacks of cement per cu. yd. of concrete, depending upon the class of aggregate used and the percentage of its voids." There is no method given, however, of determining when the voids are filled.

Consistency Requirements.—In consistency the new specification is as follows: "The materials for the pavement shall be mixed with only sufficient water to produce a concrete which will settle very slowly when deposited in a pile and which will hold its shape when struck with a templet. The consistency shall not be such as to cause a separation of the mortar from the coarse aggregate when handling. After the concrete has been lightly tamped, there shall be no free water in evidence. Individual particles of the coarse aggregate when so isolated shall show a coating of mortar containing its proportionate amount of sand." In this specification also there is no quantitative measure for any of the results demanded.

For machine mixing, it is required that the mixing shall continue at least one minute until the drum has made not less than twelve revolutions at a speed of between 12 and 18 r.p.m. before any part of the batch is discharged.

Finishing the Concrete.—For the finishing of the concrete very definite information has been given. As the finished surface must conform within ¼ in. to the templet or straight-edge laid parallel to the centre line, the procedure is given. By a combined horizontal and crosswise motion the concrete is struck off ½ in. high, then tamped, and finally recut to the exact finished pavement. When 3 ft. from the joint the templets are lifted to it and then levelled and compacted away from the joint. An 8-ft. wooden float, not less than 6 in. wide, is to be operated from two bridges, and this float is given in a detail drawing in the specification. The axis of the float is to be parallel to the centre line of the pavement. For final finishing a float 20 in. long and 6 in. wide is used, or a belt may be employed. At the joints a split float is specified. (*Engineering News-Record.*)

PUBLICATIONS RECEIVED.

"Practical Costing," by A. H. Gledhill, A.M.I.M.E.—A treatise on costing for large works. Price 3s. post-free. Obtainable from the Gledhill-Brook Time Recorders, Ltd., 26, Victoria Street, Westminster, S.W.1.

Floor Slab Reinforcement.—The July pamphlet of the British Reinforced Concrete Engineering Co., of Manchester, deals with the application of B.R.C. Fabric for floor reinforcement. Illustrations are given of buildings where the floors have been reinforced with this material.

The British Steel Piling Co.—This company have issued a pocket edition of their large catalogue, containing all the essential information regarding their products. The booklet should prove handy and useful to engineers having pile driving operations to carry out. Copies can be obtained on application to the above company at Dock House, Billiter Street, E.C.3.

PROPOSED WORKS.

Bootle.—Designs and tenders for the erection of a reinforced concrete coal bunker of 400 tons capacity are invited by the Bootle Corporation. Particulars of the borough engineer. Tenders to be delivered by September 12th.

Rouen.—A decree authorising the erection of a wharf capable of accommodating two vessels at a time.

Chile.—Tenders, returnable up to March 30th next to the Minister of Finance, Santiago, are invited for the improvement of the Port of Antofagasta. The amount to be expended on the work must not exceed £1,700,000.

Australia.—A Commission, comprising representatives of the Commonwealth Government and the Governments of the four wheat-growing States, is to frame a scheme for the erection of grain silos.

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CONCRETE AND CONSTRUCTIONAL ENGINEERING

OCTOBER 1917. VOL. XII. No. 10.

A MONTHLY JOURNAL FOR ENGINEERS, ARCHITECTS, SURVEYORS & CONTRACTORS and all interested in CEMENT, CONCRETE, REINFORCED CONCRETE, FIRE-RESISTING CONSTRUCTION and STRUCTURAL STEEL.

ISSUED MONTHLY

CONTENTS.

We draw the special attention of our readers to the second review on Concrete Railway Sleepers, which appears in this issue on page 541.

No. 119.

Registered for the Canadian Mags. Post.

Published Monthly at 4 Catherine Street, Aldwych, W.C.

A 250 cu. m. Reinforced Concrete Barge in Course of Construction at Bahia.
(*For Description see p. 553*).

CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume XII. No. 10. LONDON, OCTOBER, 1917.

EDITORIAL NOTES.

RESEARCH WORK.

Report of the Committee of the Privy Council for Scientific and Industrial Research, 1916-17.

THIS Committee has just issued its report for the year 1916-17, and all concerned in the organisation of its activities are to be congratulated upon the remarkable progress made under the exceptional difficulties of the war period. We would particularly desire to congratulate the administrative chairman of its Advisory Council (Sir William McCormack) and the secretary (Sir Frank Heath, K.C.B.), upon whom the burden of the work has fallen, whilst among the able staff who have assisted these gentlemen we think we should particularly mention Mr. Ll. Lloyd on the administrative and Mr. A. S. Barnes on the technical side.

The year under review has seen the greatest evolution in scientific research that can be found in the country's records, inasmuch as the Research Department was constituted at the end of 1916, and a fund of one million sterling has been set aside by His Majesty's Government for application to research work.

Never in the annals of the British Empire has anything of this kind been done before. For the first time the half-hearted, amateurish recognition of the necessity of research work has been replaced by something really official, standing and lasting, and the gentlemen who have achieved this have not only done well for the country, but, we think, will have a place in posterity whenever the history of scientific development in this country is under review.

It is difficult to realise what it means, when for the first time research is being given a definite position in the State and is no longer merely a subject for academic discussion, cynical patronage, and gentle sarcasm where our public Departments are concerned. There must have been many great scientists and others keenly cognisant of the void in our Imperial organisation, whereby research for the past twenty years has taken a back seat in official eyes. Research—to put it bluntly—was unpopular; "rule of thumb," with a few exceptions, held its sway; but given the start as recorded in the annual report before us, and the personnel who are at present fathering this new development, rapid progress ought now to be made.

SCOPE OF ACTIVITIES.

The Report before us shows the wide activities of the new Research Department, its infinite scope, and the careful way in which the new research work has been initiated or supported.

It is not our intention to recapitulate the department's various spheres of activity. Only in one direction do we wish to make special mention, and that is to say that it is a matter of congratulation that the problems relating to concrete and reinforced concrete have not been overlooked.

CONCRETE AND REINFORCED CONCRETE.

We observe that the Research Department are assisting both the British Fire Prevention Committee and the Concrete Institute in their endeavours to elucidate various important points, and the investigations of these institutions are being practically supported in a manner that should lead to useful results.

There is not the least doubt that concrete and reinforced concrete will be the great building factors of the future, both for economic and technical reasons. As far as the economic side is concerned, the question of fire hazard is of particular importance, inasmuch as the conservation of property in the future will be of far greater national concern than in pre-war times, and anything that can be done to reduce the millions sterling annual waste by fire is of the utmost importance, particularly as the reduction of the wastage in warehouses and factories can be largely achieved by the aid of forms of construction such as those of concrete and reinforced concrete. They are not more expensive, in fact, actually often cheaper, than what was in use in pre-war periods.

CONCLUSION.

Where we have to say so much in praise of the splendid endeavours of the new Research Department, we may perhaps be excused from making one short criticism on the Report. We think the Report as it stands should only have been issued to the Government Departments and individuals concerned. This is not the time for letting our enemies know too much of what is under consideration or how things are being done at home, and we suggest that future reports should have a strictly limited circulation, and that, as far as the general public is concerned, only a non-technical précis should be given.

This journal is primarily interested in the question of concrete and reinforced concrete, and those concerned may be assured that, whilst this journal is fully aware that the question of concrete and reinforced concrete is not being neglected at the present moment in enemy countries, and is aware of some of the work done up to the end of 1915, it is only with the greatest possible difficulty that anything can be ascertained as to what is going on at present, and what is contemplated as far as research work in those areas is concerned. What pertains to concrete pertains equally to other subjects, especially in matters of industrial research.

With the exception of this slight criticism we would repeat that, not only is the Report before us one of the most remarkable publications of its kind, but that it is a splendid record of initiative and able administration.

REINFORCED CONCRETE RAILWAY SLEEPERS.

Our readers will recall that in our July issue we published a review of the experiments and investigations that had been carried out under this head. We would, therefore, call special attention to some further particulars, published on page 541 of this issue, which we have been able to gather on this very important subject, as it is a matter which is receiving the most earnest consideration of many of our public Departments and of our railway companies.

The following article on the recent extensions to St. Thomas's Schools, Birmingham, is of special interest as an example of the use of reinforced concrete throughout for a School Building.—ED.

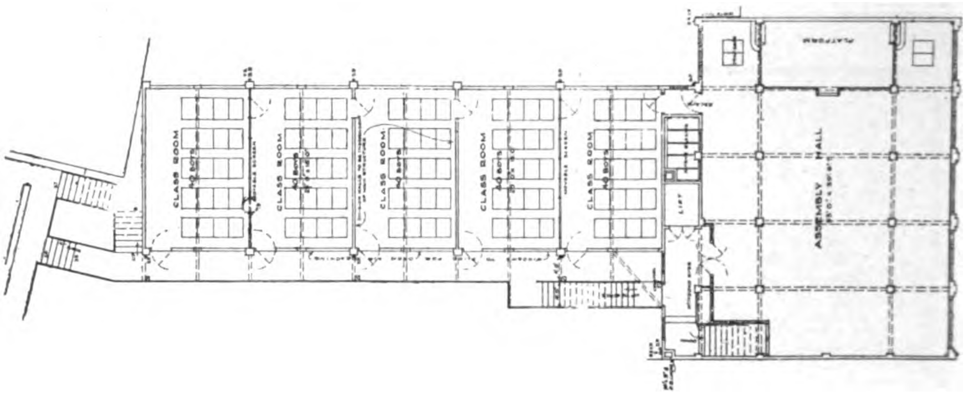
THE schools, founded nearly ninety years ago by the parish of St. Thomas's, Birmingham, are the largest Church of England schools in the city, and the additional building which was formally opened by the Bishop of Birmingham in July last is characteristic of the latest developments in design, construction and equipment, and being built in reinforced concrete throughout it possesses the double advantage of being both fire-resisting and bomb-proof.

At the time of the establishment in the year 1831 the schools, situated near St. Thomas's Church, in Granville Street, consisted of a two-storey building for the boys' and girls' departments, and a one-storey building for infants, the premises affording accommodation for about 700 scholars. In 1871 the infant school was rebuilt and the other departments were remodelled at a cost of some £1,912. Two successive enlargements were carried out in 1892 and 1894 at a cost of £2,479 on a site in Bath Row presented by Mr. J. W. Lea. In 1907 further additions were made in Chequer's Walk at a cost of £2,900, the requisite site having been the gift of the same generous donor.

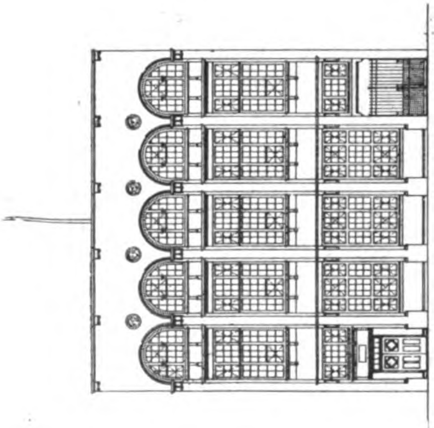
In 1890 the roll included 861 scholars, and the numbers increased steadily year by year until, in 1916, the schools were attended by 1,493 scholars. Owing to the increased numbers and the requirements of the Board of Education additional accommodation became necessary, and the writer's firm, Messrs. Harrison and Cox, were commissioned to prepare the scheme which has been realised by the completion of the present extension.

This project provided for a three-department school with ample accommodation for 700 senior mixed scholars, 422 junior mixed scholars, and 400 infants, or 1,522 scholars in all. In view of their extensive accommodation and central position at the corner of Bath Row and Granville Street, in the centre of the city, the schools may justly be regarded as one of the most important among the educational establishments in Birmingham.

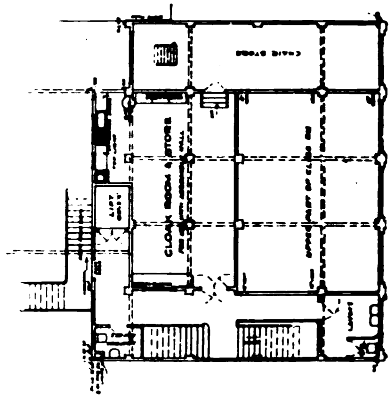
The difficulties in the way of acquiring adjoining property for school



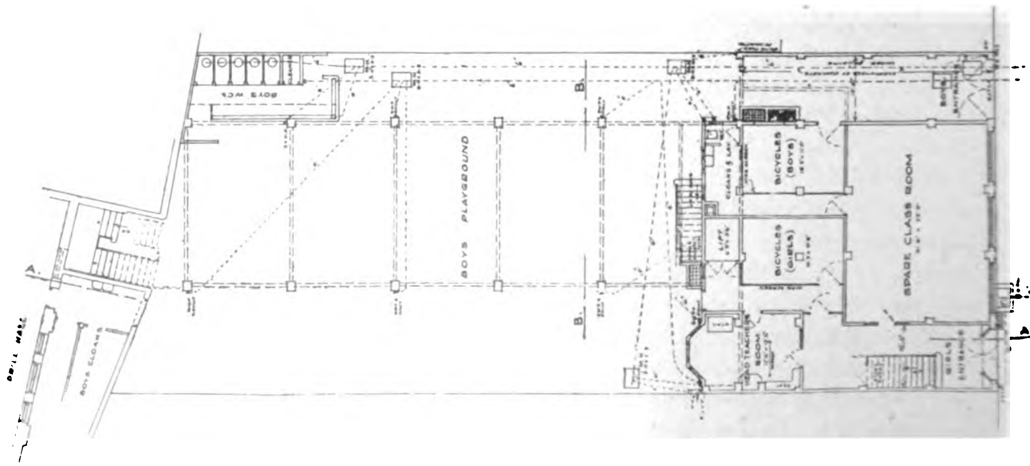
FIRST FLOOR PLAN



ELEVATION TO GRANVILLE STREET

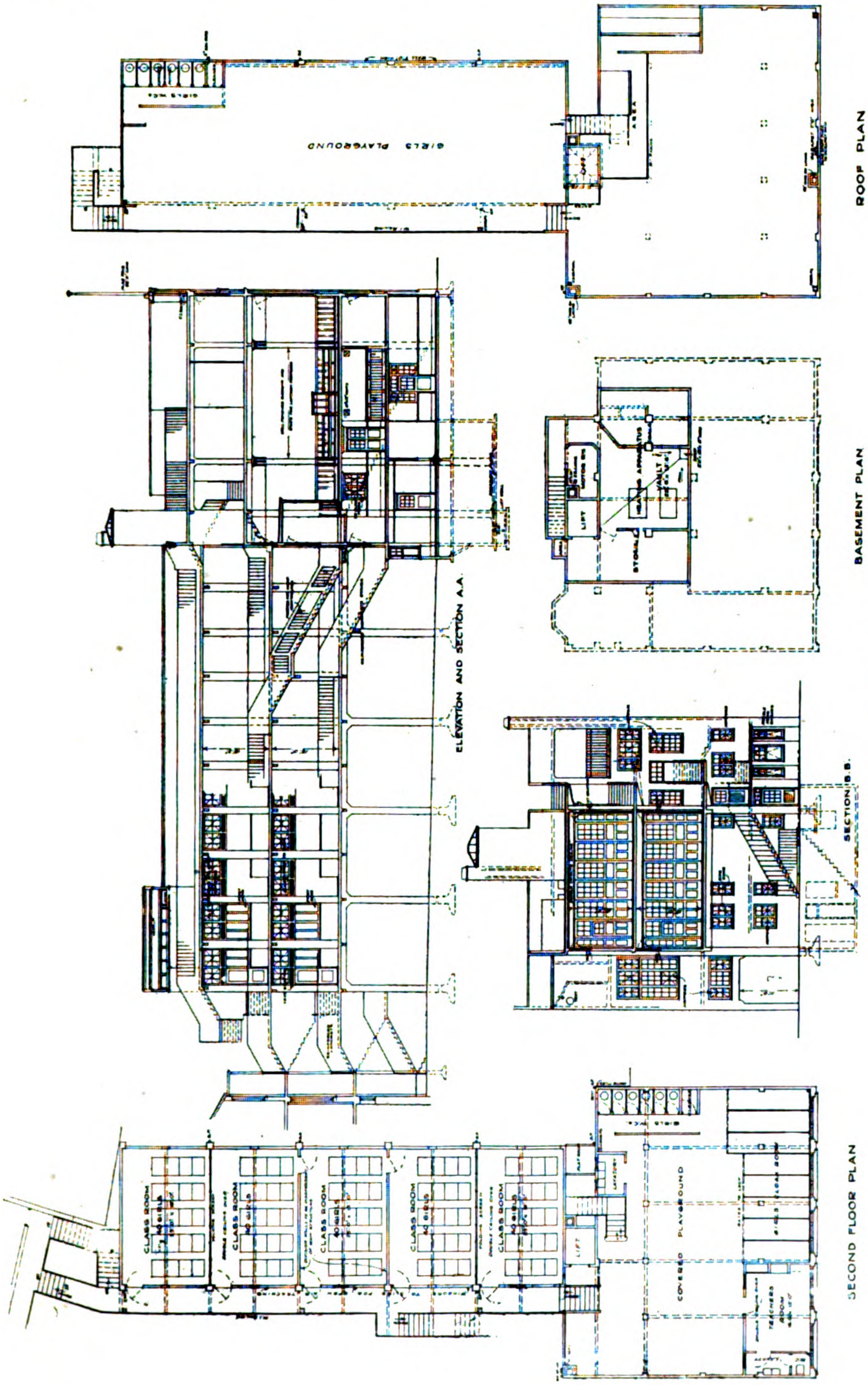


MEZZANINE PLAN



GROUND PLAN

ST. THOMAS'S SCHOOLS, BIRMINGHAM.



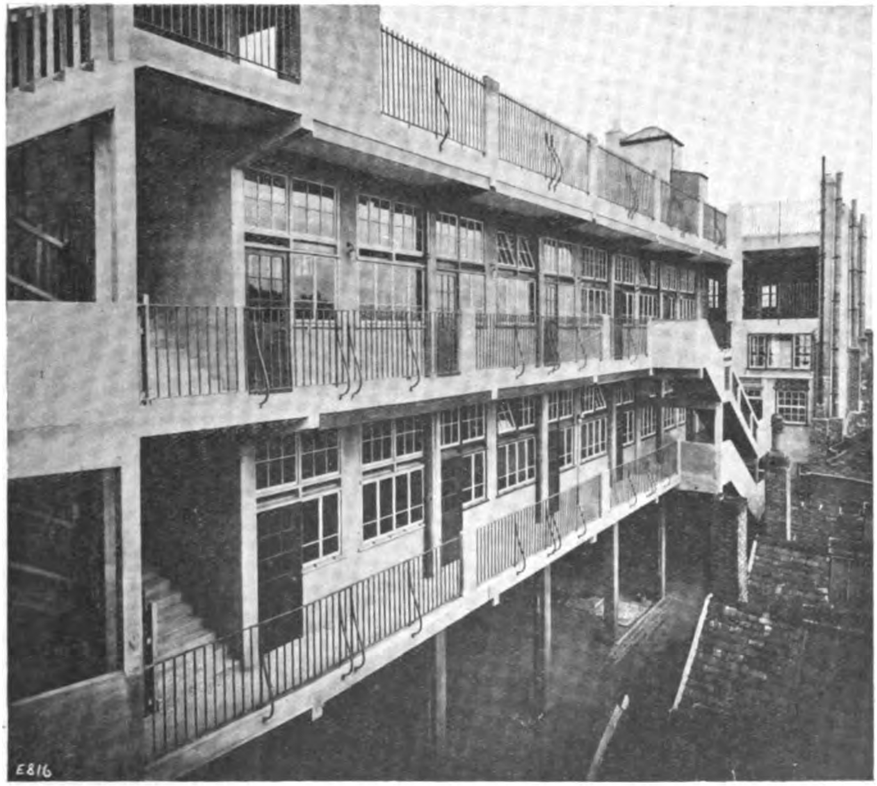
St. Thomas's Schools, Birmingham.

extensions in built-up and populous districts are often insurmountable, and in the case of St. Thomas's schools the sole available site for the new building was of a very restricted area and joined the old premises only at one narrow end. This condition naturally affected the planning of the extension and led to the adoption of reinforced concrete for the construction of the building.

Elevation to Granville Street.
ST. THOMAS'S SCHOOLS, BIRMINGHAM.

In view of the accommodation required to meet the varying and increasing needs of the schools and of the narrowness and restricted area of the site, this system of construction has certainly given results far more satisfactory than those which could have been secured by the use of any other material or method of construction.

The interior space gained by substituting a reinforced concrete structure with thin exterior walls for an ordinary building with massive brick walls was in this instance a consideration of the highest importance. The customary objections to a lofty building for school purposes are eliminated by the fire-resisting nature of the construction adopted, and which was applied to the entire fabric, including the spacious staircases connecting all the floors and the terrace roof, the latter, as well as the structure generally, affording safety



Side Elevation showing Balconies.
St. Thomas's Schools, Birmingham.

from attack by aerial bombs as well as from injury by fire. Another advantage gained by the adoption of reinforced concrete was the facility offered for the provision of a covered playground under the class rooms and of two open air playgrounds for girls on the terrace roof.

The new building is linked up with the old schools by a reinforced concrete staircase which serves the different levels of the boys' departments, while the girls' department is reached by the main entrance in Granville Street.

As shown by the drawings reproduced the elevation to Granville Street is of simple but appropriate character, suggesting at once the material of which it is constructed, a noteworthy feature being the proportionately large window area in the façade.

Over the chief entrance is fixed a bronze tablet to the memory of Mr. H. R. Birch, the late headmaster, to whose indefatigable efforts during the past quarter of a century the schools owe so much of their success.

On the ground floor is a large room dedicated to the late Rev. W. G. S. Whicker, a former rector of the parish, and which will be used as a spare class room, for medical inspections, and for other purposes. On the same floor there are also a private room for the headmaster, bicycle and cloak rooms for boys and girls, and lobbies in connection with the staircase and lift.

Additional cloak room accommodation is provided on the mezzanine floor, which extends over the ground floor with the exception of that portion occupied by the upper part of the Whicker room. Over the latter and the mezzanine floor is the Birch Memorial Hall, 53 ft. long by 40 ft. wide, to be used for assembling the children, for prize distributions, and other meetings.

Behind the front portion of the building is a large covered playground for boys, this space being under two storeys of class rooms, and as the beams supporting the latter extend from side to side of the building without intermediate support, the playground is remarkably free from obstructions in the form of columns.

The first floor behind the Memorial Hall contains five class rooms, each with accommodation for forty scholars, reached by fire-resisting staircases from the front entrance, and communicating by means of a continuous balcony and similar staircase with the old school.

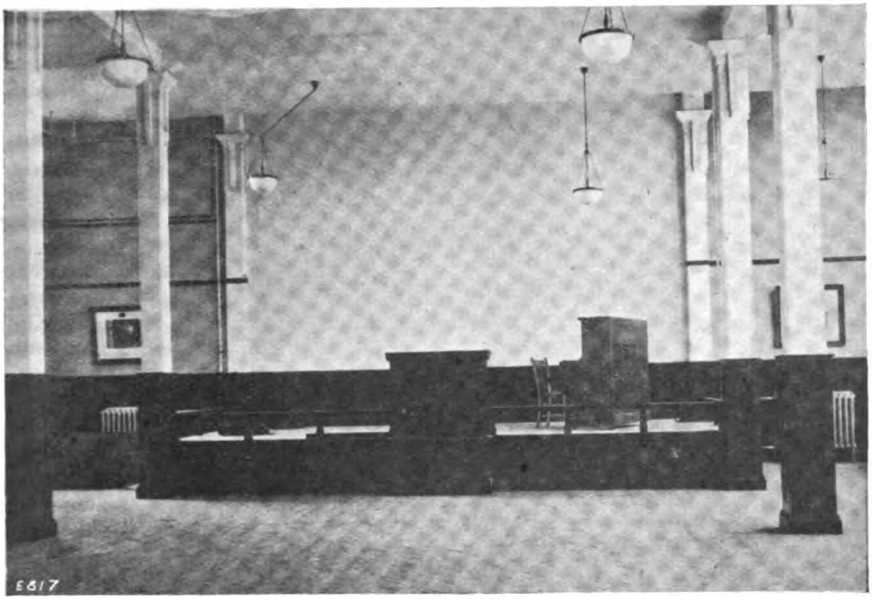
In the second floor are a teachers' room, cloak and other rooms, a covered playground for girls, and five class rooms corresponding in dimensions and arrangement with those on the floor below.

The windows of the ten class rooms, protected by the balconies, have opening casements fixed on top and bottom centre pivots, so that the effect of open air class rooms can be obtained.

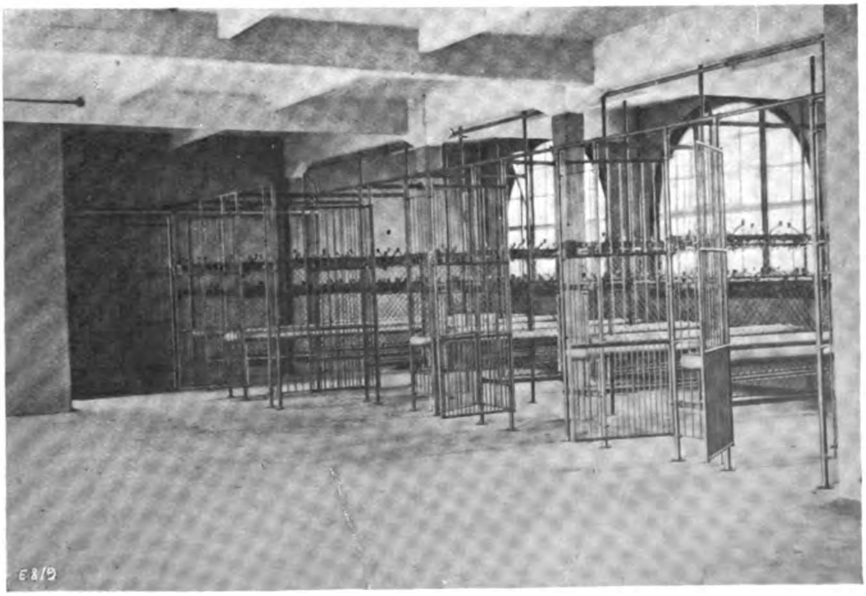
The roof over the class rooms constitutes the second playground for girls, and is provided with access stairways at each end and protected by parapet walls 7 ft. high.

Measuring 144 ft. long by 54 ft. wide by 53 ft. high the new building may be thus briefly described, from the structural standpoint: the skeleton consists of wall and interior columns by which all loads are received and transmitted to the ground; wall lintels and systems of floor and roof beams, the former supporting the exterior curtain walls and the latter taking the floor and roof loads; the skeleton being incorporated with the curtain walls and the floor and roof panels, so that the whole forms a monolithic structure of enormous strength, despite the slenderness of the various structural elements. The necessary interior partitions forming the rooms, hall, stores, stair enclosures, lift well, and other accommodation are also monolithic with the skeleton, and the same remark applies to the staircases.

The columns are provided with extended bases for suitable distribution of the loading, and their cross sections at ground level range from 11 in.



The Assembly Room.



The Cloak Room.

St. Thomas's Schools, Birmingham.

to 14 in. square, according to the load to be carried, the transverse dimensions being reduced appropriately at successive storeys. The beam spans are arranged with a special view to simplicity and economy of construction, a point sufficiently demonstrated by the fact that a thickness of 3 in. was found sufficient for the floor panels to enable them to carry with an ample factor of safety superimposed loading up to 112 lb. per sq. ft. At the same time the spans of the beams are of length sufficient to carry the floor above the Memorial Hall without any interior supports and to leave the covered playground beneath the class rooms quite free from obstruction.

One conspicuous benefit derived from the adoption of a reinforced concrete building is represented by the space gained by reason of the slenderness of the enclosing walls, which are required to act merely as weather screens, since all loads are carried by the general framework. Hence at St. Thomas's Schools the exterior walls are only 6 in. thick, as compared with the massive brickwork, from 14 in. to 24 in. thick, that would have been required for self-supporting walls of ordinary construction.

The building has been equipped and appointed on the most modern principles in all other respects. The Cambridge system of heating and ventilation has been adopted, a method which is new to Birmingham, and has proved entirely satisfactory. It provides for the admission of cold fresh air, regulated by means of inlet hoppers at a height of 8 ft. above floor level, the reason for this arrangement being that it is found to be more invigorating to breathe cold air than air that has previously been warmed. Draughts are avoided and the low-pressure hot water heating scheme is calculated so as to counterbalance the effect of the cold air inlets. The heating apparatus is installed in the basement shown in one of the drawings reproduced.

The total cost of the building and equipment was £11,500 and it was erected under the direction of the architects, Messrs. Harrison and Cox. The contractor was Mr. Thomas Johnson. Messrs. L. G. Mouchel and Partners, Ltd., of Westminster, were responsible for the design of the reinforced concrete work, and Messrs. Henry Lea and Son acted as consulting engineers in connection with the design and installation of the heating and ventilating apparatus, the electric lighting systems, and the electric passenger lift.

CONCRETE RAILWAY SLEEPERS.

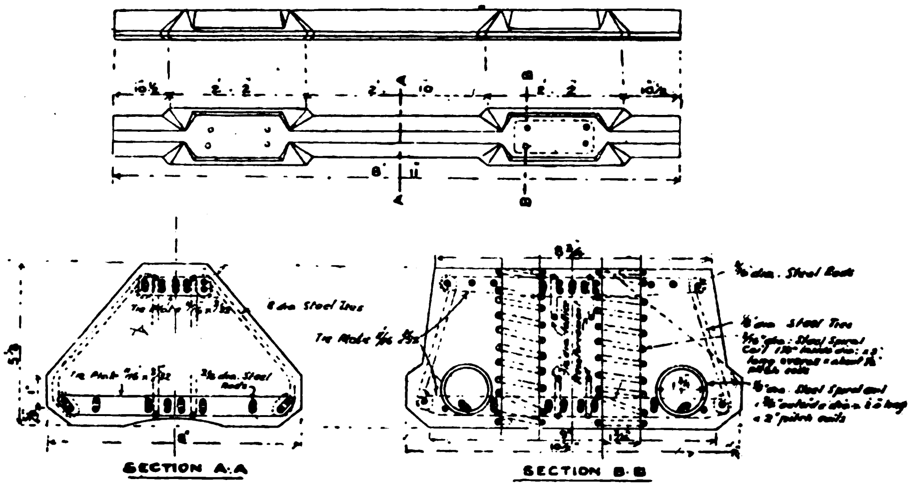
II.

Continued from July issue.—ED.

In continuing our review of the trials and experiments of reinforced-concrete railway sleepers, published in our July number, we are now in a position to make some further additions to the examples which were then placed before our readers. That the subject is one which has aroused considerable interest there is ample evidence. At the present time many experiments are being conducted with various types of sleepers on some of our most important railways, and it is undoubtedly a fact that the closest, most scientific investigation and attention is being paid to the matter. Certainly all this involves time, but that eventually the problem will be solved seems beyond doubt. So far as light railways, sidings, etc., are concerned—and there are thousands of miles of such tracks—it appears pretty certain that a well-made and properly matured concrete sleeper can readily be found. Assuming this to be the case, and it is the opinion of several engineers of authority, there is at once discovered a great means of saving timber, which the Government so earnestly desires. It is not alone the scarcity of timber suitable for sleepers, but that natural corollary an increase in price, almost to a prohibitive figure, which has rendered it very necessary to discover a satisfactory and reliable substitute. In our first article we put forward all the reasons and arguments that could be adduced in favour of a perfect concrete sleeper, such as its durability and the non-disturbance of a well-laid track, so there is no necessity to repeat them. At the same time we stated that the ideal sleeper for a heavy pounding traffic on a main line had still to be found. Railway engineers and others are busily engaged in attempts to produce the very best article for sustaining heavy wear, and in some interesting trials which will be referred to distinctly good results have been obtained. That this subject has started the inventor on a trail of thought and suggestion is, indeed, a good and useful indication that the right sort of interest has been awakened, and we are pleased to publish some information of this character. Our object in dealing with this matter, as we previously intimated, is solely with a view to help forward those who are carefully studying the *pros* and *cons* of a concrete sleeper, and we are gratified to know that our work in this direction is appreciated.

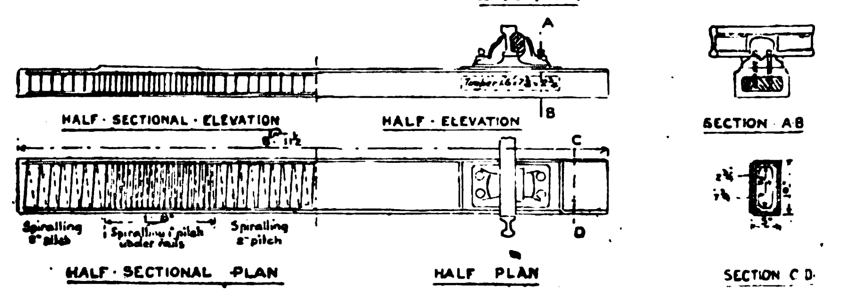
The London and North Western Railway.—It will be remembered that in describing the trials on English railways we mentioned three experiments that had been made on this line. We gave the results, but at that time were unable to show the drawings of the sleepers. It is very desirable to make this record as complete as possible, and now, thanks to the courtesy of the company, we are able to do so, and we also reproduce the comments relating to each test.

Supplied by the British Improved Construction Co Ltd London



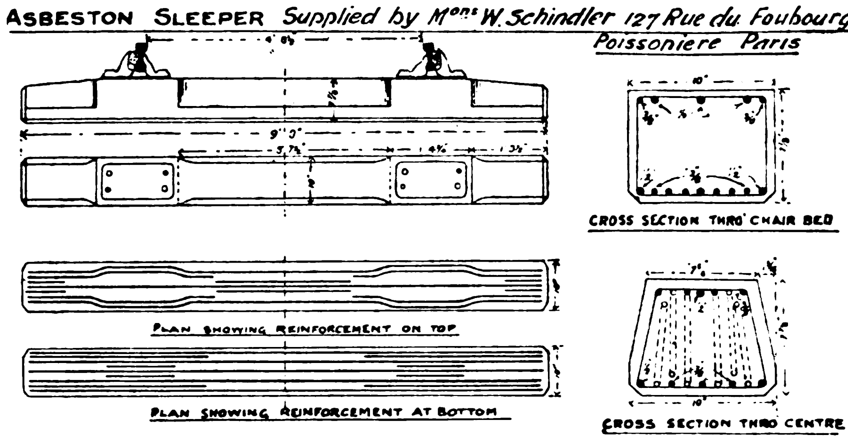
Sleepers as above were laid down on the main line under heavy traffic in 1911, but had to be taken up after about fifteen months' service. Some of them, still usable, have been repaired and are now in sidings. Others, installed for lighter traffic, are still in use, although some show signs of failure.

AUDEN'S SLEEPER Manufactured by Messrs Pearson Bros. & Campbell Liverpool

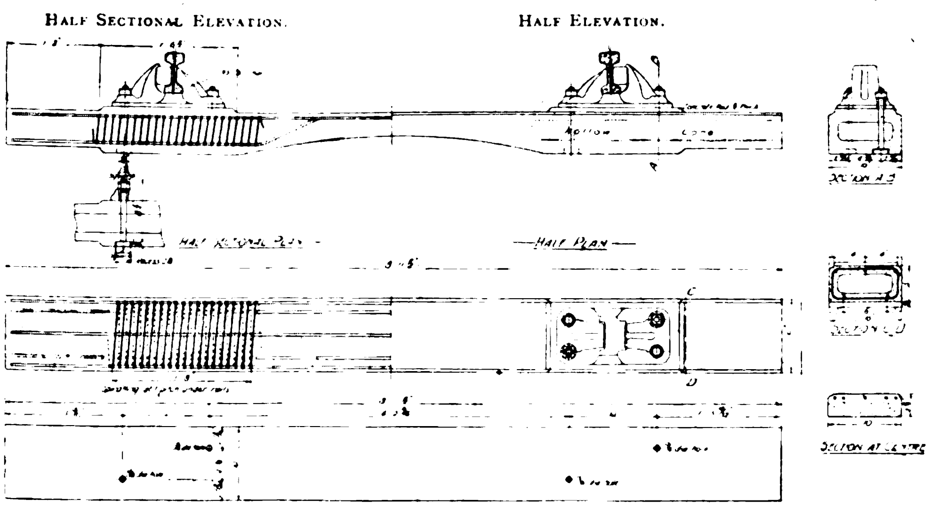


Only a few of the Auden sleepers were tried in 1912, and a small proportion are still in use, though considerably cracked.

The Asbeston type were laid in 1914—not many. The fastenings have worked loose; the sleepers cracked, and have had to be removed.

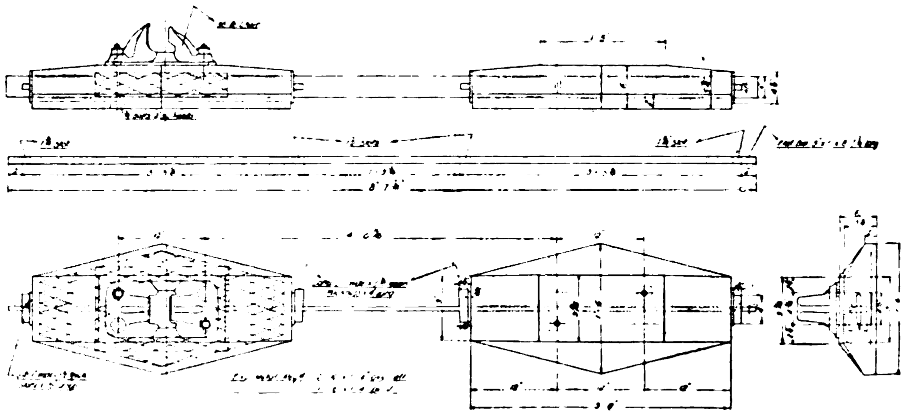


The North Eastern Railway.—An extremely interesting series of trials of five different types of concrete sleepers has been made by this company, and in two instances, as will be seen in the notes attached to plans D and E, the results are stated to be quite satisfactory.



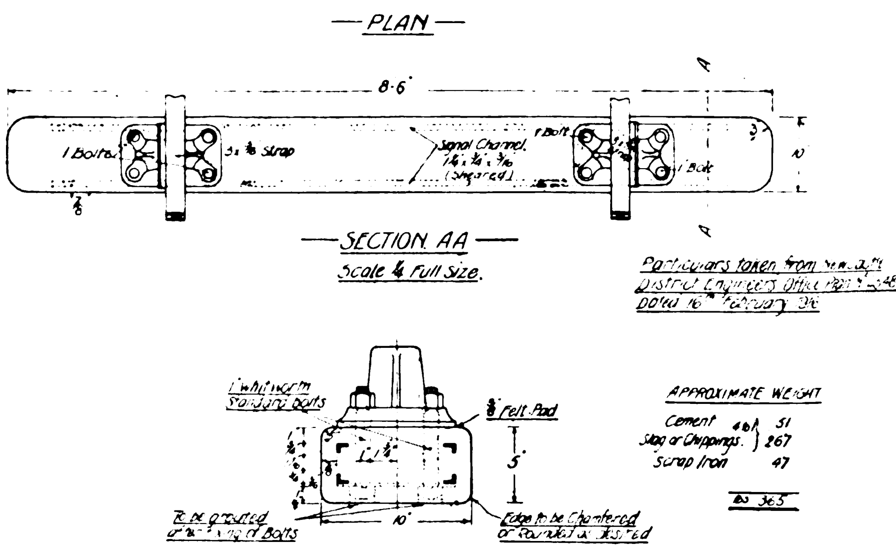
PLAN A.—TRIALS, NORTH EASTERN RAILWAY.

Plan A —This shows the type of sleeper purchased from Messrs. Pearson Bros. and Campbell, 290, Vauxhall Road, Liverpool, who made them under Mr. Auden's patent in 1912. These have given poor results, a number having broken up when handled before being laid down, and the remainder are rapidly failing under traffic by crushing at the chair seat.



Plan B.—Trials, North Eastern Railway.

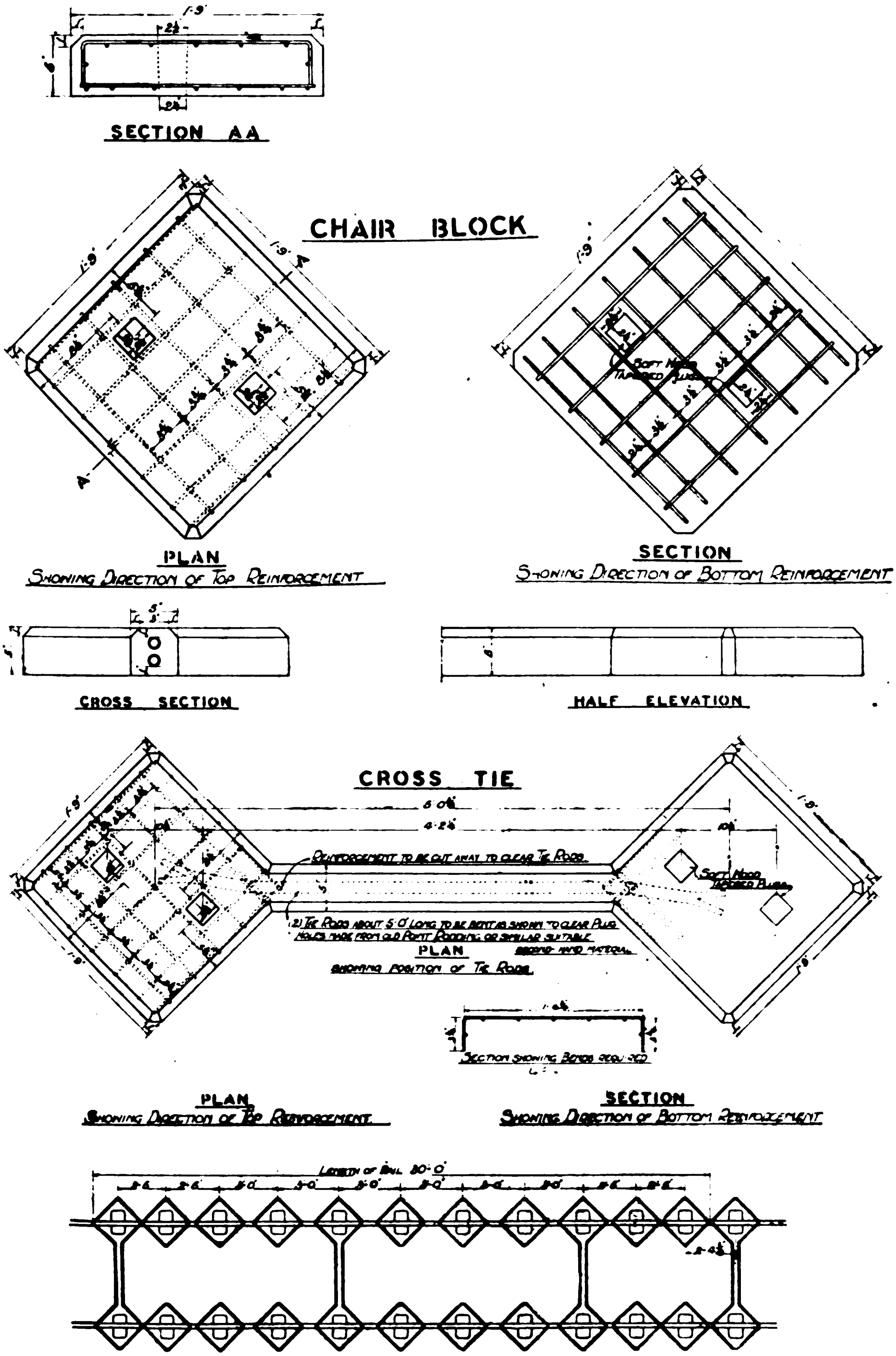
Plan B.—These were designed at York, and were laid down at the same time as those mentioned above. They promise to give satisfactory service, but the iron-work is rather heavy, and might be considerably lighter.



Plan C.—Proposed Concrete Sleeper for North Eastern Railway.

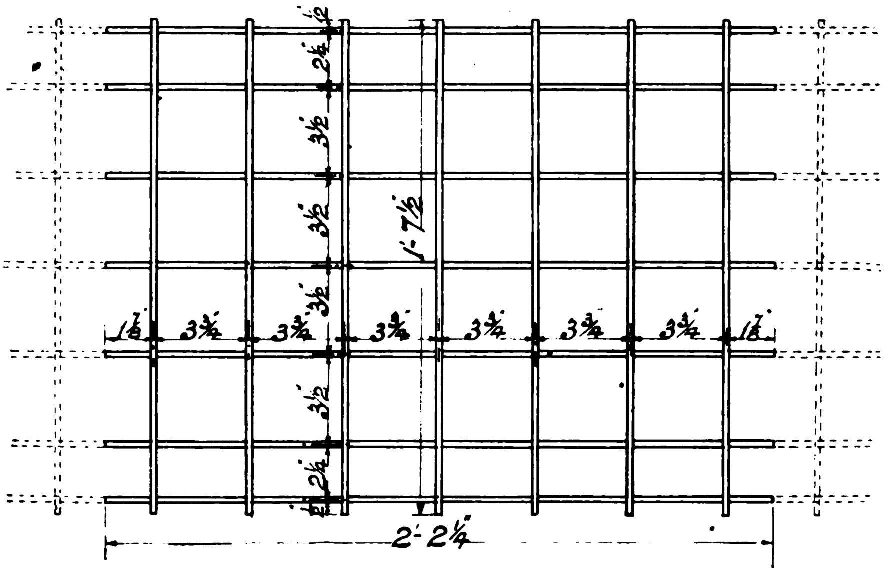
Plan C.—This design has not been satisfactory, as the sleepers have broken at the chair bed, and it is not proposed to make more of them.

Plans D & D^A.—These show a reinforced concrete chair block used for Standage Sidings. They have been tested during the last year under heavy traffic in one of a group of marshalling sidings with good results. The Clinton reinforcement not being obtainable in the form required, expanded metal was used, as shown.

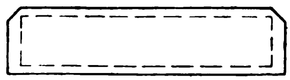


Part Plan of Track.

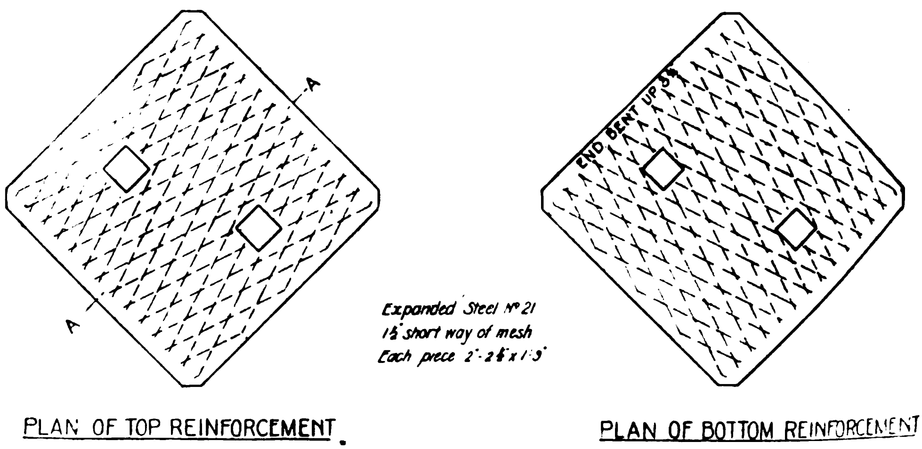
PART PLAN D.—SHOWING REINFORCED CONCRETE CHAIR BLOCK AND CROSS TIE. N.E RY.



PART PLAN D.—PLAN OF CLINTON REINFORCEMENT IN FLAT NO. 4 IMPL. S.

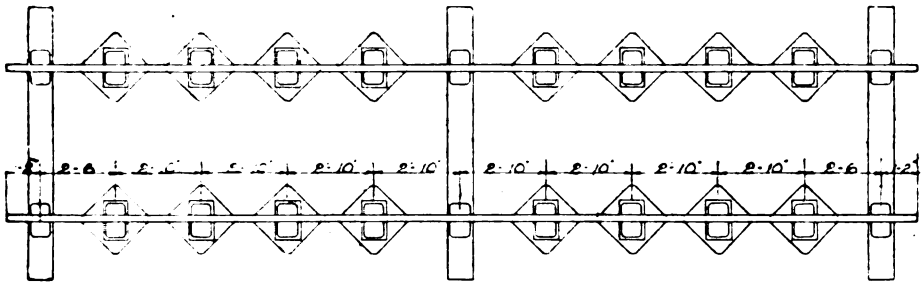


SECTION A.A.

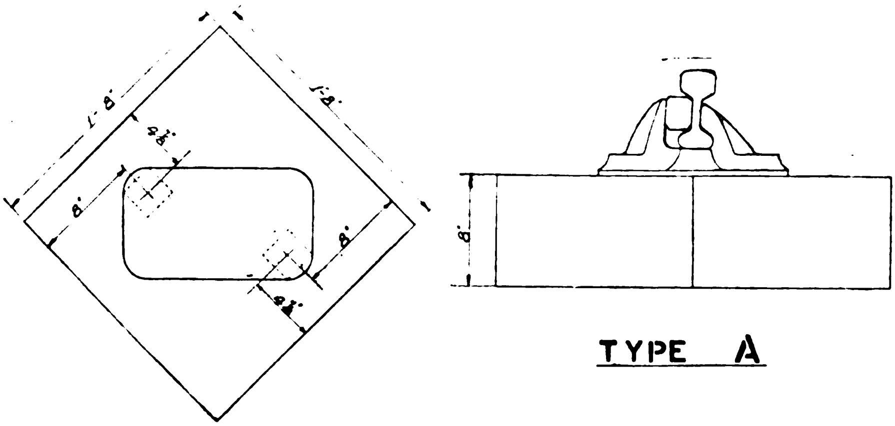


PLAN D^A.—REINFORCED CONCRETE CHAIR BLOCK, N.E. RY.

Plan E.—This is a plain concrete block which is heavier than plan D (shown on pp. 545 and 546), but has been quite satisfactory.

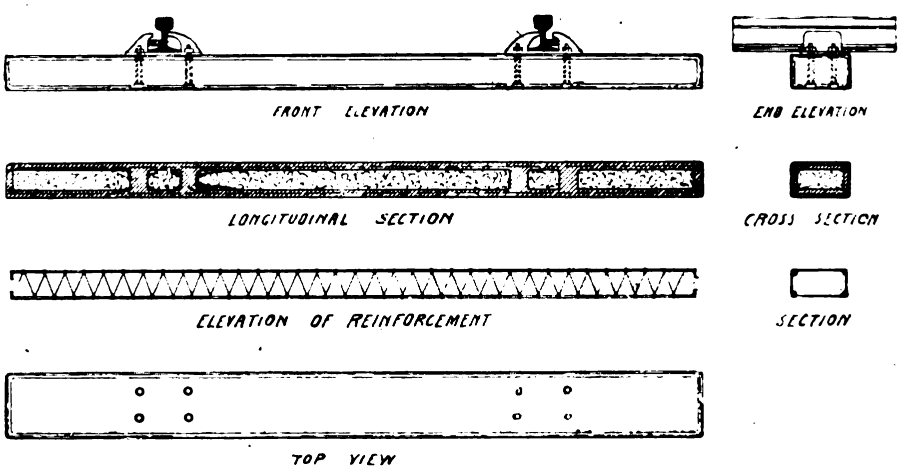


SPACING OF CHAIR BLOCKS FOR 30 FT RAIL

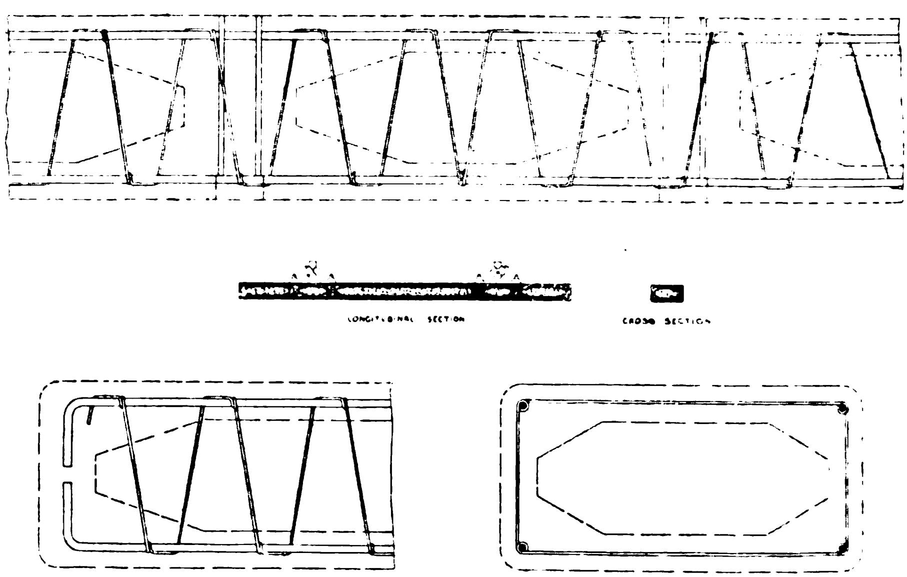


PLAN E.—PROPOSED CONCRETE CHAIR BLOCKS. N.E. RY.

A Reinforced Concrete Sleeper.—Mr. Rings, of "Fairfield," Liverpool Road, Great Sankey, near Warrington, is the inventor of a sleeper for which he claims many advantages. It is a hollow shell, extremely light, saving labour in handling and laying. No machinery is required in its manufacture. He states that the cost is low, that it is elastic and resilient. The description given of this sleeper is that it "consists of an outer shell of rich concrete, perfectly reinforced to resist all possible stresses. The compartments within the shell are filled with ready-made blocks of a light nature, such as plaster of paris and granulated slag or sawdust. These blocks are inserted during the process of filling the outer shell, and the latter, during the setting of the cement, gets a complete grip around the reinforcements and the blocks, so that when the frame is removed the whole combination represents a perfectly monolithic beam." We understand that experiments are being made with them in this country and some of the colonies, but no results are at present available. The drawings are appended. Patent applied for.

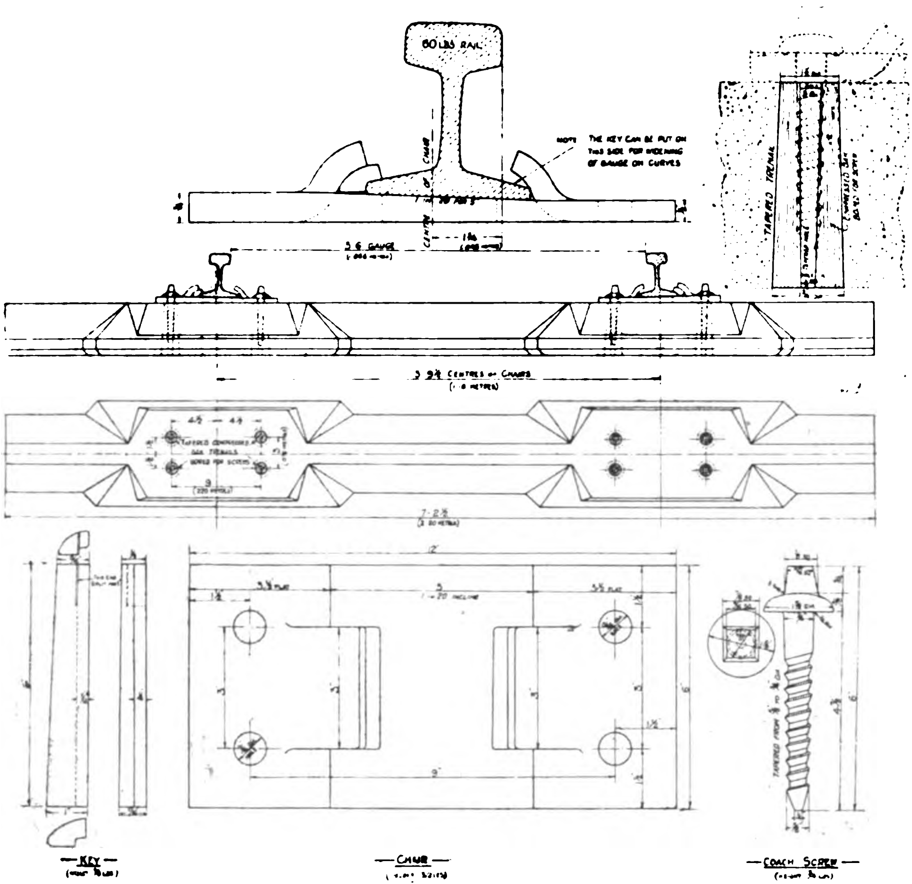


THE RINGS SLEEPER.



THE RINGS SLEEPER.

The Benguella Railway Company.— A trial of reinforced concrete sleepers by this company, for whom Sir Douglas Fox and Partners are the consulting engineers, will certainly be watched with great interest. An order for 100 of them has been placed with the British Improved Construction Company. These are somewhat on the lines of those supplied a few years since to the South-Eastern and Chatham Railway, full particulars of which were given in our July issue. These sleepers, for which special drawings have been prepared, will be sent to Lobito Bay, Portuguese Angola, for experimental purposes on the Benguella line, 3 ft. 6 in. gauge. At present the 350 miles of line open for traffic runs upon compressed steel trough sleepers, spaced 13 to the 10-metre rail.



PROPOSED REINFORCED CONCRETE RAILWAY SLEEPER AND FASTENINGS FOR THE BENGUELLA RAILWAY

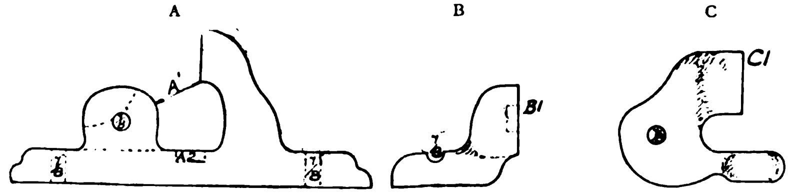
The Victoria Chair and Artificial Stone Sleeper.—This is the invention of Mr. T. Brown, Oak Villa, 83, Carnarvon Road, Stratford, E. (rights protected). The description of both chair and sleeper is fully dealt with in the specifications, the first of which relates to the chair, and is approximately as follows:—

The chair casting, as per sketch *A*, measures 1-$2\frac{3}{4}$ in. by $5\frac{1}{2}$ in. high by 5 in. wide, the width between the two parts of casting at A^1 must be wide enough to receive the bottom bed of the railway line; a mortice, $1\frac{1}{2}$ in. square, shaped to the sectional lines, to receive the fixed bracket, *B*, so that it can be fixed or removed when the chair is in position; a mortice hole, $\frac{7}{8}$ in. diameter, for fixing the brackets, and two mortice holes, $\frac{7}{8}$ in. diameter, to bolt the chair down to sleeper; a sinking on top bed of chair in centre of the position of rail is required, $1\frac{1}{2}$ in. diameter by $\frac{3}{4}$ in. deep, to receive a small spring or rubber.

The bracket. *B* is 4 in. high by $3\frac{1}{4}$ in. wide on face, the length of the $1\frac{1}{2}$-in. by $1\frac{1}{2}$-in. square arm from face line of bracket is about 4 in. The face of this bracket has a sinking $1\frac{1}{2}$ in. diameter by 1 in. deep, B^1, to receive a wood dowel, projecting beyond face of bracket and long enough to fit tight against rail, the dowel having end grain of wood next to rail; the bracket is kept in its position by a half-circle and chase across top of arm, $\frac{7}{8}$ in. diameter.

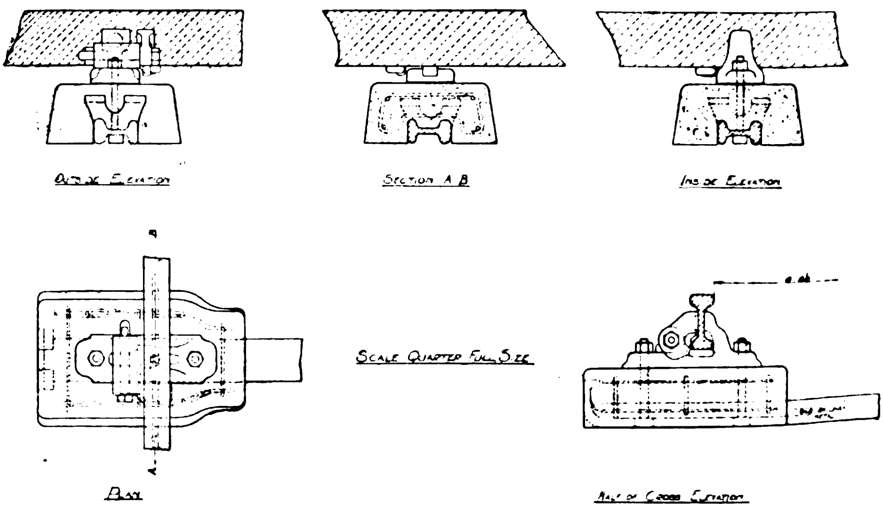
The shaped bracket, *C*, the extreme size over all is $5\frac{1}{2}$ in. by $5\frac{1}{4}$ in. by $2\frac{1}{4}$ in.; the top face, C^1, is 2 in. by $1\frac{3}{4}$ in., and fits against rail, with a slight clearance at top, and tight against rail on bottom edge. The swelled arm on bottom of bracket projects out to come under rail when in position; the thickness of this bracket is $1\frac{1}{4}$ in., with a mortice hole $\frac{7}{8}$ in. diameter, the two brackets being secured to the chair by a $\frac{7}{8}$-in. diameter bolt with a split pin at the end.

A small spring or rubber inserted in the top bed of chair and under the rail at A^2, strong enough to carry or support a length of rail (*i.e.*, according to distance apart the sleepers are placed), to keep the rail $\frac{1}{4}$ in. above the top bed of chair, and fixed at this position by the bracket, *B*. The weight of train when passing over or resting on rail, lowers it down on top bed of chair, at the same time brings bracket, *C*, into action by lowering the swelled arm, presses the top face, C^1, tight against the edge of rail, and makes a double fixing for the rail and more secure. The moment the weight is removed and rail is released it is raised by the spring to its original position, releasing bracket, *C*, and this allows for any expansion to metal.



THE VICTORIA CHAIR.

The Victoria Artificial Stone Sleeper.—This measures 1 ft. 9 in. long by 14 in. wide by 6 in. deep, with shaped and spayed sides; ends are square, and the bottom has a chase or groove on bottom bed to receive a 3-in. by $\frac{1}{2}$-in. flat bar iron as a tie (or a piece of old railway metal could be used). The outside end of sleeper is sunk to receive the turned up ends of the rod or bar, with two forks projecting to sink into sleeper, acting as a cramp.

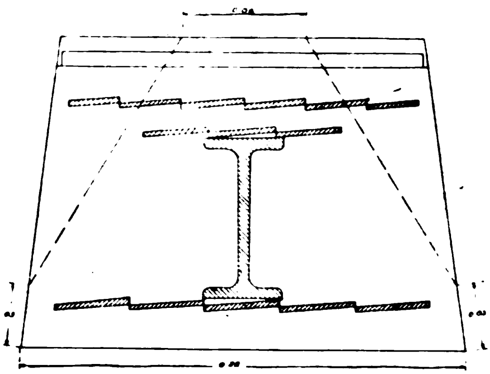


THE VICTORIA SLEEPER.

The sleepers are composed of ¼-in. mesh fine washed granite siftings, gauged *three* of siftings to *one* of best Portland cement, reinforced with three vertical rods of ⅜-in. round iron, shaped or bent to fit over bottom chase in stone, with four horizontal rods of ⅜-in. round iron inserted inside the vertical rods and forming a proper tie. Two mortice holes are required in each sleeper, ⅞ in. diameter, to bolt the chair down on a bed of felt inserted between iron and stone.

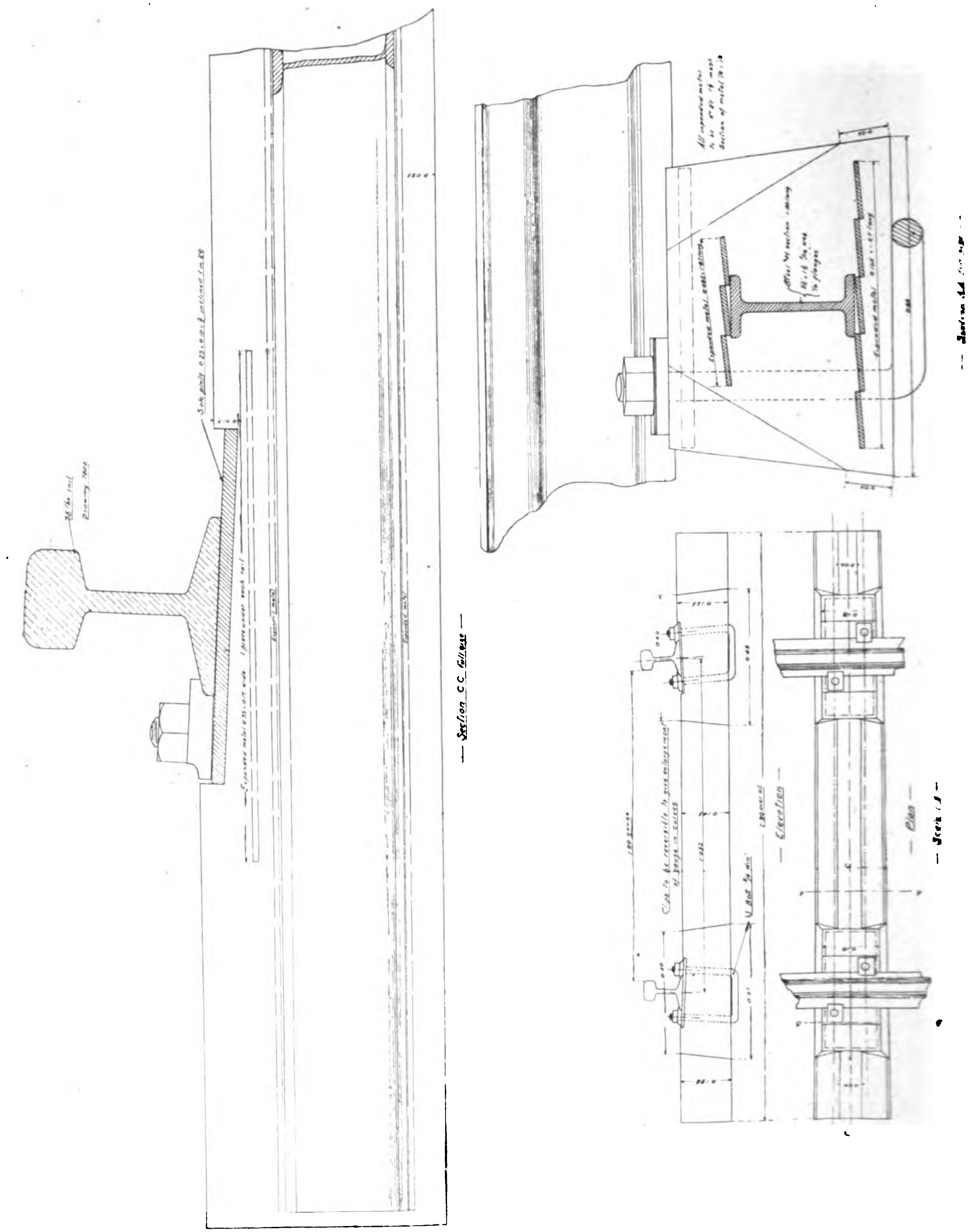
The tie rod or bar, sleeper and chair are all secured together by two bolts of ⅞ in. diameter, and thus prevents the rails from spreading out of gauge.

The Leopoldina Railway Co. made and laid 150 reinforced concrete sleepers in 1909. They were first installed in the track at Inhomerim, but after a time were removed to Entroncamento, where they were subjected to very heavy and fast traffic. The results up to the present are stated to be most satisfactory, as they show no signs of deterioration or failure.

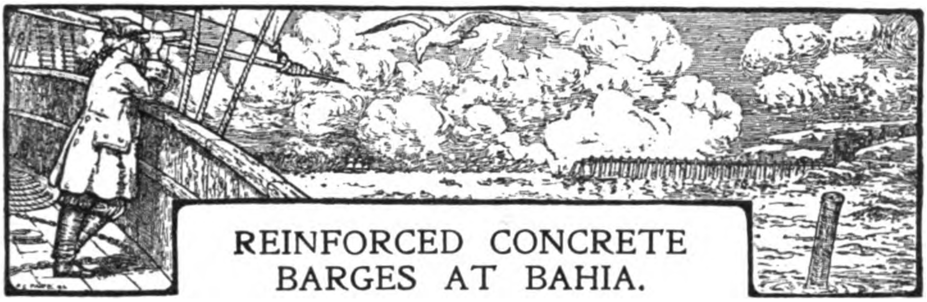


SECTION OF CONCRETE SLEEPER ON THE LEOPOLDINA RAILWAY.

They are laid on earth ballast. The full cost of these sleepers was 8s. 6d. each, but it is reported that had a much larger quantity been made the cost could have been considerably reduced. When thoroughly dry they weigh 121 kilos. Of course at that time it was purely an experiment, but, now that they have stood so well the test of eight years' continuous trial, the Company say that it would probably pay them to put some more in the track. (For further details of the construction of this sleeper see next page.)



DETAILS OF CONCRETE SLEEPERS ON THE [illegible] RAILWAY



REINFORCED CONCRETE BARGES AT BAHIA.

By G. C. WORKMAN, M.S.E., M.C.I.

In view of the great interest which is at present being shown in the subject of concrete shipbuilding, we have pleasure in presenting the following article on some work done in South America.—ED.

A NUMBER of articles have appeared recently in some of the shipping papers and in other technical journals concerning the advantage of constructing ships in reinforced concrete, especially on account of the fact that the cost of steel is at present very much greater than in normal times, whereas the cement and materials for making concrete can be comparatively easily obtained at a fairly low cost.

Many suggestions have been made for the construction of ships or barges of 200 to 300 tons, and ships of 1,000 tons and over, and certain experiments are being made in the construction of these craft in this country. It has been reported that a 3,000-ton ship has been constructed in Norway, but no further results are available. Reports of tests of small steam launches have also appeared from time to time coming particularly from America, but in every case the actual information concerning larger craft appears to be lacking altogether. Under these circumstances it will be of interest to note the particulars concerning some large reinforced concrete barges which have actually been built and used by Mr. Edmond Coignet for the construction of the Port of Bahia in South America. Typical drawings of these barges are herewith reproduced, together with a photograph showing one of the largest barges of 250 cubic metres capacity in course of construction. This particular barge was built in April, 1910, at Bahia, and its object was for the transport of dredged materials.

The dimensions of this barge are as follows:—36 metres in length (about 119 ft.) by 7 metres in width (about 22 ft.). The depth in the middle is 2·83 metres (about 9 ft.). It has a hold of a capacity of 250 cubic metres (about 9,000 cu. ft.), having dimensions of 3 metres wide by 21 metres long (about 10 ft. by 69 ft.). The thickness of the bottom and sides is only 4 cm. The internal partitions have also the same thickness. As shown in the plan, the barge is strengthened by means of a large number of ribs. It is provided with timber fenders and all necessary requisites. (See *Fig.* 1, also Frontispiece.)

The two other barges shown in our drawings have the following dimensions:—

Fig. 2 shows part plan and section of a barge to carry concrete blocks

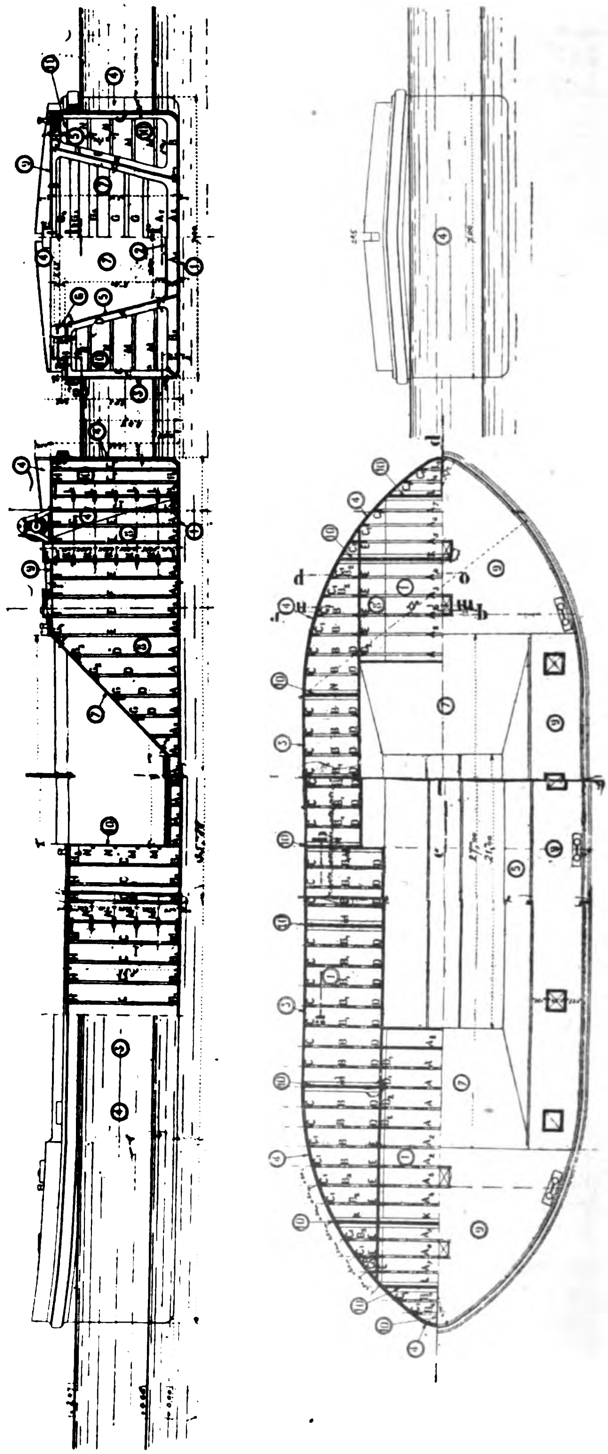


Fig. 1. Part Plan and Section of a 250 cu. m. Reinforced Concrete Barge at the Port of Bahia.

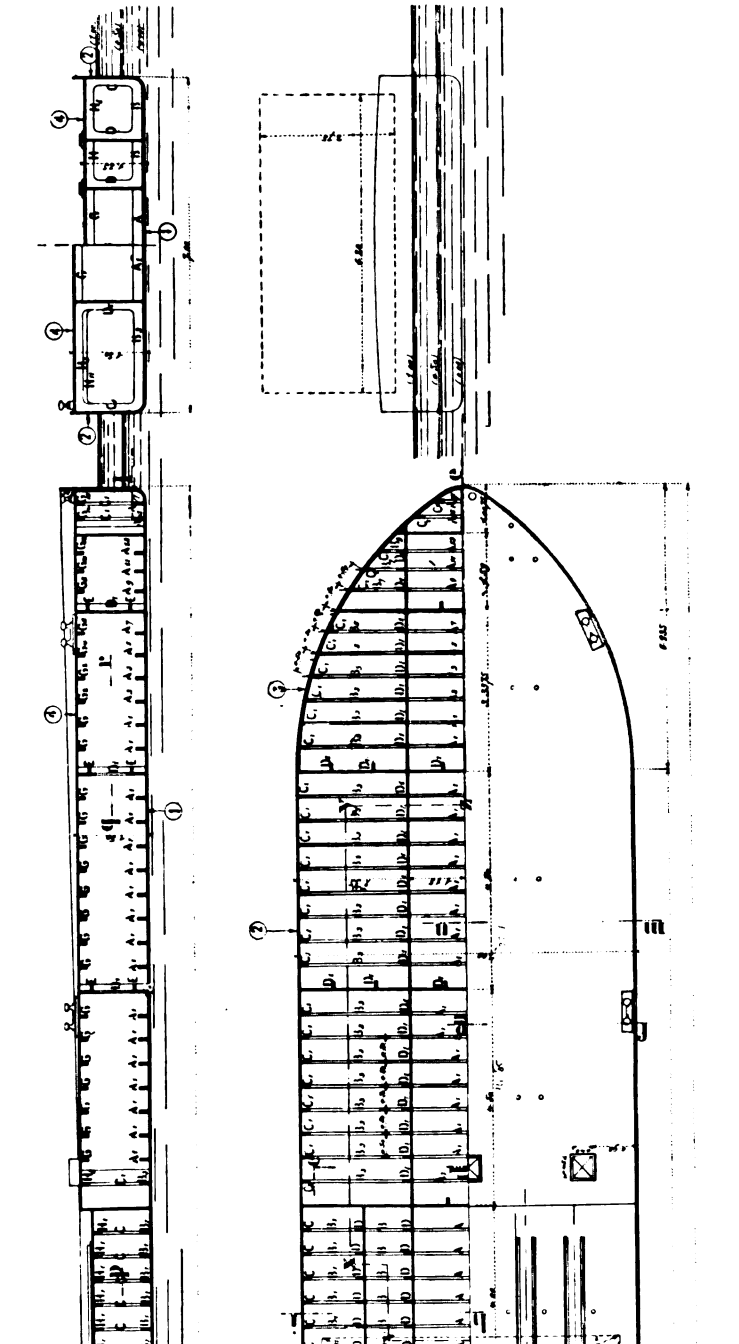


Fig. 2. Part Plan and Section of Barge to Carry Blocks weighing 120 tons.

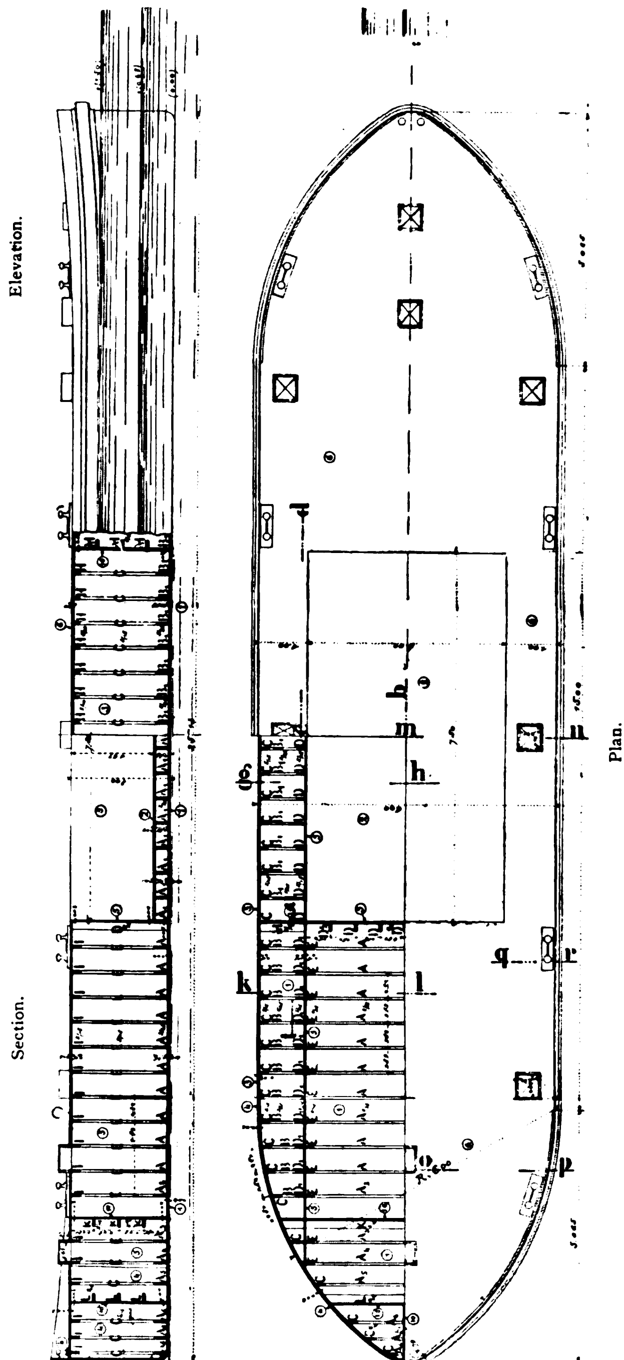
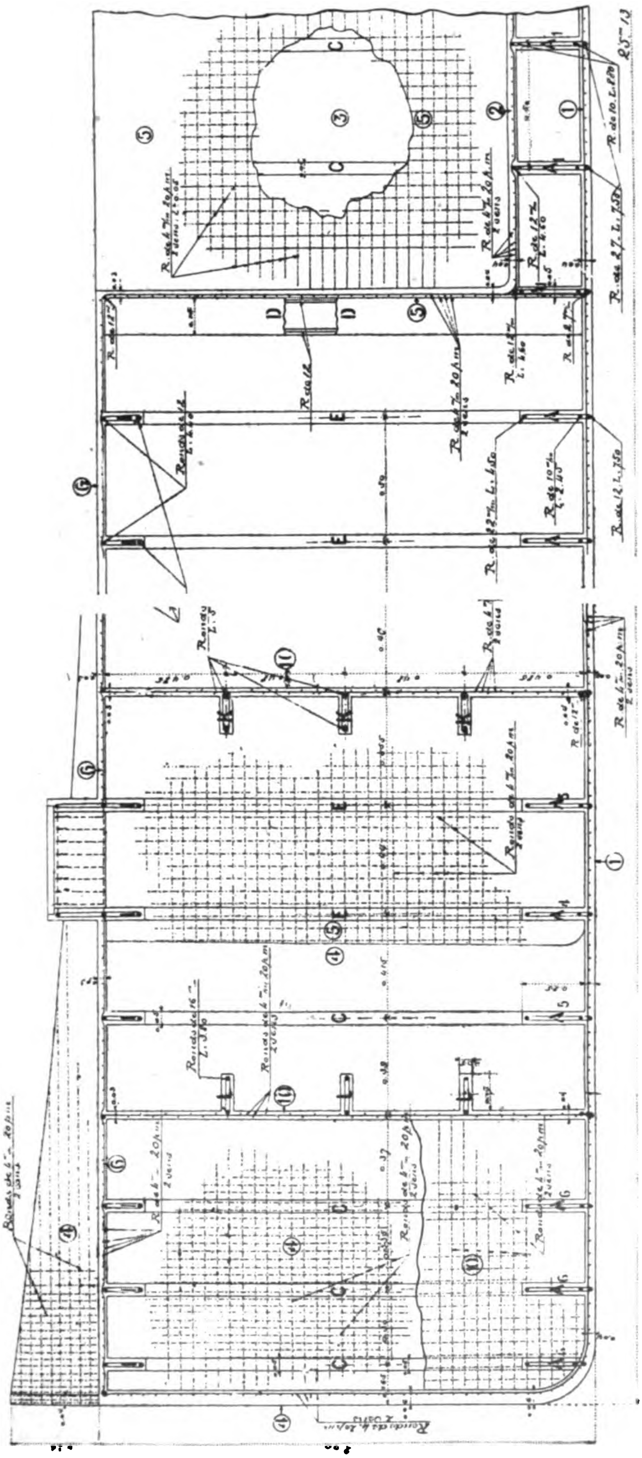


Fig. 3. A Reinforced Concrete Barge of 50 cu. m. capacity.
REINFORCED CONCRETE BARGES AT THE PORT OF BAHIA.

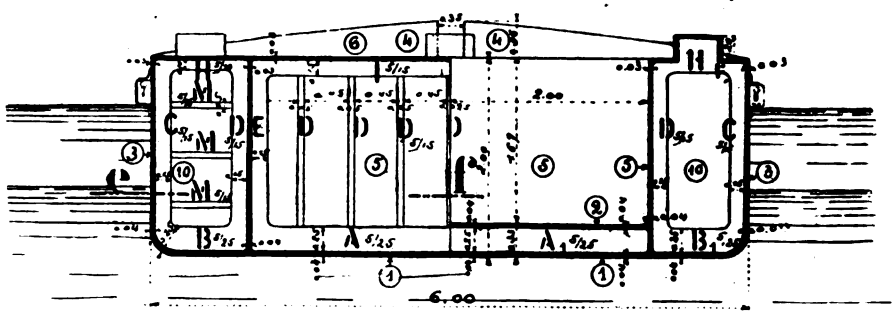


Part Section.

FIG. 4. REINFORCED CONCRETE BARGE OF 50 CU. M. CAPACITY AT THE PORT OF BAHIA.

weighing 120 tons—total length 37·87 metres (about 125 ft.) by a width of 7 metres (about 22 ft.). The depth in the centre portion supporting the masonry block is 1·25 metres (about 4ft.) between the bottom of the barge and the top of the deck. The remaining portion of the deck is at a higher level, namely, a height of 1·50 metres (about 5 ft.) between the bottom and the top of the deck. The whole of the space beween the bottom and the deck is divided up into a certain number of rectangular compartments forming bulkheads, and a large number of ribs have been provided in order to minimise the thickness of the reinforced concrete slabs forming the hull. It is noticeable that the thickness of these slabs is only 4 centimetres. The weight of this particular barge empty is 120 tons, and, as mentioned above, it has been calculated for a load of 120 tons.

The other barge (*Figs.* 3, 4 and 5), which is smaller, has a capacity of 50 cubic metres, and was constructed for the transport of masonry materials. It



Section.

FIG. 5. REINFORCED CONCRETE BARGE OF 50 CU. M. CAPACITY AT THE PORT OF BAHIA.

has a total length of 25·13 metres (about 83 ft.) and a width of 6 metres (about 19 ft.), and a depth between the bottom and the deck of 2 metres (about 6½ ft.). This barge has been provided with a central well of rectangular shape, which has the following dimensions:—7·50 metres (about 26 ft.) by 4 metres (about 13 ft.) by a depth of 1·67 metres (about 5½ ft.). Here again a large number of ribs are provided, and the space between the bottom and the deck is constructed to form bulkheads. The thickness of the bottom is only 4 cm. and the thickness of the sides is 4 cm. at the bottom, tapering up gradually to 3 cm.

The reinforcement of all the beams or ribs for the bottom and sides and deck of these barges was constructed on the Coignet System, with straight bars and stirrups. All the steel units of the beams were prepared beforehand and placed in the centering ready for concreting. The panels forming the bottom, sides, and deck simply have a meshwork of round bars of small diameter.

As shown in the drawings, these barges were not constructed with any considerable refinement as to their lines, although a certain amount of trouble was taken to round the stem and the stern. They were simply built for the purpose of utility and to enable them to be towed slowly across the bay of the Port of Bahia in fair weather. They are, nevertheless, the only *large* sea-going barges which the writer believes to have been actually constructed.

A CONCRETE MOTOR BOAT.

Our readers will recollect that in our August issue, page 466, we made a brief reference to the concrete motor boat in course of construction at the works of Messrs. Muribloc, Ltd., and known as *Cementus I.* We are now able to report from particulars sent us that a number of persons witnessed the trials of this boat at the end of August. The following are some short particulars as sent to us for publication :—

The boat, of which an illustration appears above, has now been completely tested, and with good results. Her speed is about nine knots per hour, while at a test last month she towed a barge of 160 tons at three knots in slack water, and, considering the smallness of the motor, 1 c. 7 h.p., these results were very satisfactory, and testify to the very smooth under-water surface.

The actual method of building adopted was as follows :—The keel plate was laid and stem and stern posts erected as in ordinary boat-building. The frames were then set up and faired, the whole being then sheeted with expanded metal supplied by Messrs. The Expanded Metal Co., Ltd., and faired to lines. The concreting was then proceeded with, this being applied simultaneously to both sides under pressure, the result being a thin but hard coat of great strength.

The boat has seven watertight compartments, the divisions together with the seats and floors being only ⅝ in. thick. It is stated that on test these being filled with water showed no sign of damp on the inner surfaces. No woodwork was used in any part of the boat, so that, besides being fire-resisting, she may be said to be rot-proof. The cement used was "Ferrocrete," supplied by Messrs. The Associated Portland Cement Manufacturers, Ltd. The vessel has proved remarkably strong and resilient, and during her six weeks on the tideway has been subjected to some very heavy knocks, many of them sufficient to stove in the planks of a wooden boat of her size. She has also been tested by being supported at either end and treated as a beam; also by being pivoted at the centre as a double cantilever, in both cases showing no sign of strain. Her weight is about 30 cwt. It is believed by the designers that this is the first fully lined light concrete motor boat which has yet run in this country. She was completed in sixty hours' working time from the laying of keel plate, and launched in ten days after completion, having to shoot off the ways and drop five feet, and in doing so sustained no damage.

STRESSES IN RECTANGULAR FRAMES.

I.

By G. R. MAGNEL, I.C.C. (Ghent).

In the present article the writer proposes to give a quick and accurate method of finding the stresses in a structure composed of two vertical columns or supports, completely fixed at the bottom and connected at the top by a beam strongly fixed to them. All possible loads will be considered, both live and dead, concentrated or distributed, vertical or horizontal.

The engineer has often to deal with structures of this nature in his daily practice, and, in absence of a quick and reliable method to find the exact stresses, he is compelled either to apply more or less approximate rules—which is more often guess work—or to spend hours working through the elaborate calculations required by the elastic theory. The latter are lengthy because the structure is threefold statically indeterminate, being in fact an arch with fixed ends; the problem becomes still more complicated when live loads are to be taken in account in addition to dead loads. All of which shows the usefulness from a purely practical point of view of having to hand a method giving the same result as these complicated calculations, but requiring only a few minutes.

Before describing the proposed method it should be remembered that the only way of dealing satisfactorily with statically indeterminate structures consists in using *Influence Lines*. As the reader may not be quite familiar with these lines—which are more generally used on the Continent than in this country—it may be advisable to give some explanatory remarks on the subject.

The simplest definition of an Influence Line—the latter always referring to a special cross section of the structure—is : a curve showing, by the variation of its ordinates, how a unit load moving over the structure affects the special section to which the curve refers.

Thus in the structure specially considered in this article (*Fig.* 1) the Influence Line for the bending moment at point 1 for vertical forces is a curve marked (*i*) showing how this bending moment varies when a unit vertical force moves from 1 to 2 : if a unit force acts at point K the bending moment m_1 at point 1 is given, at a certain scale, by the ordinate ab of the Influence Line (*i*). A similar curve might be drawn for the bending moment at any other point of the structure.

Instead of vertical forces, horizontal ones might be considered moving either from 0 to 1 or from 3 to 2. In *Fig.* 2 the curve marked (*i*) is the Influence Line for the bending moment at point 1 for horizontal forces moving from 0 to 1, or, a unit force acting horizontally at point K gives at point 1 a bending moment m_1 measured at a certain scale by the ordinate ab of the Influence Line (i). A similar curve might be drawn as Influence Line for the bending moment at point 1 for horizontal forces moving from 2 to 3.

If a load P (instead of a unit load) acts at point K vertically in the case of *Fig.* 1 or horizontally in the case of *Fig.* 2, the corresponding bending moment at point 1 will be P times the ordinate of the corresponding Influence Line (i).

Further if a uniformly distributed load p—which is nothing else but a series of identical infinitely small isolated forces—acts vertically from 1 to 2 in the case of *Fig.* 1, or horizontally from 0 to 1 in the case of *Fig.* 2, the corresponding bending moment at point 1 is p times the area of the corresponding Influence Line (i). If the uniformly distributed load is applied to a part only of the beam (*Fig.* 1) or the column (*Fig.* 2) the corresponding bending moment at point 1 will be p times the corresponding partial area of the Influence Line (i).

Finally a load that, although being distributed, is not uniform, can always, with sufficient practical accuracy be replaced by a certain number of concentrated loads for which the Influence Lines give the bending moment at point 1.

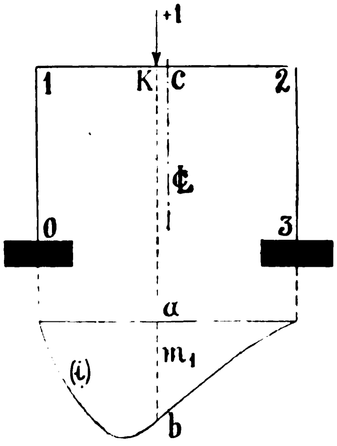


Fig. 1

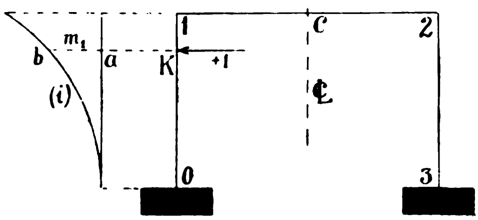


Fig 2

The above remarks show clearly the value of the information given by the Influence Lines of a structure. If these lines are plotted for the points marked 0, 1, C, 2 and 3 in *Fig.* 1 (in fact only for the points 0, 1 and C as the structure is symmetrical), both for vertical forces moving from 1 to 2, and for horizontal ones moving either from 0 to 1 or from 3 to 2, all possible information is to hand concerning the values of the bending moments in the structure for any loading, no further calculations being necessary.

It is the aim of the writer to give a new method enabling all these Influence Lines to be plotted in a few minutes. Any rise and span will be considered, as well as any value of the ratio of the Inertia Moment of the beam to the Inertia Moment of the columns, it being only assumed that both columns and beam are prismatical in section, which is nearly always the case in practice.

A.—Practical Use of Proposed Method.

It follows from the above remarks that three Influence Lines (one for each of the points 0, 1 and C) will have to be plotted, for each of the following cases:—

(1) Vertical forces moving from 1 to 2.
(2) Horizontal forces moving from 0 to 1.
(3) Horizontal forces moving from 3 to 2.

This means in all 9 different Influence Lines; but as the cases (2) and (3) relative to the same point (0, 1 or C) are considered on the same diagram, only six diagrams have been prepared, marked V_1, V_0, V_c, H_1, H_0, and H_c, the letters V and H referring to vertical and horizontal forces respectively and their indices referring to one of the points 1, 0 or C. The diagram marked V_c will thus represent the Influence Lines for point C for vertical forces; the diagram H_0 represents the Influence Lines for point 0 for horizontal forces, one part of the diagram corresponding to the forces acting on the left hand column, and the other part to forces acting on the right hand column. This will be more completely explained below.

As it will be shown in the course of this article the numerical values of the ordinates of the different Influence Lines depend upon the relative stiffness of the columns to that of the beam. This explains the important part played by the factor "a" which might be called the "*Stiffness Ratio*" being:—

$$a=\frac{R}{L}\times\frac{I}{I_1}$$

where R=rise; L=span; I=Inertia Moment of beam; I_1=Inertia Moment of columns.

It will be shown that two structures having the same Stiffness Ratio "a" but having none the less different values of either R, L, I and I_1 have geometrically similar curves as corresponding Influence Lines, so that *one* curve might represent the Influence Line of say the bending moment at point 1 under the action of vertical forces, for both structures, only the scales by which the ordinates have to be measured being different in both cases. It might therefore be said that the Stiffness Ratio determines the *shape* of the Influence Line but not the *numerical values* of its ordinates. These numerical values (the special scales by which the ordinates have to be measured) are determined, in the case of vertical forces, by the special value of the span L, and in the case of horizontal forces by the special value of the rise R.

But if, instead of letting the ordinates represent the moments due to the action of a unit force, the ordinates are made to represent these moments for unit length of beam in the case of vertical forces and for unit height of column in the case of horizontal ones, the lines obtained—which will still be called Influence Lines, no confusion being possible—will be the same for all structures having the same Stiffness Ratio "a," whatever the actual values of L, R, I or I_1. The Influence ordinates will then correspond to $\frac{m}{L}$ for vertical forces and $\frac{m}{R}$ for horizontal forces, m being the actual bending moment for unit force.

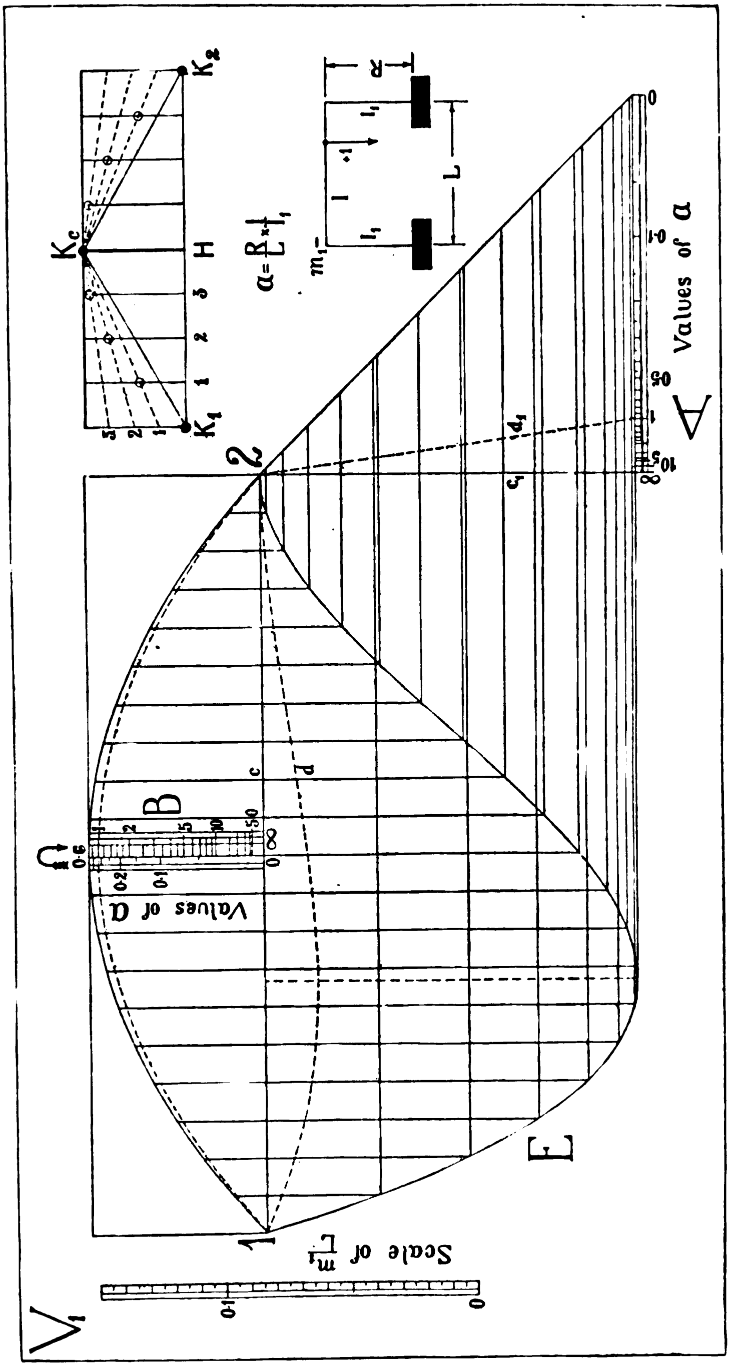
For every special practical case the first operation will be to calculate the Stiffness Ratio "a"; having found this every diagram will enable the Influence ordinates to be plotted.

After these preliminaries it is quite easy to explain the use of the six diagrams individually.

Use of Diagram V_1.

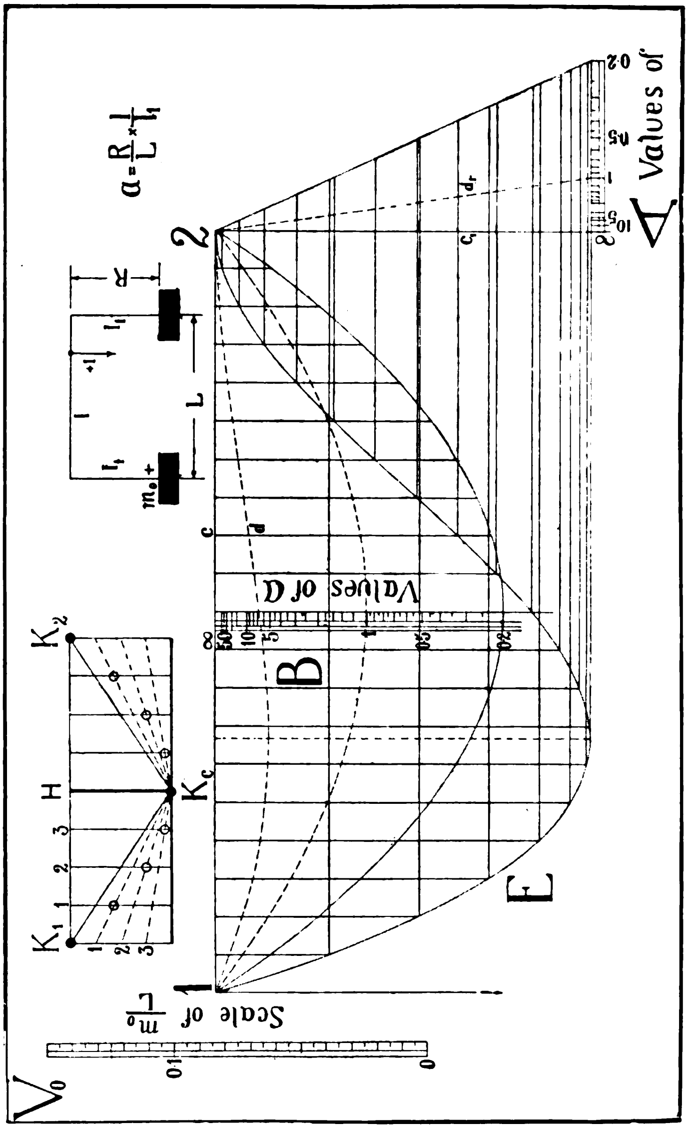
The line marked 1—2 represents the span which is divided into 20 equal parts by a series of vertical lines. Two distinct operations are necessary in each case :—

(1) Reduction of (the ordinates of) the curve marked E in a certain proportion in the following way:—Draw a line from point 2 to the point of scale A corresponding to the Stiffness Ratio "a" of the structure in question, say $a=1$ (this example has been taken on all the diagrams and the corresponding curves are shown in dotted lines) ; the reduction of any ordinate of length $2-c_1$ *f.i.* is that given by the corresponding horizon-


K1
K2
Kc
H
$a = \frac{R}{L} \times \frac{I}{I_1}$
m_1
R
L
Values of a
Values of a
Scale of $\frac{L}{m_1}$
B
E
V1
A
1
2

tal line c_1d_1 to the dotted line just drawn; this is plotted at *cd* on the original ordinate and gives a point *d* of the reduced *E* curve shown in dotted lines.

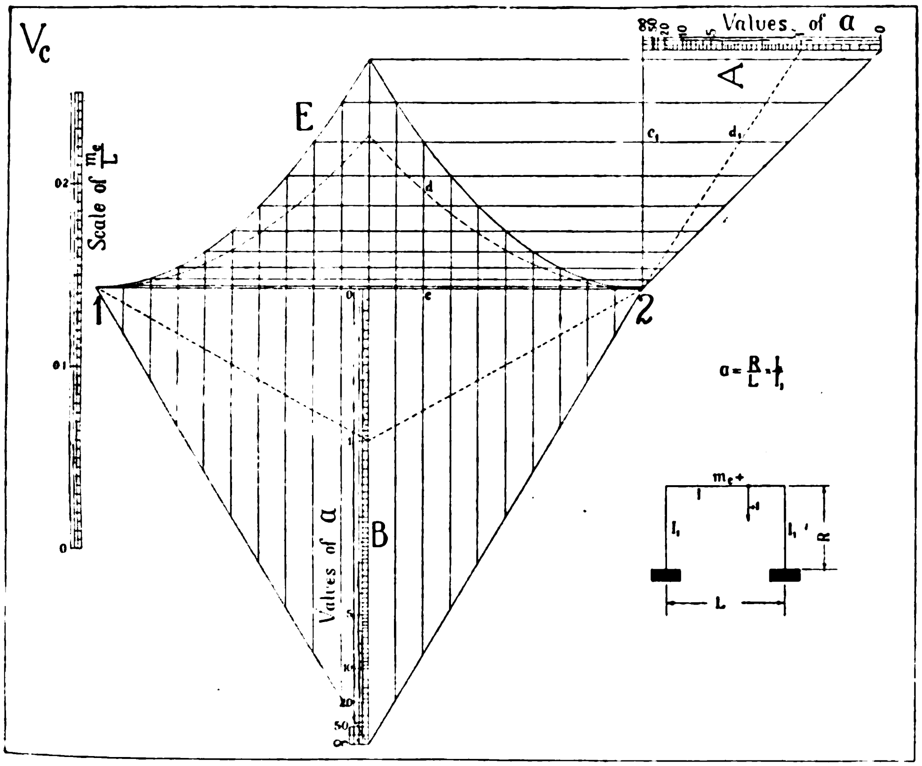
(2) Construction of a parabola having as apex the special point of scale *B* corresponding to the Stiffness Ratio "*a*" (say $a=1$) and passing through points 1 and 2 (shown in dotted lines). The construction of this parabola is very easy and is diagram-



matically shown in the top right hand corner of the diagram. The ordinates of the V_1 Influence Line (values of $\frac{m_1}{L}$) are then obtained as the vertical distances between the two dotted curves, these distances being measured at the scale drawn at the left of the diagram.

Use of Diagram V_0.

The above explanation applies without modifications to this second diagram, the only difference being that the parabola is placed under the line 1—2 instead of above it. The final Influence ordinates are again obtained as the vertical distances between the two curves.



Use of Diagram V_c.

The above explanation still holds good, the only difference being that the parabola is replaced by a triangle with base line 1—2 and apex at a certain point of scale *B*. The curve *E* is different in shape as compared to those of the two previous diagrams but is to be reduced and used in the same way.

(To be concluded.)

A WATER TOWER AT VELSEN.

REINFORCED CONCRETE AND WATER TOWER CONSTRUCTION IN HOLLAND.

By
S. L. A. ORIE,
Civil Engineer.
Ginneken.

(Concluded.)

(Revised and Abbreviated.—ED.)

Continued from last issue. As indicated, we have somewhat revised and abbreviated Mr. Orie's original MSS.—ED.

THE sections and elevation in *Fig.* 9 show a water tower at Zandvoort. In this case the outer covering is of solid reinforced concrete cast between shuttering in the ordinary way, no special system having been adopted. Attention has been specially paid to architectural rendering in this instance. The structure is not only intended as a water tower but also as a belvedere. The tank is entirely in the roof.

The bottom of the tank is vaulted, and in the opinion of the writer of the article this is a form of construction to be recommended for water tanks, especially very large tanks. The chief argument in favour of this vaulted construction is that a uniform distribution of the load is easily attained around the outer edge of the tank such as is not always given when the beam and slab type of bottom is adopted.

It is also claimed that the centreing employed is not so large in quantity nor cut up in such a wasteful manner, as the very small pieces necessitated at the junctions of the radial beams are avoided, and the labour is more in the latter case.

A photograph of the finished structure is given in *Fig.* 10, and the general arrangement of the construction can be gathered from the drawings illustrated in *Fig.* 9.

Fig. 11 shows details of the water tower at Ouderkerk on the Yssel. As will be seen from *Fig.* 12 the construction is of the plainest kind. The masonry is of local stone known as yellow Ysselstone. The base of the tower is built in hollow concrete blocks. The bottom of the tanks consists

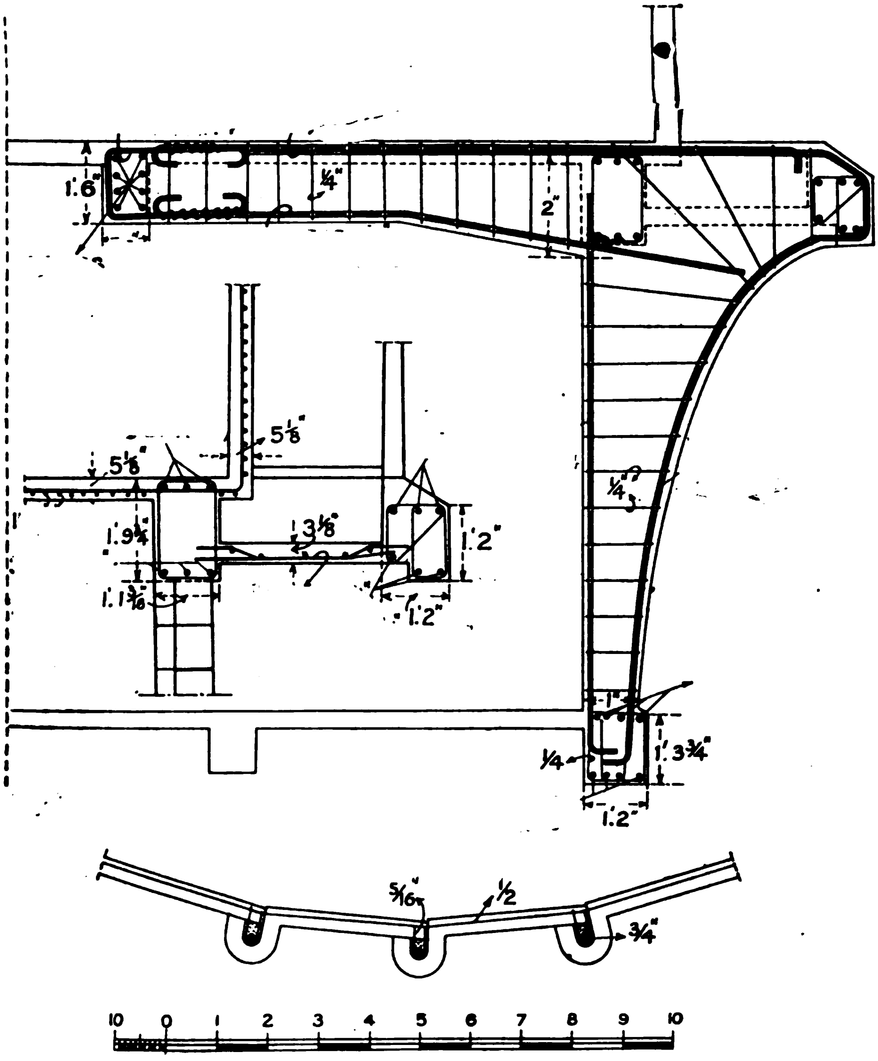


Fig. 8. Details of Construction of Ysselstein Tower.
(*See last issue.*)
REINFORCED CONCRETE WATER TOWERS IN HOLLAND.

of a vaulted floor. Springing from beams forming a hexagon on plan, which are in turn supported by the six main vertical columns which rest on piles below ground. These columns are stiffened by intermediate slabs and beams, which are introduced to provide floors at intervals on the height, and the roof over the tank is formed as a flat of the slab and beam type.

Fig. 13 shows the water tower at Dubbledam. The architectural details were designed by Messrs. Visser and Smit, architects, whilst the constructional

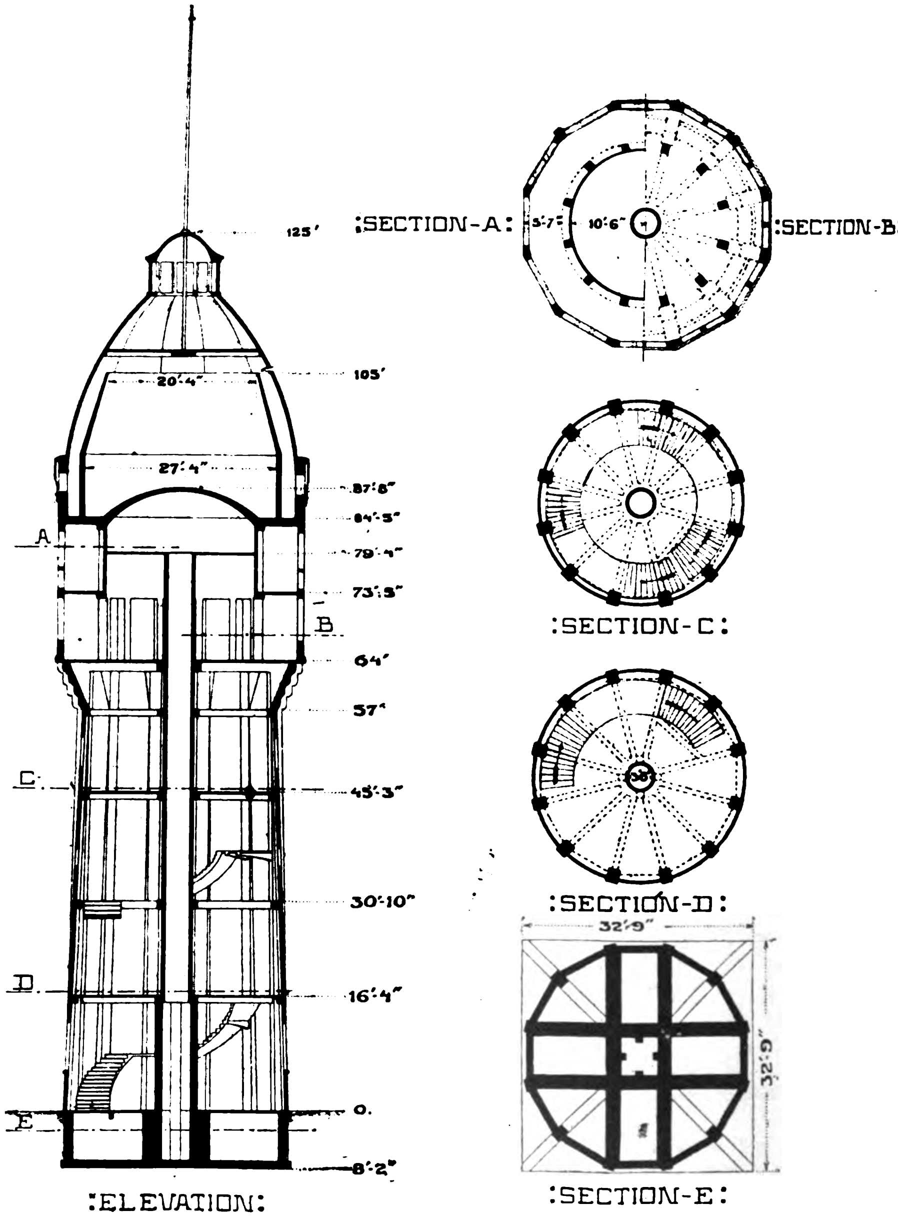
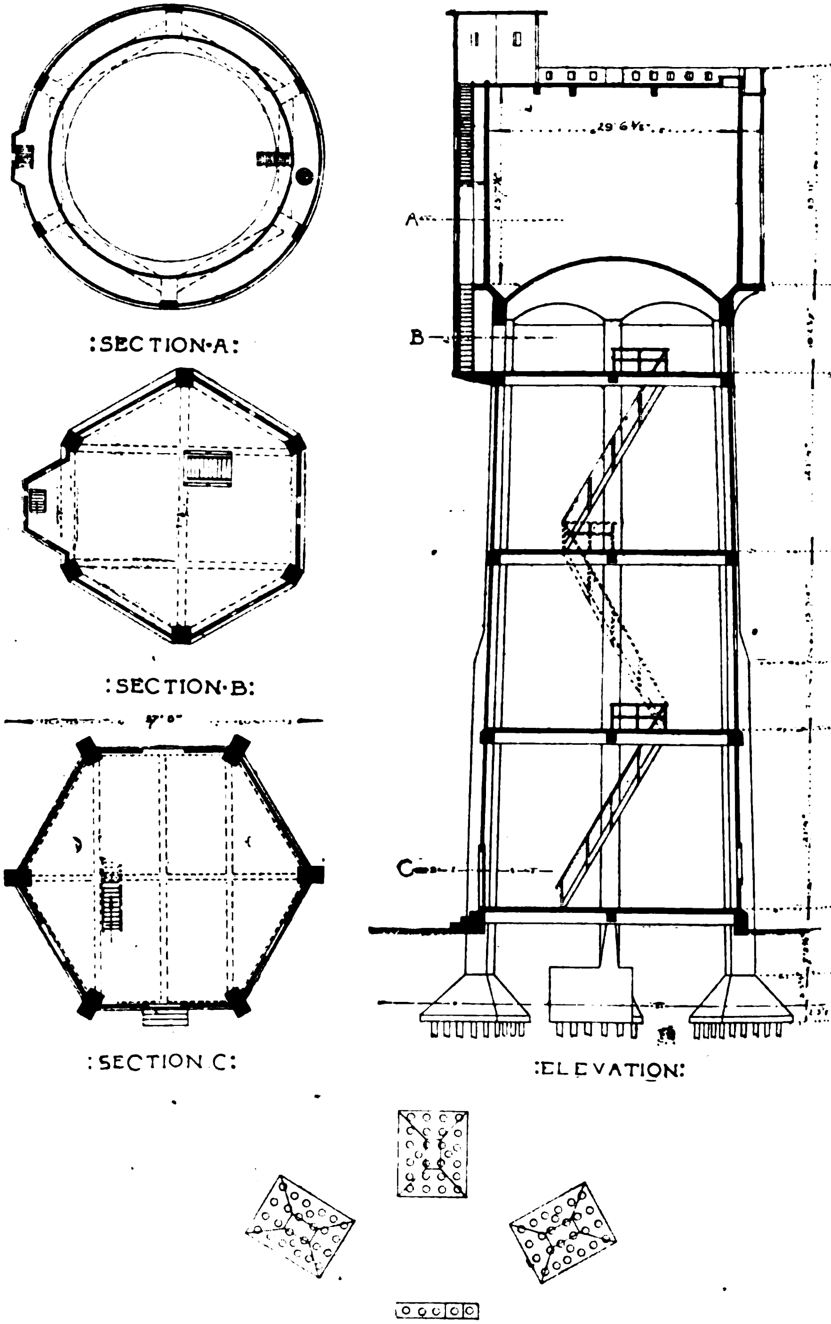


Fig. 9. Water Tower at Zandvoort.
REINFORCED CONCRETE WATER TOWERS IN HOLLAND.

details were designed by the writer. This tower has only recently been completed, and a photographic view is shown in *Fig.* 14. Here again a vaulted bottom has been built for the tank, but, unlike the other examples given, the tank is not directly supported by the pillars but the weight is conveyed to them by a concrete ring resting on these pillars. This was done in accordance with the desire of the architects, who wished the outline of the tower to present a straight vertical line without a projecting tank. In the example it will be noticed that an opening was required in the collar for the stairs, and as the opening interrupted the continuity of the circumferential reinforcement,

Fig. 10. Water Tower at Zandvoort.
REINFORCED CONCRETE WATER TOWERS IN HOLLAND.

it became necessary to introduce the circular ring to take the pressure and prevent any tendency to spread, while the ring conveys the weight to the pillars and ensures uniform loading. In ordinary cases the collar and the vaulted bottom will ensure uniform loading and provide satisfactory construction without the introduction of a circular beam ring, but this will not apply unless the reinforcement is continuous and the inverted saucer-like form is maintained complete over the whole area, more especially at the outer edges through which the pressure is transmitted.



Part Foundation Plan.

Fig. 11. Tower at Ouderkerk.

REINFORCED CONCRETE WATER TOWERS IN HOLLAND

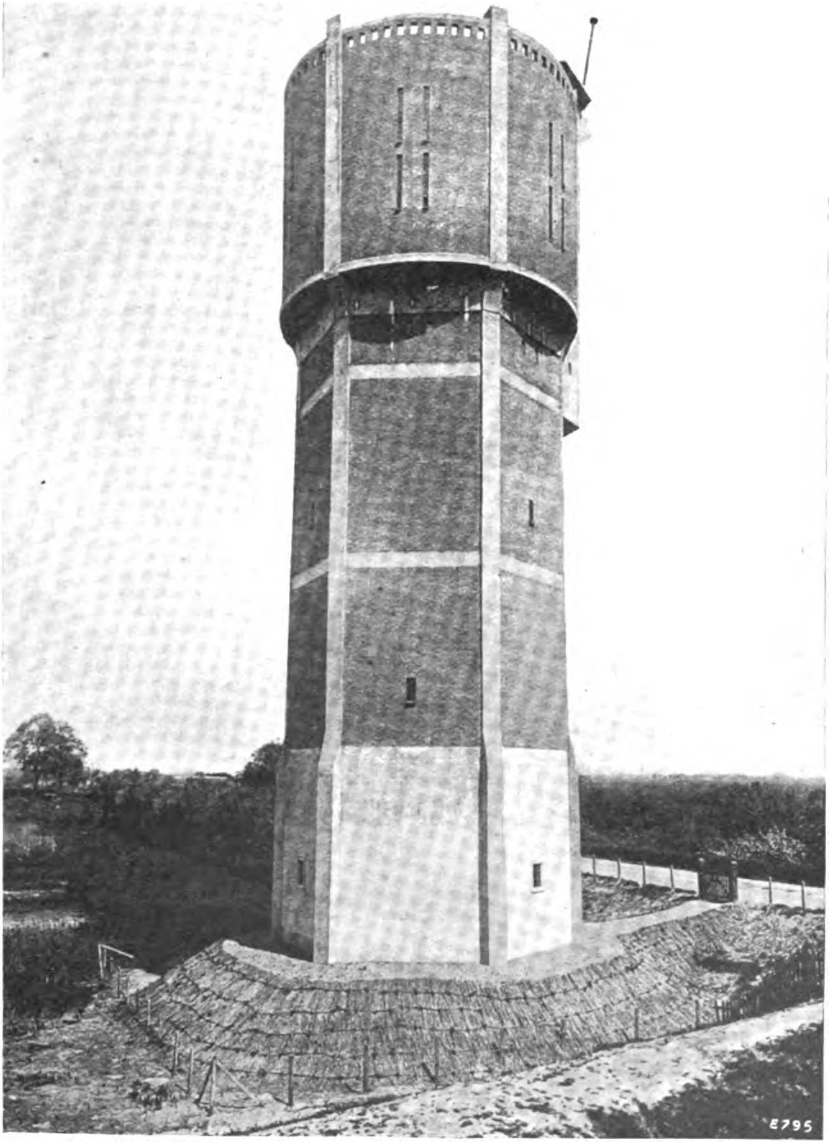
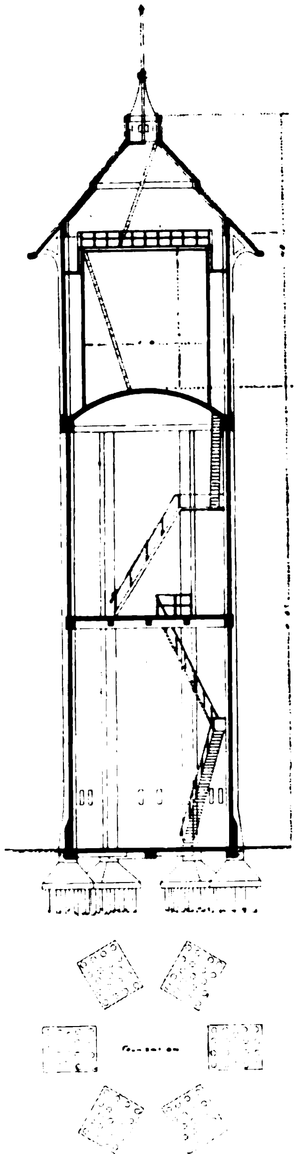


Fig. 12 Water Tower at Ouderkerk.
REINFORCED CONCRETE WATER TOWERS IN HOLLAND.

Fig. 15 shows the construction generally of the bottom of the tank and the outer walls. The roof is a simple slab construction without beams.



Figs. 13 & 14. Water Tower at Dubbeldam.

Reinforced Concrete Water Towers in Holland.

In conclusion, in the photographic illustration shown at the beginning of this article—the water tower at Velsen—the typical character for which the structure is intended is, of course, lost, but it has merits from an architectural point of view, and may be of interest to those who specially study and have to design buildings of this kind. It is a typical illustration of the development that has taken place in the design of water towers, as the earliest types consisted merely of a simple frame constructed to support a tank at a high

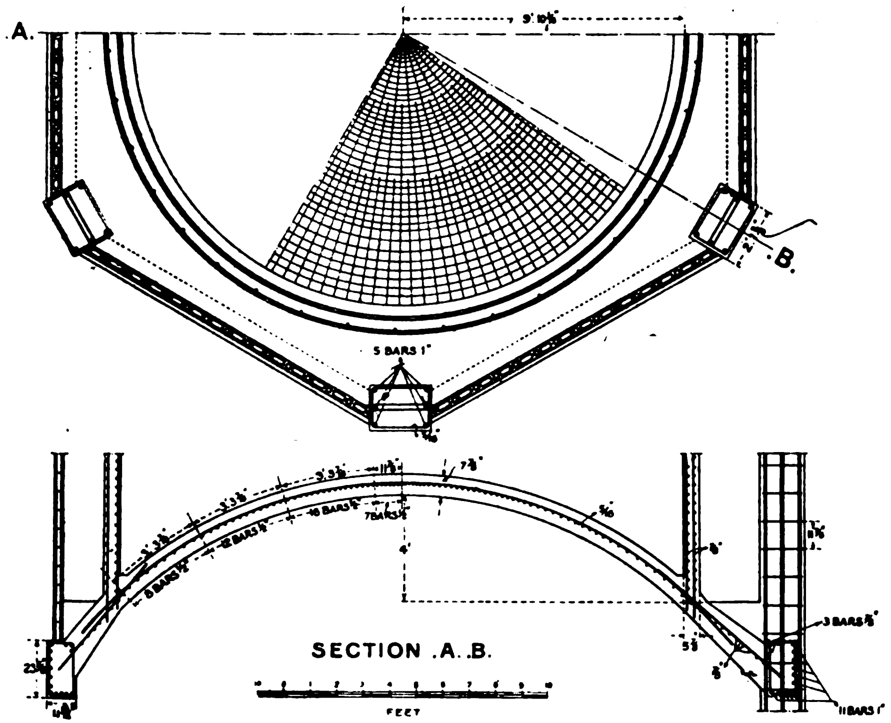
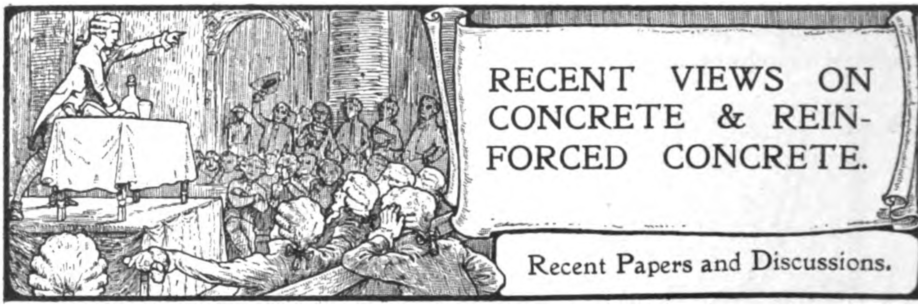


Fig. 15. Details of Construction of Water Tower at Dubbeldam.
Reinforced Concrete Water Towers in Holland.

level, and in this example a structure is produced which disguises both construction and purpose, while every effort has been made to give a building which is pleasing to the beholder.



It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.—ED.

THE AMERICAN CONCRETE INSTITUTE.

ARTISTIC STUCCO.

By JOHN B. ORR.

The following is an abstract from a paper read at the Thirteenth Annual Convention of the American Concrete Institute, held in February of this year, and is reprinted from the Institute's Proceedings, Vol. XIII.

WHAT great possibilities can be conjured up in these two words. Stucco is among the oldest in some form or other of man's early attempt at the artistic. With all the possibilities, and despite the fact that there can be found to this day portions of stucco in a good state of preservation after standing the wear of many centuries, there is no other form of building material that has fallen more into disrepute than stucco. This is especially so in the United States. The causes can be largely traced to the slipshod methods of procedure that have gradually crept into our building industry. To-day the main point of view or achievement that is looked for is whether a contractor can complete in sixty days what should take three or four times longer. Shorts cuts are taken wherever they can; things that appear small in the successful completion of the work are sacrificed for time. The boy learning the business does not learn how good to do it but how fast to do it. The view he sees as a successful craftsman is not to do better and try to improve on the specifications for the work but just how much he can scamp and get away with.

Some contractors govern their cost by these methods and we get the results so often noticeable in modern construction, competition in price instead of competition in value or good work. The good contractor who tries to figure at a price that will permit good work, in many cases is forced out of business, leaving the field open to the cheaper man and cheaper methods. I believe every form of encouragement and instruction should be given the craft to encourage good work. Your body which sits in convention is an exemplary method for the betterment of the work.

HISTORY OF STUCCO.

We find that stucco was used in building almost as soon as buildings were found to be necessary. It grew from the crude mud huts to the artistic treatment of exteriors to be found in the old world to-day. Stucco is an Italian term usually applied in Italy to an exterior plastering, although we can trace it further back under a different name. The old Egyptians and the classical Greeks used a form of exterior plastering extensively. However, I have always looked upon Italy as the mother of the plastic art, and responsible to a great extent for the artistic effects of exterior plastering generally known in this country as stucco. In Great Britain stucco is a somewhat indefinite term for various plastic mixtures. Robert Adam adopted stucco as a covering over houses built of brick and cobblestone, and it was used extensively during his period.

In going over several books in my collection I find that the Temple of Apollo, at Delphos, and even the first Parthenon under the ægis of Pallas was plastered with stucco. Vitruvius calls the exterior plastering Tectorium Opus. This was composed of three coats of lime and sand and three coats of lime and marble, the united thickness not being more than one inch. The first coat was of common but very old lime and sand (lime that had been "soured" three or more years); when it was nearly dry a second and third coat was applied and left fairly straight. The work was then laid over with another two coats of lime and marble and finished with a coat of fine marble powder; this finish of marble powder being trowelled into it before it was dry. The marble mortar was beaten to render it tough and plastic. The successive coats of marble mortar were trowelled into each other before they were dry. The tectorium was then painted in brilliant colours while it was still fresh. In certain conditions the surface was then rubbed with wax and pure oil for the purpose of adding to the brilliancy and endurance of the colours.

Slabs of this tectorium have been found and preserved from the ruins of Pompeii and Herculaneum and are in the Museum of Portici. Specimens also from the same place are in the South Kensington Museum, London. It was found that some of this work was coloured integrally, while in others it was coloured by the use of

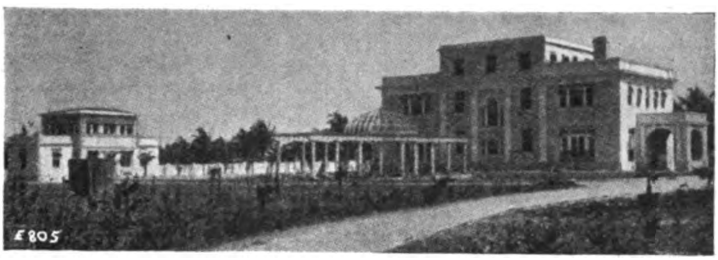


Fig. 1. Florida Residence with Stucco Finish.

a wash which was applied over the surface while it was still fresh. The early workers in stucco had each their different formulas for treating the stucco to make it weatherproof. Pliny mentions fig juice as being used in exterior plaster; elm bark and hot barley water were mixed with the stucco used on Justinian's Church of the Baptist, Constantinople.

Bullocks' blood was employed for this purpose in the mortar for Rochester Cathedral, England. White of eggs and strong mort of malt was used in the lime for Queen Eleanor's Cross, Charing Cross, London, in the year 1300. My mention of these different methods and treatments is to show the care and wide range of methods and mixtures that was used in the endeavour to make the stucco weatherproof, and the difficulty that the old craftsman had to contend with in getting these results.

Modern manufacture has overcome this to a large extent, and has made the path of the stucco workers easier. It is a curious fact that the fountain of possibilities in modern stucco has hardly been tapped. I give for the reasons: First, fear of the permanency of the material; second, neglect by the architects in not studying the possibilities; third, the difficulties in getting the work executed, owing to the ignorance of the craftsman in this branch of the plastic art. In reply to the first, anyone who has travelled or has gone into stucco historically can prove the permanency of the material before and after the introduction of portland cement as the material. By the introduction of portland cement and waterproofing compound much has been done to simplify and make permanent the mixture. The danger in most cases to be overcome is the manipulation of same.

How to Eliminate Crazing.

My greatest obstacle to overcome has been crazing or check cracking. This I have cured by what I believe to be the only sure method. The richer you get the mix, the more danger there is in check cracking. Rapid drying, heat in cement, soft sand, these all help to cause check cracks. I have taken precautions against these dangers, and have done what I could with the local materials that are obtainable here. I had good results in some cases and in some others check cracks did appear despite the fact that I had made every effort to avoid them; I never yet had any to scale or fall off. My next attempt I made using an overwash of liquid stucco. This last method has proved very satisfactory. In Florida we have several obstacles to overcome although we do not have the freezing weather. We get a very poor sand, that is impregnated to a certain extent with salt. The sand is not sharp enough. We have quick drying weather and strong sun heat, and I believe this to have been a severe enough test to show that the stuff would not craze. To the architect and designer, as a layman, I offer a few suggestions and criticisms. As a general rule they do not give enough study to the possibilities in colour effect such as are to be seen in Europe, Cuba and other Latin countries. Then, in ornamentation they seem to forget that they are working in a very plastic material that lends itself to the fullest extent in obtaining lights and shadows.

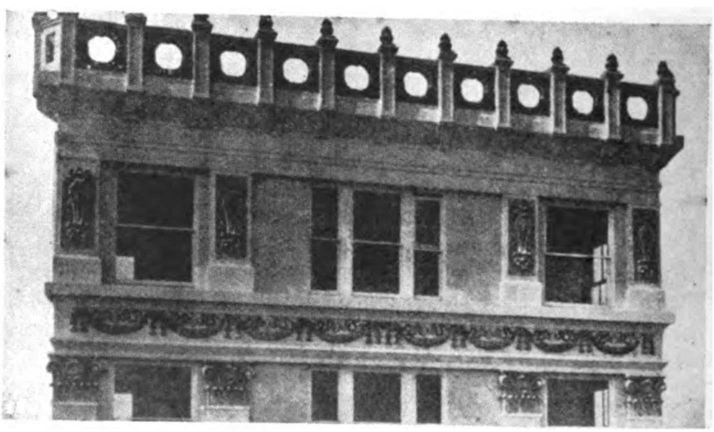


Fig. 2. Some Upper Story Relief Work in Stucco.

I believe that to get the full effects, relief work in stucco should have the appearance of being modelled in place with this material. It should not have hard lines, and in no case should it have the appearance of carving as in stone. The work should retain all the touches of the modelling, these touches that give the sketchy effect which is lost in the carving in stone. In the preparing of the models the modeller should accentuate the detail and not attempt to smooth up the model. These markings, when brought out, all serve to make the work plastic and alive. It also helps in obtaining light and shade when colours are used as the finish. Even when the work is coloured integrally these markings of the tool all stand out, and bring out the work better to the eye when the buildings weather. In other words, he should not attempt to get in the clay any smoother work than he could get if he was modelling with stucco right in place instead of modelling in clay.

Low Relief Work Easily Obtained

By proper maniulation of colours and attention to the above details great beauty can be obtained from work in low relief. Several jobs which I have under way at present I am using this method on and am getting what I believe good results. I am not attempting to confine the relief work to panels, but am using the walls as the background, getting an effect as if the work was actually modelled in stucco and keeping the relief work very low and plastic. As a general rule it seems to be the practice of designers in stucco to copy stone; this, in my opinion, is entirely wrong. Stucco is a distinctive material and should be used as such. In ornamental moulding and relief work I use a combination of several colours (which match with the general colour scheme of the exterior of the house) to bring out the effect and give light and shade. I use the darker tints in the background and work out the lighter tints to the high lights, blending all the tints by rubbing the one colour into the other. By doing this you bring out all the plastic beauty of the modelling and give an artistic appearance to the whole scheme. My colours on stucco I bring out by the use of a wash of liquid stucco.

A study in colours for the stucco of buildings is the work of an artist, and should be given this care with due consideration to the surroundings in which the house is to be built. I look to see the sketchy effect and also like to see the building weather properly, not stay one solid colour, but get the soft effect that only a stucco can take on—a blend of several shades which come by age—and this is my objection to cement paint on residences; it looks artificial. Its use, in my opinion, as before stated, is limited to certain types of public buildings where the surrounding buildings, street and sidewalk have the tendency to harden the effect.

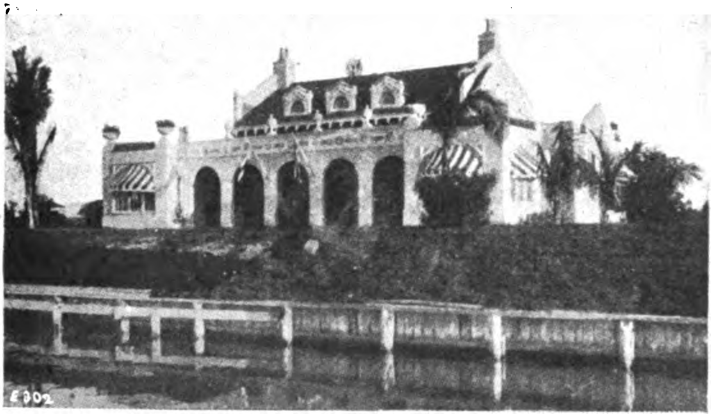


FIG. 3. STUCCO WORK ON CLUB HOUSE, OCEAN BEACH, FLORIDA.

HOW TO GET COLOUR EFFECTS.

Conditions like this call for an entirely different treatment than the residence that sits in grounds where one gets the benefits of the colour effect of flowers and foliage. My idea in getting effect and tone to a residence is that a study of the whole scheme, including the landscape work, should be taken into consideration and let the residence become a part of the landscape on which it sits, and not make it look like an obstacle that has been put in the way of the beauty of nature. In public buildings there is a big field for the stucco worker in producing the effects that are obtained by the use of terra cotta. Stucco can be made a formidable competitor of this material. It can be made permanent, and has as wide a range of colours as polychrome terra cotta. When this is the result that is required, this is the method I use and into which I use cement manufactured paints as a background applied over stucco surface for the colour effects. I apply the stucco according to the methods and specifications given later. When the stucco is thoroughly dry I then apply a priming coat of a good cement paint, using the material thin and working it into the stucco surface with the brush, being careful not to use the material too thick, so that it will not spoil the texture of the surface, the texture of which should be a smooth sand finish. If the effect wanted is in a blend of several colours my system is to cover the surface of the stucco with two coats of cement paint as mentioned above.

I then mix up my blending materials in the form of a stain, using good mineral colours ground in oil, which I thin down with prepared oil. I apply this stain over my relief and ornamental work in the various tints desired. I then rub off the high lights and in general blend in the colours to give it the soft effects. On the plain surfaces I apply the stain in the colour desired, then rub off as much as possible; this gives a very pleasing mottled effect that blends in with the under coating of cement paint and takes away the hard appearance.

In some cases I colour the work integrally, a liquid form of the stucco of the same colours with a binder and hardener and waterproof being added. This material, when properly applied over a fairly rough texture makes a fine finish, and when one gets familiar with its working fine colour effects are obtained. This liquid stucco is applied with a brush, like paint. The stucco surface when finished does not look like paint but retains the softness of the stucco with an unlimited range of colour effects. On the ornaments and trim I use colour effects with this wash in very much the same method as I specify for my treatment on public buildings, except that the material is a stucco composition. To get the shading great care and taste must be used. This liquid stucco coat should be applied before the stucco surface is dry, usually, wherever possible, a day after the stucco is finished. It then dries and sets along with the stucco and makes a good bond. Spraying with water helps to make the surface bind, using a very fine spray. It gets harder with age, and being of practically the same composition as stucco it retains all the soft tints and makes a house very attractive, especially when it has good surroundings. It seems to catch all the shadows and to change with different positions of the sun, reflecting the colour of the surrounding foliage. It is this soft colour effect that has made the homes of Italy and the south of France the Mecca of the students of art.

The specifications which I give are taken from an article I wrote some time ago, and which covers practically all conditions and treatments except possibly the texture for obtaining the Italian effects. The stucco in this case should not be perfectly straight except in the moulding and trim. The moulding and trim should be treated as specified, the plain surfaces to give the appearance as if the stucco was applied over cobble stone. No straight edges should be used. The surface should be worked up to a condition with easy modulations. After it is partially set, go over it with the edge of a trowel to slight the roughened surface, being careful not to leave trowel marks. Apply over this the liquid stucco with the desired tints.

Specifications for Stucco on Concrete Work.

Preparation of Surface.—The entire surface to be examined and all loose form scale removed from the surface (*i.e.*, the scale is caused by cement adhering to forms from the previous pours. When the form is not entirely filled in the one day's operations, a film of cement adheres to the form in places and sets when the pour is made. This film invariably forms a scale surface on the face of the concrete when the forms are removed). The entire surface to be gone over with a hand pick or an axe to roughen the surface; if brick, rake out joints. This is for the purpose of forming key for stucco. The surface to be brushed clean and thoroughly soaked, ready for application of stucco.

Proportions: Straightening Coat.—The proportions of this coat shall consist of four parts of portland cement of approved brand, to twelve parts of sand and two parts of hydrated lime, the above materials to be thoroughly mixed dry. Then temper the mortar with water to which has been added one part of concentrated water-proofing paste to every 25 parts of water.

Finish Coat.—The proportions of this coat shall consist of 5 parts of portland cement to 12 parts of sand, and 15 per cent. of hydrated lime (if white colour is desired, use Medusa white cement and local white sand); the above materials to be well mixed dry. Then temper the mortar with water to which has been added 1 part of concentrated waterproofing paste to every 18 parts of water.

Application Stucco: Straightening Coat.—Care has to be taken that the surface is thoroughly saturated with water to ensure perfect bond, then apply straightening coat. Bring the surface to a true and straight condition, using a traversing rod (no darby float to be used on first coat) then scratch the surface with a wire or nail scratch.

Application of Finish Coat for Smooth Surface.—If stipple, use same process, only stipple before set. If rough-cast dash the finish material with a broom. Thoroughly saturate the first coat surface with water until it presents a glaze appearance; when this glaze disappears, which will be in a few minutes, apply the finish mortar, which should not be too soft, and bring the surface to a true condition with darby float. When the mortar will permit go over the surface with hand float, bringing to a true finish free of cat-faces or voids; the entire surface to be gone over with burlap or hand float and patted to take out float marks. No joints to be allowed in the work where they can be seen. The entire surface to present a uniform appearance in colour and texture. Mortar should be applied as quickly as possible and at all times protected from the sun.

Protection.—Special care should be taken to avoid too rapid drying; if in the direct rays of the sun it shall be protected with burlap or wet canvas, and when sufficiently resistive should be sprinkled with water for at least six days.

Stucco on Metal Lath.—In stucco on metal lath specify three-coat work with good fibre in first and second coats. Waterproof in second and third coats.

Forming Moulding.—Cores for moulding shall be formed of concrete by concrete contractor, allowing about 1 in. for finish. All moulding to be run and finished with hand float to give same texture as rest of surface and to help bind the surface. When a condition arises where a heavy coat of mortar is necessary, a key for the mortar shall be formed by driving galvanised nails into the core.

Having thus given specifications for stucco work it would be well to go over them for the benefit of the craftsman desiring to follow this method of procedure.

The cement, sand, etc., should be well mixed in its dry state and then tempered with water, to which the required amount of waterproofing material has been added. Following this the mixture should be worked to a good plastic condition. In making application good pressure should be used in order to ensure a good bond. In applying the straightening coat do not use the darby float because the working of this tool is liable to drag the material and interfere with the bond. Rather use the straight edge. Use the rod with an up-and-down slanting motion to cut off the excessive material and leave a rough surface, then scratch with a wire, being careful to scratch before the work is too hard.

After the straightening coat has been applied the moulded and ornamental members should then be worked out. It is common practice with many plasterers to add plaster of paris or some of the patent hard-wall gypsum plasters to the material used for ornamental and run work. This is for the purpose of making the material set quickly, but is a wrong policy and should be avoided. The mechanic who has pride in the execution of his work will not adopt those methods if he knows that bad results will follow by his so doing. Plaster of paris and patent hard-wall plaster are diametrically the opposite to portland cement. The result is easy to foresee. The work blisters, scales, and falls off, the set of the cement is killed, and the material becomes like powder.

The reason that some mechanics use these methods is to gain speed in finishing the work. If, however, the moulding and projections are worked together with a little system it will be found that finished results can be obtained with very little more time than through the use of foreign materials. All the mouldings and other run work should have running strips set so that the craftsman can build up the various mouldings gradually by giving each one as big a coat as will hang, doing the same to the others, and so on. By the time he has got to the last piece, he will find the first piece is ready to receive another coat. The running moulds should be muffled, allowing about ¼ in. for finish. After the mouldings and run work are brought out to a complete finish, they should be gone over with floats, so as to insure the surface having the same texture as the rest of the wall.

In applying the finish coat, all splashes and pieces of projecting cement should be scraped off the straightening surface. The whole surface should then be saturated with clean water, and it is at this point that the water-proofing plays such an important part. If the undercoat is waterproofed, it will hold the moisture of the finish coat and will allow the cement its own time to set. The ultimate adhesion, also the uniform working and strength of the finish coat, depend on this. If the moisture, or "blood," of the cement is absorbed by the suction of the undercoat, the cement will become inert and will crack, peel or scale.

In working the finish coat, bring it to a true, straight surface by use of a straight edge and darby float. This material should not be mixed too soft. A good method is to have one set of plasterers lay on the material and then have another set follow with rod and darby, working it carefully in all directions until it is brought to a full and straight surface. After the moisture has disappeared from the surface, gently scour it with a good cross-grain wood float. Care must be taken if dry spots should develop in floating not to throw water on the wall, but to dampen the float until the desired moisture is showing. Never stop the cement where the joint can be seen. Make all joinings at mouldings or projections.

Next, after floating, the object is to be rid of the float marks. This is done by gently patting the surface with a float or by using a pad made of burlap. If the finish is accomplished by this method, good results will always be obtained.

When the work is in the direct rays of the sun, it should be protected with burlap or oil duck cloth hung up in the form of a shade. When the work is sufficiently resistive, it should be kept moist for at least six days.

We have on the market several forms of damp-proof cement paint which make a good preservative of stucco. I advise the use of this material on commercial and public buildings, especially those that are in a large manufacturing centre. Such damp-proof coatings protect stucco from the atmospheric chemical action caused by smoke, etc., and at the same time are damp-proof and protect the surface from hair cracks.

For residential work, I advocate the wash method, as it is cheap and can be renewed at very little expense. It artistically weathers with age. It has many more advantages. Among these are the ease with which it can be applied and the wide scope of the colours that can be used. It serves as a good damp-proofing mix and gives the opportunity for many artistic effects. It is the method I use to obtain the Italian and antique effects on stucco. This wash is composed of waterproofing, good mineral colours, cement, and lime with a binder and hardener added. This material has to be used carefully, and the stucco coat surface must be left in a condition that will form a good bond between the materials.

MEMORANDUM.

Housing.—The National Housing and Town Planning Council is arranging a Technical Conference, with the following items of reference:—

(1) The methods by which the best designs and lay-out plans can be secured for housing schemes to be carried into effect at the close of the war in both urban and rural areas.

(2) The provision of workable solutions of technical difficulties arising in regard to—

(*a*) The shortage of materials (and more especially timber) where such shortage is due to the abnormal demand which will arise at the close of the war.

(*b*) The economical adoption and use in building construction of new materials or new forms of materials.

(*c*) The substitution of materials in construction, *e.g.*, the substitution of concrete, for timber, in floor joists, etc.

(3) The provision of labour-saving appliances in the equipment of houses.

(4) The provision of useful opportunities for experiment.

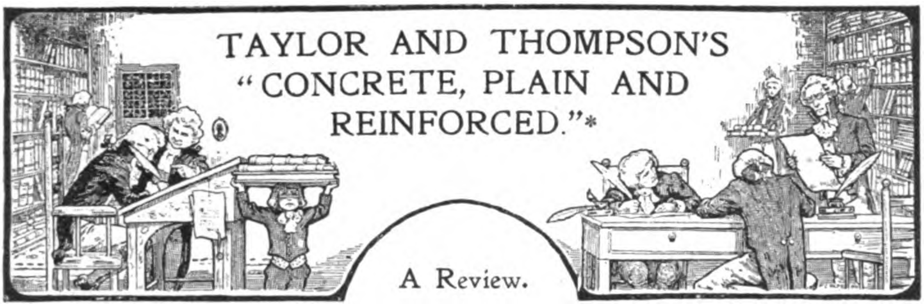
(5) The statement of the scope and possibilities of useful standardisation in the production of component parts.

(6) The statement of the points on which the by-laws usually in operation in (*a*) urban, and (*b*) rural areas should be amended in order to permit of the adoption of new ideas in building construction.

(7) Methods by which the proper planning of those areas in which after-the-war housing schemes to be carried into effect can be secured—including the relaxation of conditions as to road width in residential roads.

TAYLOR AND THOMPSON'S "CONCRETE, PLAIN AND REINFORCED."*

A Review.



By EWART S. ANDREWS, B.Sc., M.C.I.

THIS American book, of which a third edition has recently appeared, holds a very high place in the literature of concrete engineering, and deserves more than a passing notice; the writer has, therefore, been requested to give it a detailed review. We will state at the outset that the book as a whole is excellent and is almost indispensable to all who deal literally in concrete matters, and that any criticisms that we shall make are offered in the hope that it may ultimately become an ideal example of what an engineering book should be. It is not a student's book in the sense that it is suitable for teaching step by step the principles underlying the application of concrete to practice; it is a book for men actually engaged in the design and execution of concrete work.

The publication aspect of the book is excellent: it bears evidence in several places of thoughtful presentation which helps to make its very extensive subject-matter easily accessible; we refer particularly to the partial reference index on the front cover and to succinct statement of essential elements in concrete construction in the first chapter, and to the clear cross-references throughout the book. At the end of the book there is a long classified list of references to concrete literature. While we admit that a great deal of the pioneer work in reinforced concrete has been done in the United States and on the Continent (due to our insular conservatism reflected in our Government, which is largely responsible for the prevention of the earlier development of this method of construction in Great Britain), we think that something of value might be found in British periodical publications other than the *Proceedings of the Institution of Civil Engineers*, which is the only one referred to. In the opinion of Messrs. Taylor and Thompson, apparently, the *Proceedings of the Concrete Institute* and CONCRETE AND CONSTRUCTIONAL ENGINEERING do not contain anything of value for reference. Nor do we find among the list of text-books any reference to Messrs. Faber and Bowie's excellent treatise on "Reinforced Concrete Design"—a book which Mr. Edward Smulski, the contributor to whom acknowledgment is made in the preface for valuable assistance in the portion on "Reinforced Concrete," might have studied with profit; but of this more anon.

* 885 pp. Published by Chapman and Hall, Ltd., London. Price 23s. net.

The references to current literature appear at first sight to be extremely valuable; but further experience proves them to be rather annoying, especially when they are given as substitutes for the information which the reader hopes to find in the book. This is not the only American book in which we have been tantalised by not finding the information for which we were seeking and concerning which the index raised our hopes; the same weakness occurs in Frye's "Civil Engineer's Pocket Book." In fact the book appears to be over-indexed, and the indexing follows the letter too much instead of the spirit. We will give examples which illustrate our difficulty: we want to find the effect of soda on the strength of concrete, but we are only led from the index to references to other sources of information—mostly American, of course. Now although the book is intended principally for American readers, even they have not always a library handy, and it would be very helpful if a brief summary were given of the effect of soda in the author's excellent succinct style. Of course, life is short and paper is dear, and the book is already very full; but it would not take much more space to summarise these references. Our objection reminds us of the Scotsman's objection to smoking, that when you smoke your own tobacco it costs too much, and when you smoke your friend's tobacco you have to fill your pipe so full that it winna draw.

As an example of our criticism of the indexing we will take "Contraction," which only refers us to current literature; if we happen to try "Shrinkage" we shall find a reference, "See Contraction Reinforcement, p. 565," and when we read that article we find a reference to p. 261, where the real information that we are seeking is to be found.

We will note in passing a mis-statement on p. 795 which is an obvious oversight: we are told that the "modulus of elasticity of a rich mix is low," which should, of course, be that the "modular ratio of a rich mix is low."

The early part of the book is excellent in almost every respect, and deals with what may be summarised as materials. Following the "Essential Elements in Concrete Construction," to which we have already referred, and an equally good one on "Elementary Outlines of the Process of Concreting," we have "Specifications for Reinforced Concrete," but only one specification appears to be given, namely, that employed by Mr. Sanford E. Thompson, the author, in his consulting practice. In respect of the important subject of shear or diagonal tension reinforcement, this specification follows the common American form and is as follows:—

> In calculation on beams the maximum shearing stress in a section shall be used as the means of measuring diagonal tension stress, and the following allowable values for the maximum vertical shearing stress are recommended:—
>
> (*a*) For beams with horizontal bars only, and without web reinforcement, calculations by the formula given in section 60 (in our standard notation $s = \frac{S}{ab}$ for rectangular and $\frac{S}{ab_r}$ for **T** beams) 40 lb. per sq. in.

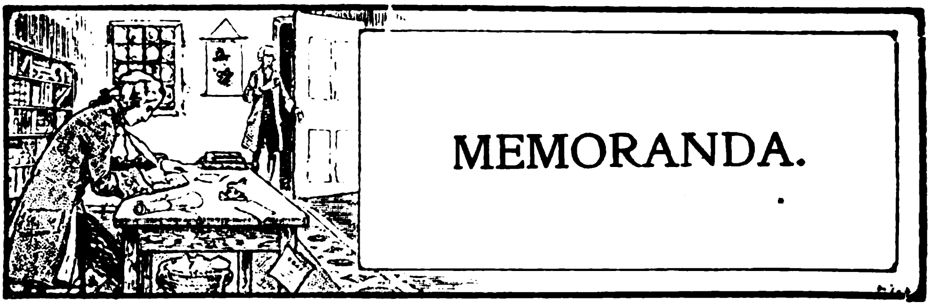
(b) For beams thoroughly reinforced with web reinforcement the value of the shearing stress being calculated by the above formula, 120 lb. per sq. in. The web reinforcement shall be proportioned to resist two-thirds of the shearing stresses, as computed by that formula.

(c) For punching shear 120 lb. per sq. inch.

Now if the shear stress has exceeded that which the concrete alone can carry, the concrete must be regarded to all intents and purposes as having been cracked, so that it cannot be regarded as offering any resistance; the *whole* of the shear or diagonal tension, therefore, should be resisted by the reinforcement. This is very clearly set out in Messrs. Faber and Bowie's book, and has been incorporated in the L.C.C. Regulations. We do not see, therefore, why the reinforcement should be designed to take only two-thirds of the shear. This criticism is directed more against the general American practice than the authors' particular views. It is true that on p. 418, in a very important chapter on "Tests of Reinforced Concrete," which we shall notice in detail later, it is stated that Bach's tests prove the rib takes an appreciable part of the shear; the test figures quoted, however, are not sufficiently detailed to enable us to test this point fully. It requires a special dissecting skill to extract the meat out of test results, and we rather doubt if the correct conclusions have been arrived at; they certainly differ from those of Mörsch, whose book on "Reinforced Concrete Design" obviously influenced Messrs. Faber and Bowie and is one of the most sound treatises which have yet appeared.

Further, we believe that experiments have shown that the most satisfactory method of designing shear reinforcement is that based upon "truss-action," which Messrs. Faber and Bowie explain at length, and which Mr. Faber's later researches have justified, and of which no mention appears to be made in this book. Following the chapter on "Specifications" we have chapters on "Classification of Cements," "Chemistry of Hydraulic Cements" (by Mr. Spencer B. Newberry), "Specifications and Tests of Cement," "Tests on Aggregates," "Voids and other Characteristics," "Strength of Cement Mortars," which are excellent.

(*To be concluded.*)



Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

A London Tramway Bridge in Reinforced Concrete.—The following are some particulars of a reinforced concrete bridge constructed in the Metropolis over the lines of the London and South Western and the London, Brighton and South Coast Railways outside Clapham Junction Station. The bridge has been constructed under the direction of Mr. G. W. Humphreys, engineer-in-chief to the London County Council. Our particulars are taken from the *Times Engineering Supplement*:—

The new bridge is constructed on the Mouchel-Hennebique system of reinforced concrete and intended to provide more adequately than the old bridge, which it replaces, for the heavy tramway traffic conducted by the Council.

The new span comprises a series of eleven reinforced concrete beams, each 48 ft. long by 2 ft. 2 in. wide near the top and 1 ft. 4 in. wide at the bottom. The finished depth of the beams is 3 ft. 7 in., the dimension having been about 2 in. less before the addition of a surfacing layer applied after the whole of the beams and decking were assembled in place. At the east end the beams are seated on an existing bed-stone course, and at the west end they are carried by a stringer girder forming part of the adjoining steel span. At the top they are rebated to receive purpose-moulded slabs completing the decking, the slabs ranging in width from less than 12 in. to 48 in., according to requirements. The slabs are simply dropped into their places, their upper surface and that of the beams being flush, and the whole of the construction is cemented together by the finishing layer of monolithic reinforced concrete, about 2 in. thick.

The spacing of the beams was arranged so that the two sets of tramway metals are carried directly by four of these members, the rails being laid on steel plates provided with teak packing strips. The plates are anchored securely by bars embedded in the beams, and the rails are held down by clips. Three reinforced concrete conduits are provided between three pairs of beams, two for the tramway power conductors and one for gas pipes, Post Office cables, and electric light cables. The beams form the sides of these conduits, and the bottom consists of slabs laid on brackets projecting from the sides of the beams.

When all the purpose-made structural members had been moulded and seasoned the old steel decking and girders were removed, and the reinforced concrete beams were slung and adjusted in place, and the slabs quickly followed, thus completing the span with the exception of the finishing layer of reinforced concrete and the paving.

At the official test the test load consisted of two tramway service vans, each representing a load of 20 tons on four wheels at 6 ft. 6 in. centres. The vans were run close-coupled over the "down" tramway track, with the results that the maximum deflection proved to be no more than 0·4 mm., or about 1-32,000 of the span of 43 ft. between supports, and that a vibration-recording instrument showed only a gradual deflection.

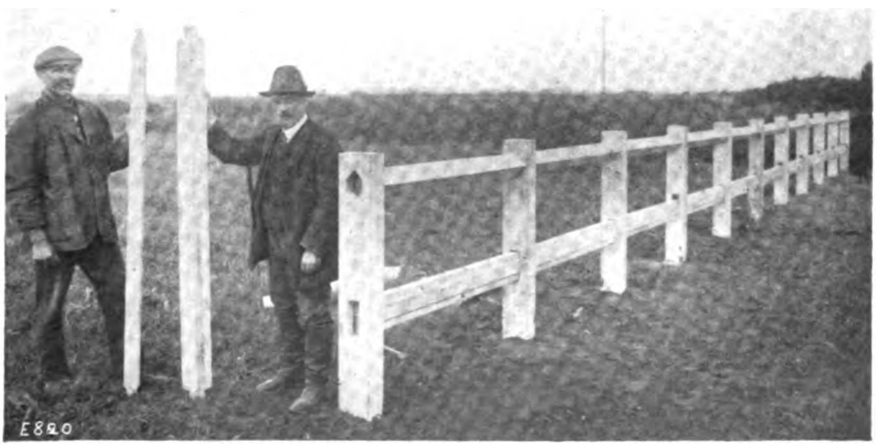
The execution of the work was superintended, on behalf of Mr. Humphreys, by Mr. W. C. Copperthwaite, the chief assistant engineer to the London County Council. The contractors were Messrs. Holloway Brothers, Ltd., and Mr. J. S. E. de Vesian, of Messrs. L. G. Mouchel and Partners, was responsible for the reinforced concrete details.

Grain Storage in London.— In connection with the extension works for the London Port Authority, which will be carried out after the war, a scheme has been approved for the discharge and storage of grain. The site selected for the proposed new works is between the South-West India and Millwall Docks, where the greater portion of the grain business is already carried on.

The most important section of the work will be the construction of a reinforced concrete silo granary with a total capacity of 40,000 tons immediately to the west of the existing central granary. It will be possible to increase the storage accommodation of the silos by an extension of the southern end, whilst further floor storage can be provided by an extension of the central granary in a similar direction. Ample facilities will be provided for the turning over of grain out of condition, and the equipment will include a special thermometer installation, dryers and coolers, graders, separators, winnowing machines, weighing machines, sacking machines, telephone and signalling apparatus and fire appliances.

Bridges in New Zealand. — Dealing in his annual report on New Zealand with the question of bridges, Mr. Dalton, the Trade Commissioner, says the majority of bridges in the Dominion are constructed of timber, but there has been a tendency of recent years to build bridges of structural steel, of concrete, and of reinforced concrete. It is not unlikely when the war is over, and steel and iron can be more readily obtained, that development will be in the direction of these latter forms.

Reinforced Concrete Fence Posts.—The accompanying illustration shows a short length of a reinforced concrete fence which is being made for the Great Yarmouth Corporation by the Borough Surveyor and Architect, Mr. J. W. Cockrill. The posts are 6 ft. centres apart, and the rails are kept in position by having dove-tailed



ends, which are grouted up where fixed; this is clearly seen in the illustration by the two rails which are being held vertically. The hole for grouting the top rail is at the top in centre of posts, the lower rail hole for grouting is at one side.

Concrete Roads in U.S.A.—In the course of an interesting article on "The Americans at War," published in the *Times,* Lord Northcliffe makes the following remark, to which we call the attention of our readers. He says: "The hard concrete roads of the United States are now made by machinery with a thoroughness and permanence which should attract attention in Europe. In a town outside San Antonio, 12 miles of rail, 25 miles of road, 31 miles of water pipe, 30 miles of sewer, were accomplished in 45 days. . . ."

In connection with this question of concrete roads, we learn that there has been quite an extraordinary demand for the pamphlet by Mr. Percy Boulnois, to which we made reference in our August issue.

Officer: "Here, Sergeant, I'll lend you this little book—it tells you all about the stuff you're using for that dam, what size struts and walings and where to place them. Don't lose it, it's my only copy and I simply can't get on without it."

Sergeant: "Thank you, Sir, I should like to have a copy."

Officer: "That's easy, write to the B.S.P. Co., they'll send it you."

Concrete for Ship Repairing and Ship Protection.—Quite a number of the daily and weekly papers have recently made reference to the use of concrete for ship repairs. As far back as 1907 we published in this journal a short note on such repairs in the United States. It was stated that concrete had been successfully used to repair a hole in the hull of a sunken steamer. The vessel struck on a rock which stove in the iron hull, the principal break measuring about 35 ft. in each direction, the rock projecting into the gap for about 11 ft. Heavy canvas was placed over the rock and concrete over the canvas, after which the vessel was successfully floated and towed into dock.

In a later issue it was reported that at a meeting of naval and mechanical engineers, held in Genoa, Signor L. d'Adda, an Italian naval engineer, lectured on a proposal to protect large armoured ships with concrete or reinforced concrete instead of steel plates.

His idea was to use a 1 : 1 : 4 concrete composed of Portland cement, sand, and basalt or porphyry, broken to pass a 4 or 5 cm. ring. The armour is built up in three layers, of which the outermost is the richest in cement and is further hardened by chemical treatment, the other two layers are less hard.

In the case of reinforced concrete the height of the armoured belt is 3 m., 1·5 m. of which is submerged. The deck above this belt is protected by a belt of concrete 1 m. thick. The concrete is enclosed between two thin steel plates parallel to one another to serve as a protection against surface cracking. The reinforcement consists of a network of vertical and horizontal steel rods, and if desirable also of one or more vertical sheets of metal. In a similar manner concrete may be used for the protection of the turrets, casemates, and conning towers. In cases where it is impossible to obtain a sufficient thickness of concrete, a layer of 30 to 45 cm. of concrete may be used in combination with steel armour plate 10 to 15 cm. thick.

Reinforced Concrete Ships.—The Committee of Lloyd's Register of Shipping have approved plans for a number of non-propelling barges, some of them to carry 500 tons deadweight, and also of a motor-vessel, to be built of reinforced concrete, for the British and Scandinavian coastal trades. These vessels will be built under the inspection of the Society's surveyors, with a view to classification in Lloyd's Register Book. Plans of other reinforced concrete vessels of larger carrying capacity for certain sea trades are under consideration.

Concrete Blocks.—Messrs. John Holt and Co. (Liverpool), Ltd., have used concrete blocks for the construction of two large stores at their Port Harcourt branch in West Africa. The buildings are now nearing completion.

Large Concrete Mole at Brest.—The newspaper *Heure* publishes a telegram from Brest stating that the Council-General has voted a sum of 655,000f. for the construction of a concrete mole 250 m. long at Brest, capable of accommodating the largest vessels. The total cost will amount to 3,300,000f.—*Reuter*.

Reinforced Concrete Floating Dock.—The Frederikshavn Shipyard and Floating Dock, Jutland, Denmark, is at present building a reinforced concrete floating dock on a field facing the sea. It is being built on a foundation of boards, 100 ft. long and 60 ft. broad, on which is mounted a skeleton of 340 iron pillars, connected at the top with girders. The reinforcement of the bottom consists of a network of rods and wires. The concrete is poured in wooden moulds round the pillars; the outer and inner walls of the dock will be 4 metres thick, and the bottom will have the same dimensions. The sides of the dock are divided into six compartments, which can be filled with water by opening the bottom valves, and they can be emptied by power installations in a small compartment in each of the six water tanks. The floating dock, when completed, will weigh some 700 tons; the work, as in so many other cases, has been retarded through shortness of raw materials, and it can hardly be launched till the end of the year. The launch will take place at high water straight from the field into the sea, and the structure will afterwards be towed to its place at the yard. It will be used both for the building of new vessels and for repairs, and can be connected with the present dock, so that for the future larger vessels can be repaired at the yard.—*Engineering*.

PUBLICATIONS.

Road Reinforcement.—The September pamphlet of the British Reinforced Concrete Engineering Co., Ltd., Manchester, contains some particulars on the use of reinforcing material in road construction. There is an interesting article on "Old Experiments with Road Surfacing," going back to the sixteenth and seventeenth centuries. There is also a short article by Mr. W. J. Hadfield, City Surveyor, Sheffield, on reinforced concrete roads in that city.

The Allied Trading Publications, Ltd., of Victoria House, 117, Victoria Street, S.W., has been established with the definite object of making known the industrial and commercial resources of Great Britain to each of the countries brought into close relation with her through the war.

A book is at present in course of preparation in which all the resources of Great Britain will be detailed. This volume, besides an introduction referring to different questions of commercial and industrial interest, will contain a series of articles written by specialists showing the essential details of each branch of industry. After each article pages will be at the disposal of traders to display their specialities.

The work will be published simultaneously in French, Russian, and Italian, and will be distributed *gratuitously* in Belgium, France, Italy, and Russia through the medium of Chambers of Commerce, federations, and industrial associations.

CONCRETE THE MONEY SAVER

CONCRETE STRUCTURES FOR STORING FRUIT AND VEGETABLES.

The following article is reprinted from "Concrete," U.S.A., and may prove of interest to many of our readers.--ED.

THE possibilities that lie in the use of concrete for building structures to store and preserve fruits and vegetables have hardly been touched in this country. Such structures range from the farmhouse cellar or a specially built cellar of simple construction, to the elaborate buildings maintained by large produce handlers for carrying enormous amounts of produce under refrigeration by elaborate mechanical means. This article is intended to point out how the simpler types of storage structures can be built for use either by individual producers or by communities.

The simplest and least expensive is the concrete root cellar, details of which are illustrated (*Fig.* 1). This type of structure is well suited to meet conditions where

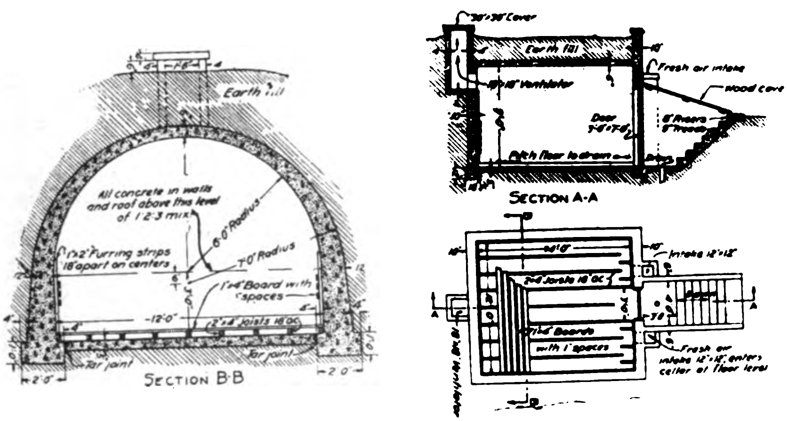


FIG. 1. A CONCRETE ROOT CELLAR WITH PROVISION FOR COOLING AND VENTILATION.

quantities to be stored are not very large, and where it can be built in a hillside or elsewhere so that water will not be likely to prove troublesome and where earth cover can be readily secured. Lacking perfect drainage it would be better to build the cellar entirely above ground, using an air insulated wall.

SUGGESTED PLAN FOR CONCRETE STORAGE CELLAR.

The cellar illustrated was designed by the Portland Cement Association, which says :—

"This concrete storage cellar has been so designed that it can be made any length desired. It is 12 ft. wide and 14 ft. long as designed and 9 ft. deep on the inside. The entire structure—floor, walls and roof—is of concrete.

"Concrete mixed in the proportions of 1 : 2½ : 4 may be used throughout except for the floor and the arch of the roof, for which a 1 : 2 : 3 mixture should be used. All side walls are 16 in. thick at the base and taper to 6 in. thick at the crown. End walls are 10 in. thick.

"This design has been prepared with special reference to ventilation. During cool evenings manhole and cold air intake covers are removed and the cold air

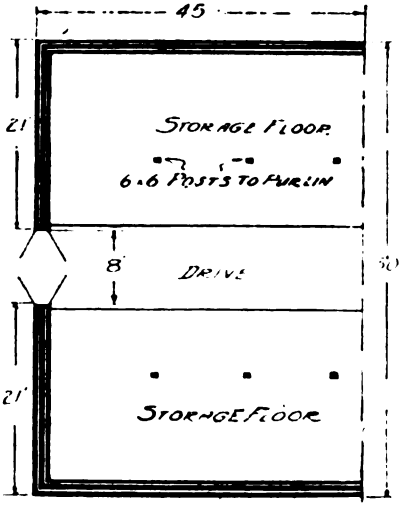


Fig. 2. Half Plan of a Simple Concrete Storehouse.

permitted to pass down the intakes, circulating through the passage between the concrete floor and the false floor of the bins. The false floor is made of 2 by 4 joists, covered with 1 by 4 boards nailed 1 in. apart. Openings in the floor allow the air to pass up through the stored contents, thus cooling them.

"The outside walls are built so that cool air can circulate up along them. The warm air passes out through the manholes. In the course of one night the entire air in the storage cellar is in this way changed many times, thus thoroughly cooling the cellar before morning."

In general such storage is for fruit and vegetables (the requirements of which are essentially the same) that will not require an elaborate cooling system except where the produce is to be carried over a long period of time, when a very expensive system of insulation and mechanical refrigeration becomes necessary. The object of the house described is to provide a storage of even temperature where there will be no danger of frost and where good circulation of air and a reasonably constant temperature and moisture content can be maintained. A temperature of about 40° F. is considered desirable for vegetable and fruit storage. Under certain conditions it will be desirable to install some system of artificial cooling and suggestions are given for a comparatively inexpensive arrangement.

Experience has shown that very satisfactory buildings can be constructed by using three walls of concrete, or two walls of concrete with a second air-space created by means of furring strips and plaster. Two methods are generally available for economical construction, first to use some sort of concrete block or units, preferably of a type having no web so that the air spaces may be continuous, except as broken by occasional horizontal and vertical baffle walls to prevent local air currents within the air spaces, and second, by building a triple wall, each wall separated by air spaces. In either case, extreme care should be taken to see that the walls are laid up so as to be absolutely tight against cracks or air leakage, which very greatly reduces the insulation. For this reason, if built of block, they should be of a rough texture that can be plastered, securing a tight job. Where wall machines are used for storage work, a special outfit which builds the three walls at one operation is generally used, but a satisfactory building can be constructed by using a double wall which should be furred and lathed for additional insulation.

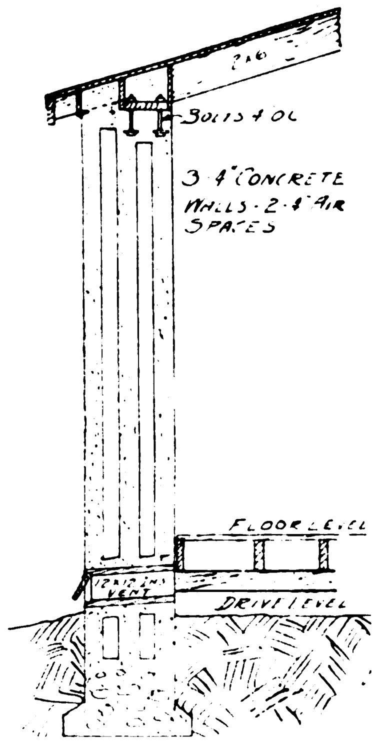


FIG. 3. WALL DETAIL SHOWING THE INTAKE, FLOOR AND ROOF CONSTRUCTION

INSTALLING A COOLING SYSTEM.

In localities where quantities of fruit are raised it is often desirable to have some place where products can be kept cool before shipment. *Fig.* 6 illustrates diagrammatically a system that can be installed for this purpose in a concrete building of a construction similar to that illustrated, which, however, should be provided with a tight ceiling and as carefully insulated as possible. Airtight ice bins are installed near the top of the building on each side. Provision should be made for suitable doors opening in these bins for icing without admitting more air than is absolutely necessary. In some cases it may be possible to build an ice house adjacent to one side of the house and to provide a chute from side to side of the building so that the ice could be handled directly from the ice house to the bin.

From the bottom of the ice bin a duct leads to a small blower which takes the cold air from the ice, forces it back through a duct, shown by the illustration as located in the wall, as in the hollow concrete construction the duct can be built in at comparatively small expense. The cold air is distributed through openings along the side of the wall and settles toward the floor where it is returned to the ducts leading back over the ice. A duplicate system is installed on the other side of the building. It will also be noted that by changing dampers under the ice bin the air can be drawn directly from the outside of the building, and by opening ventilators in the roof the entire air can be changed in a very short time. By using crushed ice and salt it is possible to carry a temperature close to zero with this arrangement. This system provides a perfect control of air and temperature conditions within the range made possible when ice is the cooling medium.

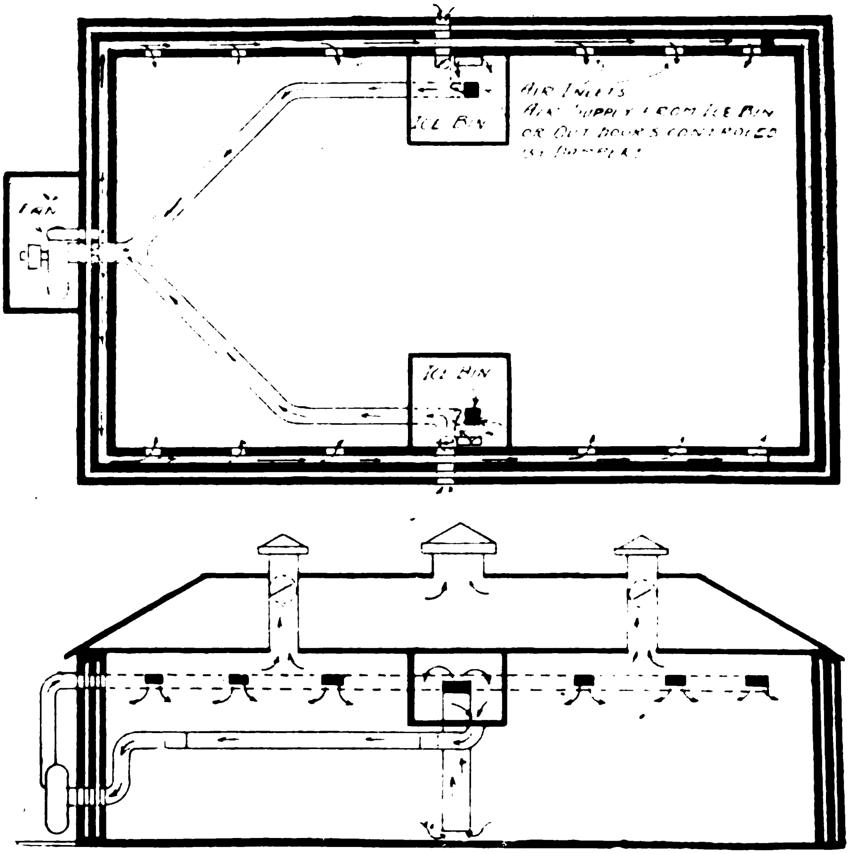


FIG. 4. DIAGRAM SHOWING GENERAL ARRANGEMENT OF ICE-COOLED STORAGE.

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CONCRETE AND CONSTRUCTIONAL ENGINEERING

NOVEMBER 1917. VOL. XII. No. 11.

A MONTHLY JOURNAL FOR ENGINEERS, ARCHITECTS, SURVEYORS & CONTRACTORS and all interested in CEMENT, CONCRETE, REINFORCED CONCRETE, FIRE-RESISTING CONSTRUCTION and STRUCTURAL STEEL.

ISSUED MONTHLY

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THE CUNARD BUILDING, LIVERPOOL.

(For description see page 595.)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XII. No. 11. LONDON, NOVEMBER, 1917.

EDITORIAL NOTES.

CONCRETE AND HOUSING.

NEVER before has the Government shown a greater interest in housing problems than at the present time, and the appointment of a special housing committee at the Local Government Board has certainly been a step in the right direction.

The great difficulty of the immediate post-war building operations must, however, be the dearth of suitable building materials, for a certain time must elapse until the brickfields come into operation, until timber supplies become available, etc. The high cost of bricks, so materially affected by labour and carriage, and the expense of timber more or less affected by freightage, will further necessarily require much thought.

It is in no *ex parte* spirit that we accordingly again press the advantages of concrete for housing schemes, not only for the primary features of buildings, such as walls and floors, but for many other purposes, such as roofing and for innumerable minor purposes.

This journal has already done its share in indicating the advantages of the use of concrete for what may be termed cottage property. Our Competition organised just before the war was a most valuable and fruitful contribution to the subject, and readers are reminded that the illustrated summary of the results of this Competition is obtainable upon application (post free) at the offices of this journal.

Unfortunately there is an invariable conservatism in the professional and official circles that handicaps the introduction of fresh ideas, and it will be necessary to press the merits of concrete, both from the practical and the economical point of view, so that the advantages of this method of construction may become better known and its introduction be demanded by the public and not merely recommended by a limited number of professional advisers.

It is useful to note that our daily press is now taking a greater interest in the subject, and articles appearing in the daily press now quite frequently advocate and acknowledge the great economy that might be effected. One daily paper in the North, in referring to the use of concrete for cottages, says: "We are a wasteful nation. We are tipping, at considerable cost, thousands of tons of good building material, suitable for house-building, and we are importing millions of bricks, at great cost, into the city. In many parts of the country concrete houses have been built economically. . . . If we are to have economical houses, there is nothing to touch this concrete construction, if the aggregate can be obtained easily. They can be built by any intelligent labourer."

We also welcome the new propaganda of the recently formed Concrete Utilities Bureau, of 6 Lloyds Avenue, London, E.C., which is giving valuable information in a popular form that should have a most beneficial effect in the direction indicated.

The efforts made to popularise the subject by the Portland cement industries and by the concrete blockmaking and reinforced concrete specialists are in the right direction, and thus help in times like the present towards an end that is in the interests of the State, in the interests of the community and the individual small householder. That such propaganda also favourably affects the prosperity of those manufacturers and contractors who have shown sufficient foresight to take up what must be a great building material of the future goes without saying, and they merit such reward as their endeavours may bring them.

We have spoken of the housing problem, which in itself is a gigantic one, but there will be an equally great demand after the war for factory and workshop accommodation on simple and economic lines, for which concrete and reinforced concrete particularly lend themselves.

Whilst we, accordingly, press the advantages of the material at this stage for those who are concerned in housing questions, we desire to suggest that the use of the material for larger buildings also requires the greater consideration of the Government departments concerned.

THE CUNARD BUILDING, LIVERPOOL.

By E. G. W. SOUSTER, A.R.I.B.A.

The building here described ranks as one of the largest reinforced concrete buildings so far erected in this country ***and has many interesting features, both from an architectural as well as from an engineering point of view. We are indebted to "The Builder" for the illustrations on pp. 598 and 599.—ED.***

GENERAL DESCRIPTION.

LIVERPOOL has during the past few years witnessed the erection of several very large and magnificent structures, and the new offices of The Cunard Steamship Co., Ltd., occupying an island site opposite the river front, add appreciably to the glory of the city, and form a worthy headquarters for one of our largest shipping lines.

The site of the structure is the centre portion of the old St. George's Dock, and the building provides accommodation for the Cunard Co. and also ample space for letting, part of which is already occupied by the Pacific Steam Navigation Co., the Booth Steamship Co., Messrs. Edward Bates and Sons, the Anchor Brockelbank Line, and the United Alkali Co., Ltd.

The main front of the building faces the Pierhead, the rear elevation to Goree and the side elevations to Water and Brunswick Streets.

The opposite side of Water Street being occupied by the Royal Liver Building, and the opposite side of Brunswick Street by the offices of the Mersey Docks and Harbour Board, the selection of the architectural character of the building was difficult.

These three buildings fill the whole river front of the site formed by the closing of the St. George's Docks, and in a Utopian State a uniform building line and restrictions as to heights of strings and cornices and general grouping would have been insisted upon.

This, however, was not done, and the architects were confronted with a difficult problem. The dock offices are in the English Renaissance style with a central dome and cupola finished towers at angles, whilst the Liver Building is entirely dissimilar to it.

As no possibility existed of combining the three structures into an harmonious group, a structure which would not conflict with either was decided upon, and the elevations are conceived on Italian Renaissance "Motifs" especially reminiscent of the Farnese Palace.

The lower ground floor forms a solid plinth for the structure, and on it rests the heavily rusticated and battered ground floor, which is finished with a carved string.

The next story is of mezzanine type, is less prominently rusticated and breaks the contrast to the ashlar facing of the next three stories, which are strengthened at the corners with a wide strip of rustication.

The fifth floor forms a fenestrated frieze, and is crowned by a very heavy cornice, which projects 6 ft. beyond the building line. Between the windows of the frieze are large cartouches carved with the arms of the Allies and supported on either side by large ship fenders. Above the cornice the building is finished with a heavy blocking course 14 ft. high, strengthened at the angles by superimposed masses of masonry.

The building is axially planned, with four main entrances in the centre of each façade, and these form the only projections beyond the general wall faces.

These four entrance porches have semi-circular heads lining with those of the ground floor windows and form the frames of the entrance doors, which are flanked by 14-ft. Doric columns with entablatures, the space above being filled by a heavy grille, and the sides of the porches have diagonally coffered ceilings above the carefully detailed panels on the walls.

Clear vistas are obtained from these entrances through the building, so that the axes of the building divide it into four divisions, but the longitudinal axis is broken at the meeting of the transverse with a double screen of columns on either side.

From the transverse corridor, which is 20 ft. wide, staircases and a series of seven lifts give access to the upper part of the building, which is planned with two large open areas about 65 ft. by 55 ft. on either side of the upper transverse corridors.

The lantern lights at the base of these wells light the longitudinal corridors and the public spaces and offices abutting thereon on the ground floor.

Besides the lifts already mentioned, three other lift wells are formed abutting on a corridor running parallel to the short axis of the building and placed one room deep from the Pierhead entrance. This corridor gives access to the General Manager's room on one side and to the first-class passengers' rooms on the other, and the lifts serve the Cunard Co.'s rooms on the lower ground and fifth floors.

This lower ground floor, which provides space for second and third class passengers, baggage, stationery, etc., is also approached by steps direct from the street, whilst the lower basement floors are used for baggage, heating, and the engineering services necessary for a building of this magnitude.

The board room, directors', conference, and secretary's rooms are placed on the fifth floor on the Pierhead frontage, and their finishings have an architectural character and restraint that reminds one of the finely conceived interiors of the eighteenth century, and in them many old mantelpieces of this period have been used.

The remainder of this floor is occupied by the accountants' offices, naval architects' staff, typists' rooms, dining rooms for directors and staff, etc.

The roof, which is covered with an asphalte flat, is in one sense another floor, for on it are placed kitchens and the necessary kitchen adjuncts, a restaurant for tenants in the building, with several private luncheon rooms, a caretaker's house, and several spare offices.

Externally these roof buildings are masked by the stone blocking course which runs 14 ft. above the normal roof level.

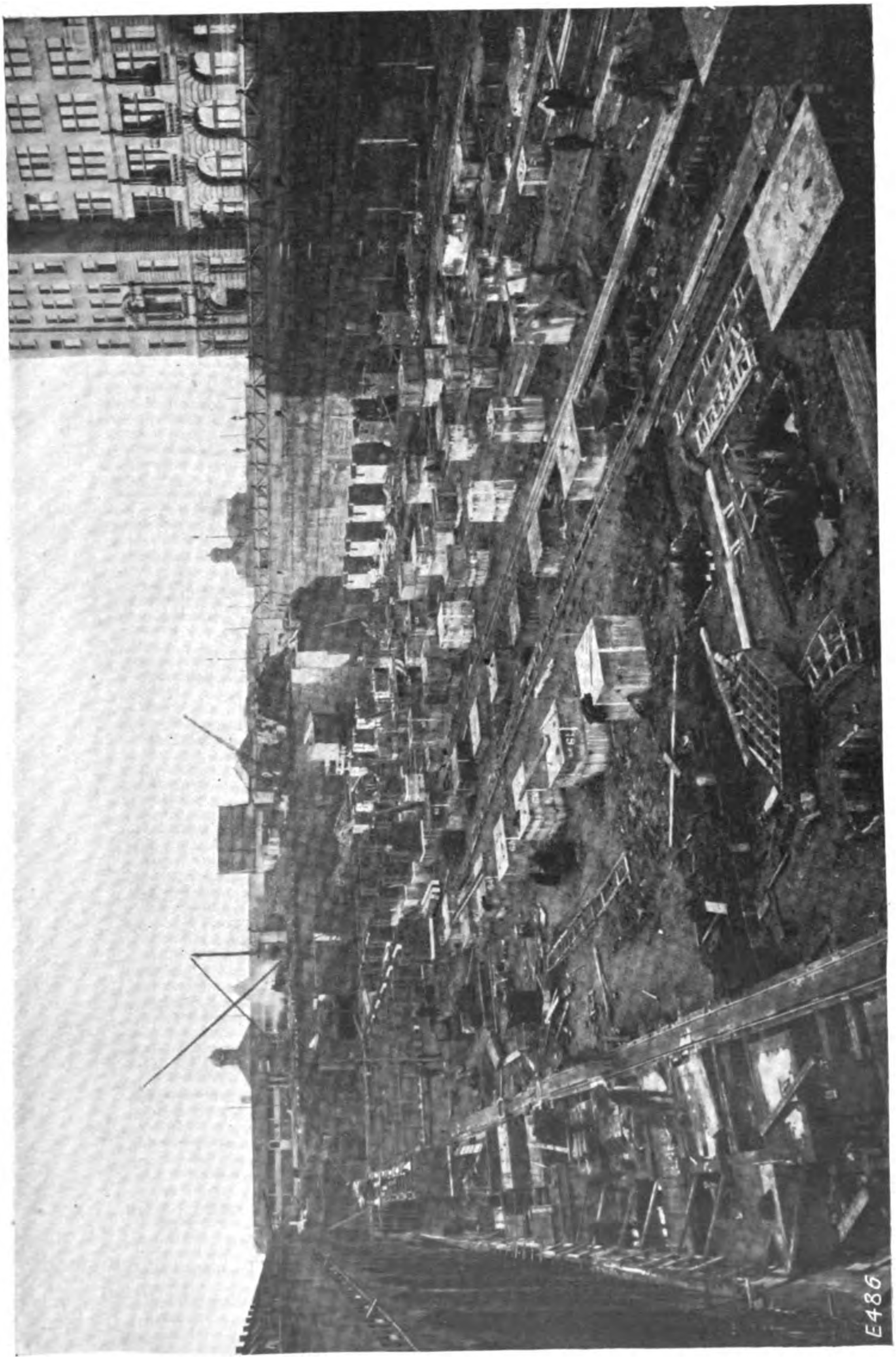
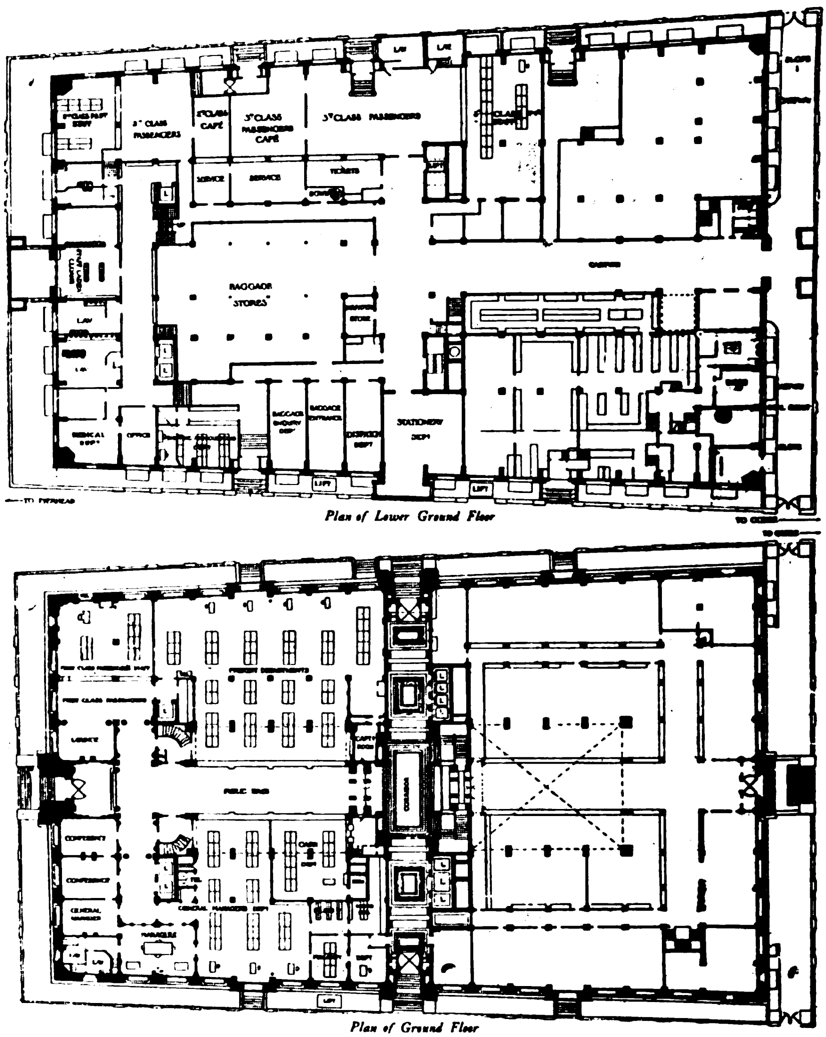


Fig. 1. View Showing Concrete Piers to Foundations.
THE CUNARD BUILDING, LIVERPOOL.

FOUNDATIONS.

The site of the building is almost a rectangle, its dimensions being 170 ft. on Pierhead, 200 ft. on City front, and its side dimensions 330 ft.

On this site a building has been erected having a floor area in its eleven floors of 451,170 sup. ft., or nearly 11 acres.



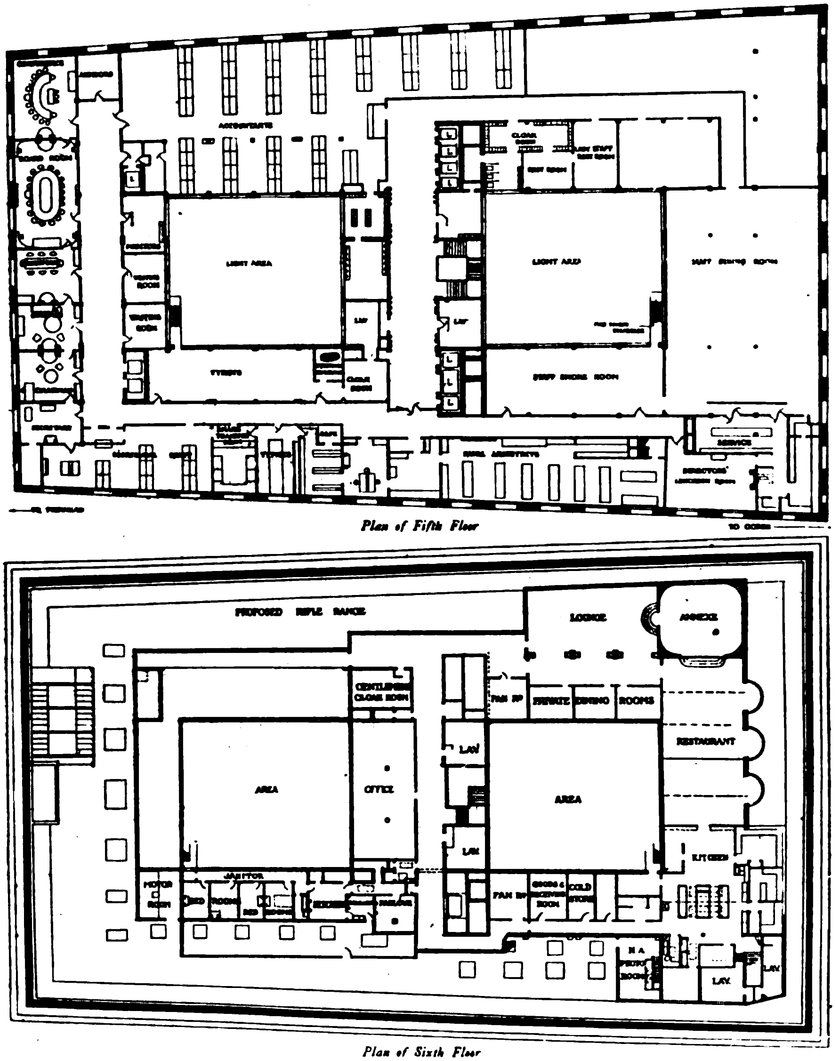
By courtesy of "The Builder"]

Fig. 2.
THE CUNARD BUILDING, LIVERPOOL.

Standing on the site of an old dock and in close proximity to the river, water troubles were to be expected, and the problem of keeping the water from entering in at the high spring tides was a serious one. A mass concrete wall 8 ft. thick was built on the river front, and along the Brunswick Street side a reinforced concrete wall 300 ft. in length keeps out the tidal water which rises and falls in the arches below the street.

Automatic electric floats working into a well were also used, and this problem having been solved the foundation work was commenced.

After a series of exhaustive tests Appley Bridge stone was decided upon for the aggregate of the concrete, and it may be of interest to mention that



Plan of Fifth Floor

Plan of Sixth Floor

By courtesy of "The Builder."]

Fig. 3.

The Cunard Building, Liverpool.

the average ultimate compressional strength of 6-in. test cubes was found to be 105 tons (equivalent to 945 tons per square foot).

The concrete was composed of this stone with Mersey dredge sand and Earle's Pelican cement mixed in 1 : 2 : 4 and 1 : 1 : 2 proportions according to the situation of the work.

During the progress of the work four 6-in. cubes were made in cast iron boxes each week, and the average ultimate compressional strength of all cubes made (when tested at 28 days age) was found for the two qualities of concrete respectively to be 68·5 and 97·4 tons per cube.

The foundations were carried down to the sandstone bed which underlies the surface clay at the Pierhead end of the site, and which occurs at 12 ft. 6 in. below Ord. Datum at one end of site and 26 ft. at the other.

On this rock mass concrete piers varying from 4 ft. to 8 ft. 9 in. square were formed, and these piers run up to mezzanine floor within the building and to ground floor level in the external walls. (See *Fig.* 1.)

SUPERSTRUCTURE.

Above this the stancheons and supporting piers are of reinforced concrete with continuous spiral reinforcement.

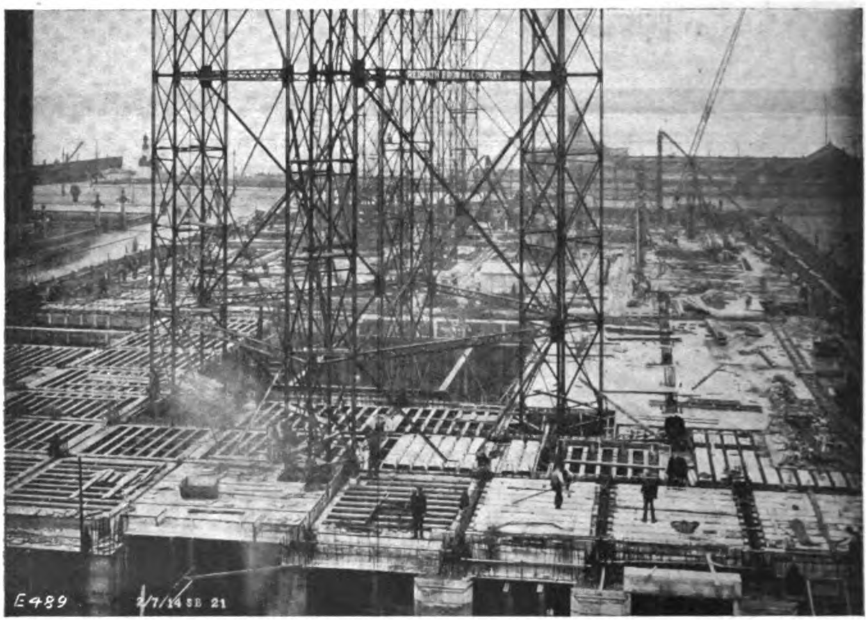


Fig. 4. View Showing Construction of Floors.
THE CUNARD BUILDING, LIVERPOOL.

A 6-in. reinforced concrete slab with secondary and main beams forms the mezzanine floor, which is designed to carry 150 lb. per ft. sup. live load, and the main beams were all designed on the elastic theory. Owing to the heavy Portland stone facing which is carried by the external beams, eccentric loading was calculated for in designing the wall columns.

Above the mezzanine all floors are formed with a 2-in. slab resting on floor ribs 8 in. deep at 2-ft. centres, and they have been designed to carry a live load of 150 lb. for the lower ground floor and 100 lb. per ft. sup. for all other floors, also a great saving in the cost of centreing was effected by using hollow steel tiles for these floors, which were used again for each floor.

Over the public spaces on the ground floor and at base of the light courts large roof lights have been formed. These are carried on reinforced concrete corbels projecting from the beams over the columns, and a reference to *Fig.* 6 will show how little space is taken up by the constructional members.

One of the most interesting features of the building is the main cornice, which projects 6 ft. from the centre line of the external beams and about 12 ft. at the angles of the building.

In order to support this cornice reinforced concrete cantilevers were formed, as shown in *Fig.* 5. The modillions at 4 ft. centres have a dovetailed slot cut in on the top of the stone, and over each a cantilever is formed which carries the modillion and the two courses of stone above it. In the course above the modillion the stone is hollowed out on either side to prevent tipping.

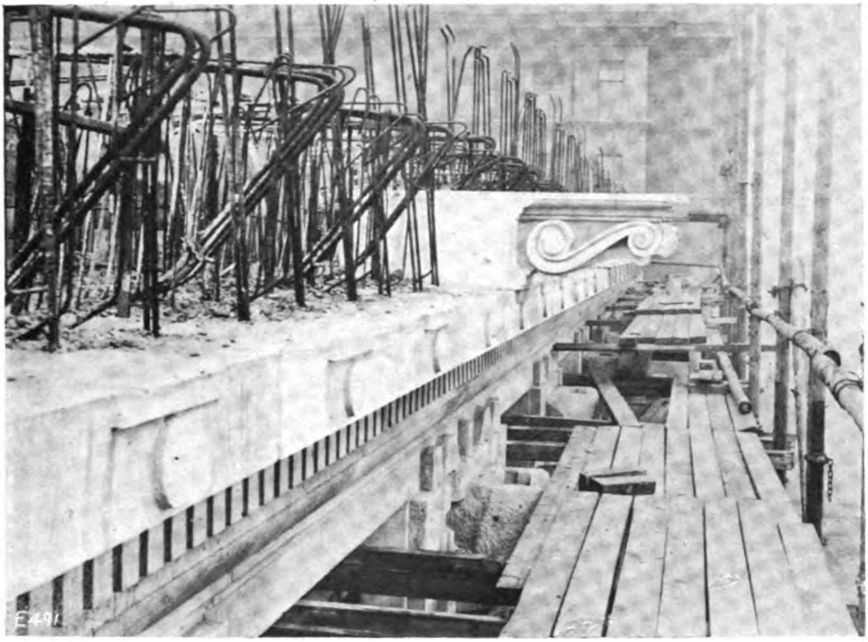


Fig. 5. Detail Showing Construction for Main Cornice.
THE CUNARD BUILDING, LIVERPOOL.

The two courses below the modillions are also dovetailed, thus preventing any movement should the stones crack or decay. The small cantilevers carrying the modillions are anchored back to a large mass of reinforced concrete, which is carried on the external beams, and the whole is again anchored back to a beam which is tied at its ends to the main floor beams.

At the corners it was necessary to employ a much stronger cantilever. The concrete was therefore taken up to the level of the top course of the stone, thus allowing an extra depth of beam to be provided.

Above the cornice a screen wall is built, the reinforced concrete frame consisting of buttresses 14 ft. high over each external pier and two connecting beams one at top and one at centre. The buttresses are tied back in a similar

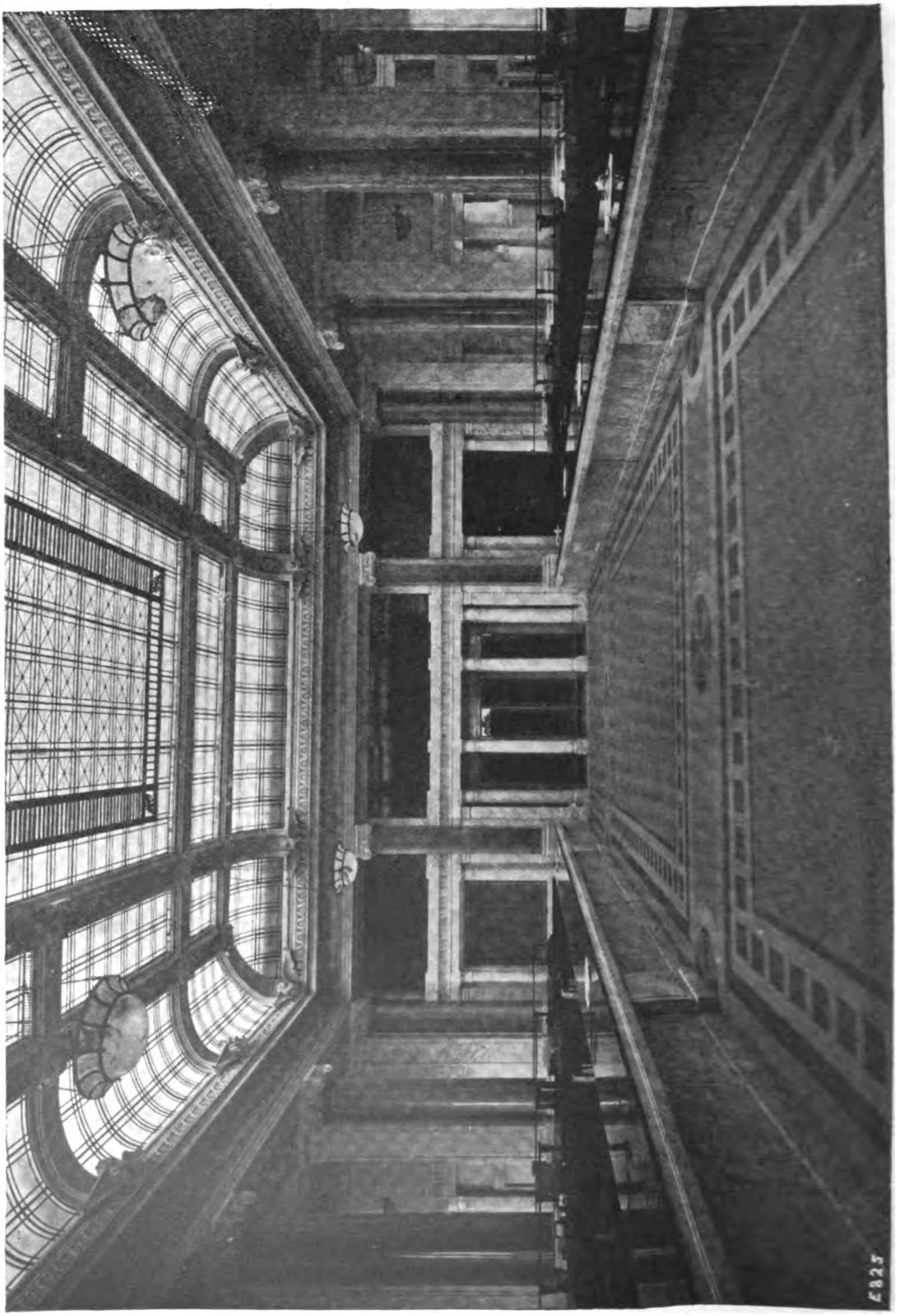


Fig. 6. A View of General Hall.
The Cunard Building, Liverpool.

Photograph by Bedford Lemere.

manner to the cornice cantilevers. This wall was designed to resist the gales of 80 miles per hour which are experienced in Liverpool.

GENERALLY

The fresh air for the entire building is drawn through watered screens to a chamber in the first basement, from whence it is driven by fans to the various rooms, and the vitiated air is extracted and discharged at the roof level by fans.

The heating is carried out on the "accelerated low pressure system," very small pipes being used and the circulation aided by pumps.

The heating chamber is in the second basement at the old dock level, and is 20 ft. high.

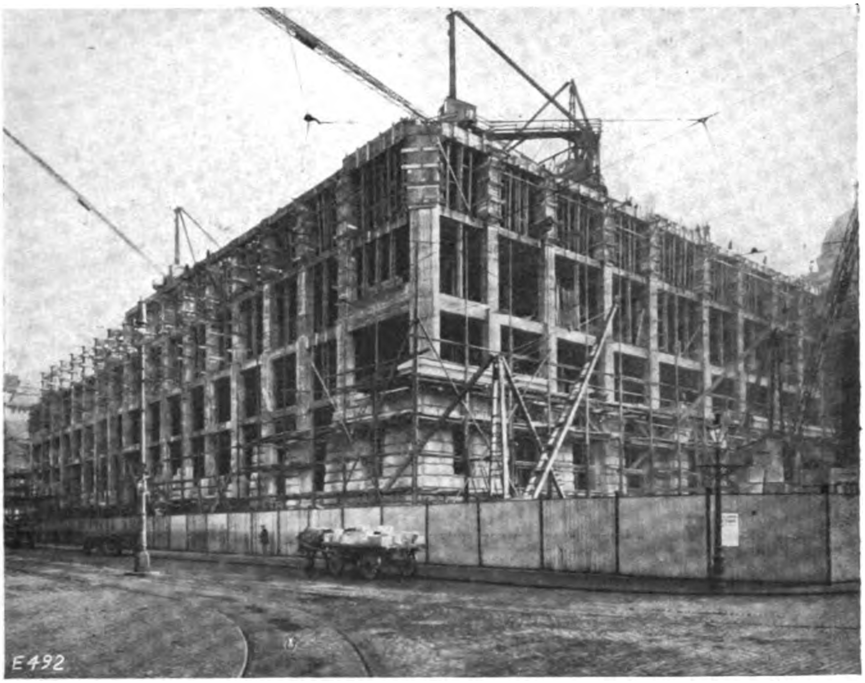


Fig. 7. Building in Course of Construction.
The Cunard Building, Liverpool.

Besides this heating system fireplaces are installed in many of the rooms, and in order to obviate the great loss of space that would be occasioned on the upper floors by providing a separate flue for each fireplace, only one steel and brick cased flue has been provided for each block of fireplaces above each other.

These flues have extract fans at the roof level to provide a forced draught, and each flue has a regulation damper. These flues are connected on roof level by means of horizontal ducts to a central chamber, from whence the smoke is discharged into the open air in a way that minimises the thick black column of smoke that usually takes away all possibilities of using the flat roof of a building. The ashes and waste from the floors are taken by shoots from each level to a chamber in the basement, from which a sloping cartway leads to the street level.

The building is lighted throughout by electricity, and it may give some idea of the magnitude of the building to state that over 40 miles of light cable and 21 miles of bell, telephone and clock wires have been used.

The architects for the building were Messrs. Willink and Thicknesse, FF.R.I.B.A., of Liverpool, with Messrs. Mewes and Davis, FF.R.I.B.A., of London, as consulting architects. The general contractors were Messrs. W. Cubitt and Co., of London, and the designs of the reinforced concrete work were prepared by the Trussed Concrete Steel Co., Ltd. (Kahn System), of Westminster, under the supervision of the consulting engineer, Mr. B. L. Hurst, M.Inst.C.E., of Craig's Court, Whitehall.

STRESSES IN RECTANGULAR FRAMES.

II.

By G. R. MAGNEL.

(Concluded from October issue.)

Use of Diagram H_1.

THE line OC represents the rise and is divided by a series of horizontal lines in 10 equal parts. A curve marked E will again be noted in the diagram and is to be used in the same way as in the case of the V diagrams; it will be reduced to a certain scale (as the dotted curve through d) by means of the reducing line from point C to the point of the reducing scale A corresponding to the Stiffness Ratio "a," say 1 in the dotted example. The vertical ordinate $c_1 d_1$ thus obtained is then plotted horizontally as $c\,d$.

Further, instead of *one* B scale, *two* B scales are shown, marked B_R and B_L; the former applying to forces acting on the right hand column, the latter to forces acting on the left hand column. In each of these two cases the second operation consists again, as in the case of the V diagrams, in tracing a parabola, having this time its apex at 0, being tangent to $0\,C$ and passing through the ratio point of the B scales, either B_R or B_L according to which column is being considered. Here again the final Influence ordinates are the distances (horizontal) between the reduced curve E and the parabola in question measured at the moment scale at the bottom of the diagram.

The construction of the parabolas is again shown in a special sketch on the diagram.

Use of Diagram H_0.

The above explanation holds good in its general lines, the only difference being that in this case the parabola passing through the point of the B_L scale is not tangential at point 0 to the line $0\,C$ but to the line $0\,F$, which alters the parabola plotting somewhat, as shown in the top right hand corner of the diagram.

Use of Diagram H_c.

Only one operation is necessary in this case, namely the first one consisting in the reduction of the E curve, as in the previous diagrams, by means of the reducing scale A. The ordinates cd thus found are the actual Influence ordinates, the values of which are measured at the scale at the bottom of the diagram.

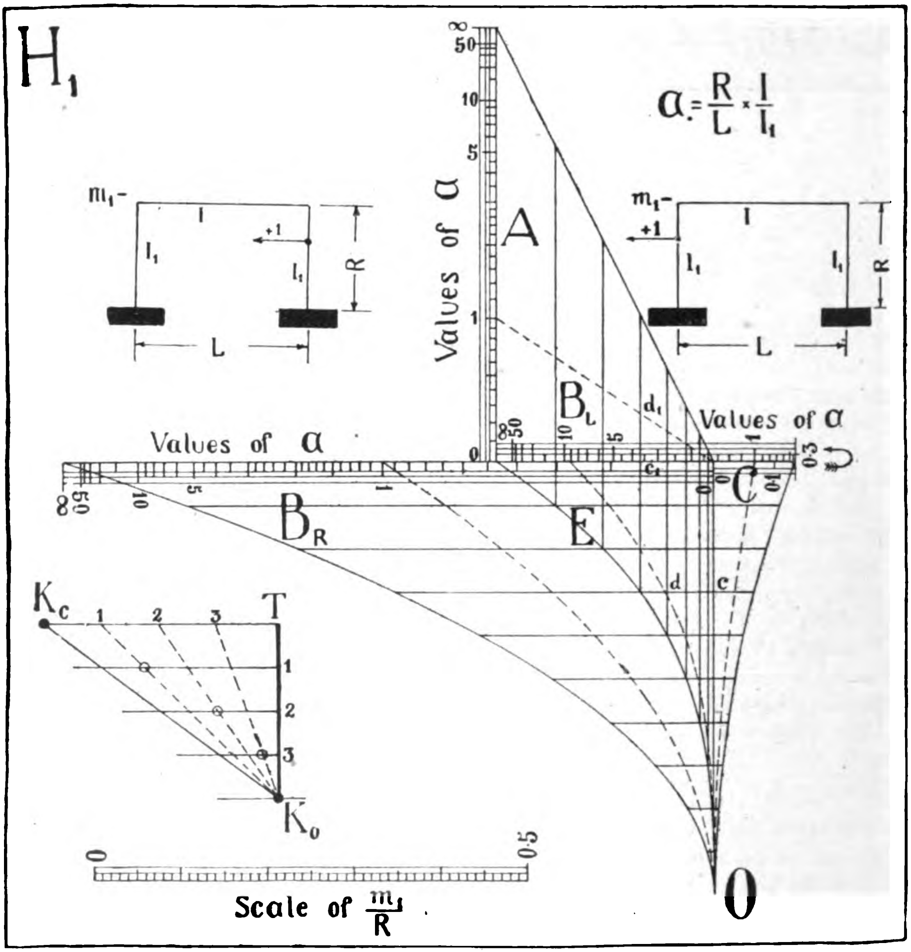
The Influence Line is the same whether the force acts on the left or on the right hand column, the sign being the only difference. This accounts for only one curve being necessary, the difference in sign being shown in writing on the two small sketches of the structure drawn at the top of the diagram.

On all the other diagrams the signs of the moments are shown in the same way.

The best way of using the six diagrams without spoiling them by plotting every time, is to draw the special curves corresponding to the case in question on a sheet of tracing paper placed on top of the diagrams.

B.—Short Theoretical Proof.

A very usual assumption in the arch theory—and a permissible one when the arch is not very flat—is that the work done in compression and shear is negligible as compared to the work done in bending.



The same assumption has been made in this case and the corresponding restrictions in the practical use of the method are smaller than in the case of ordinary arches.

Without entering into the rather lengthy calculations required, it might be useful to note that the diagrams explained above will give reliable results as long as

$$\left(\frac{r}{R}\right)^2 \times \frac{2\,a+1}{a\,(a+2)} < \frac{1}{60}$$

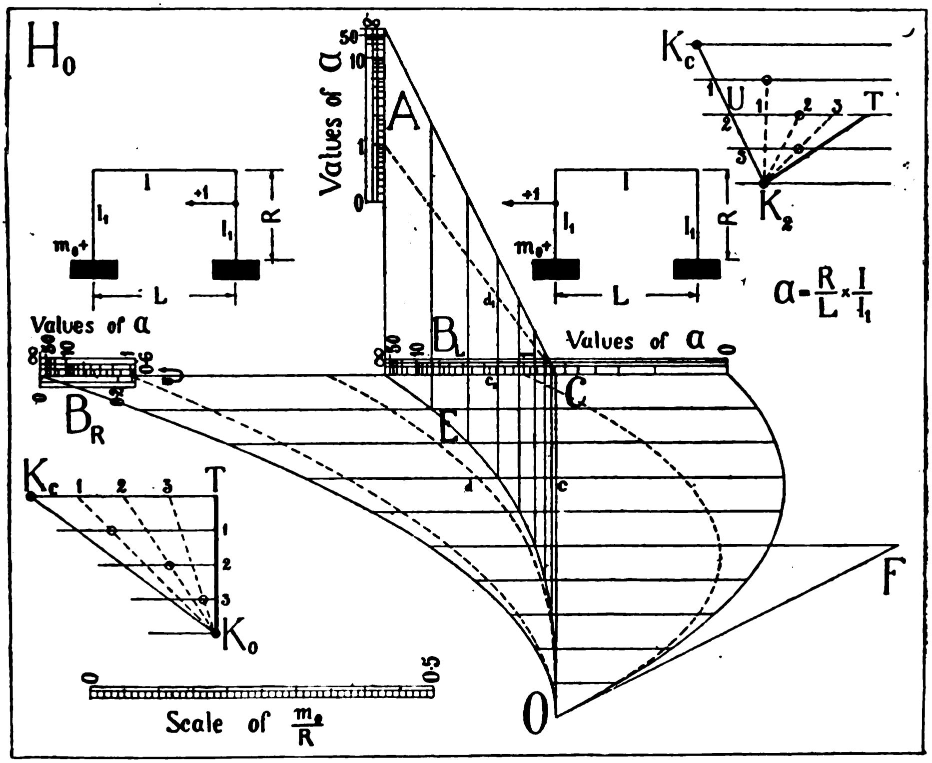
where r=radius of gyration of the beam.

This is generally the case in practice.

General Arch Formulæ.

The general formulæ giving the values of the three unknown quantities at the left haunch of a symmetrical arch with fixed ends, namely the vertical reaction P_0, the horizontal one Q_0 and the bending moment M_0, due to the action of any loading, are:—

$$\left.\begin{aligned} P_0 &= -\frac{\int \frac{Mx}{I} ds}{\int \frac{x^2}{I} ds}; \quad Q_0 = -\frac{\int \frac{Mz}{I} ds}{\int \frac{z^2}{I} ds}; \\ M_0 &= -P_0\frac{L}{2} + Q_0\rho - \frac{\int \frac{M}{I} ds}{\int \frac{1}{I} ds}, \end{aligned}\right\} \quad (1)$$



in which all the integrals are to be taken throughout the arch line and where:—

M = the bending moment at any point of the arch loaded by all the external loads to be considered, but rendered statically determinate by making its left haunch completely free, the structure being cantilevered out from the right haunch.

x = the abscissa of any point of the arch line with regard to its centre, the values of x being positive to the right and negative to the left.

ρ = the height of the elastic centre, namely:—

$$\rho = \frac{\int \frac{y}{I} ds}{\int \frac{1}{I} ds} \qquad (2)$$

the integrals being again taken throughout the arch line ;

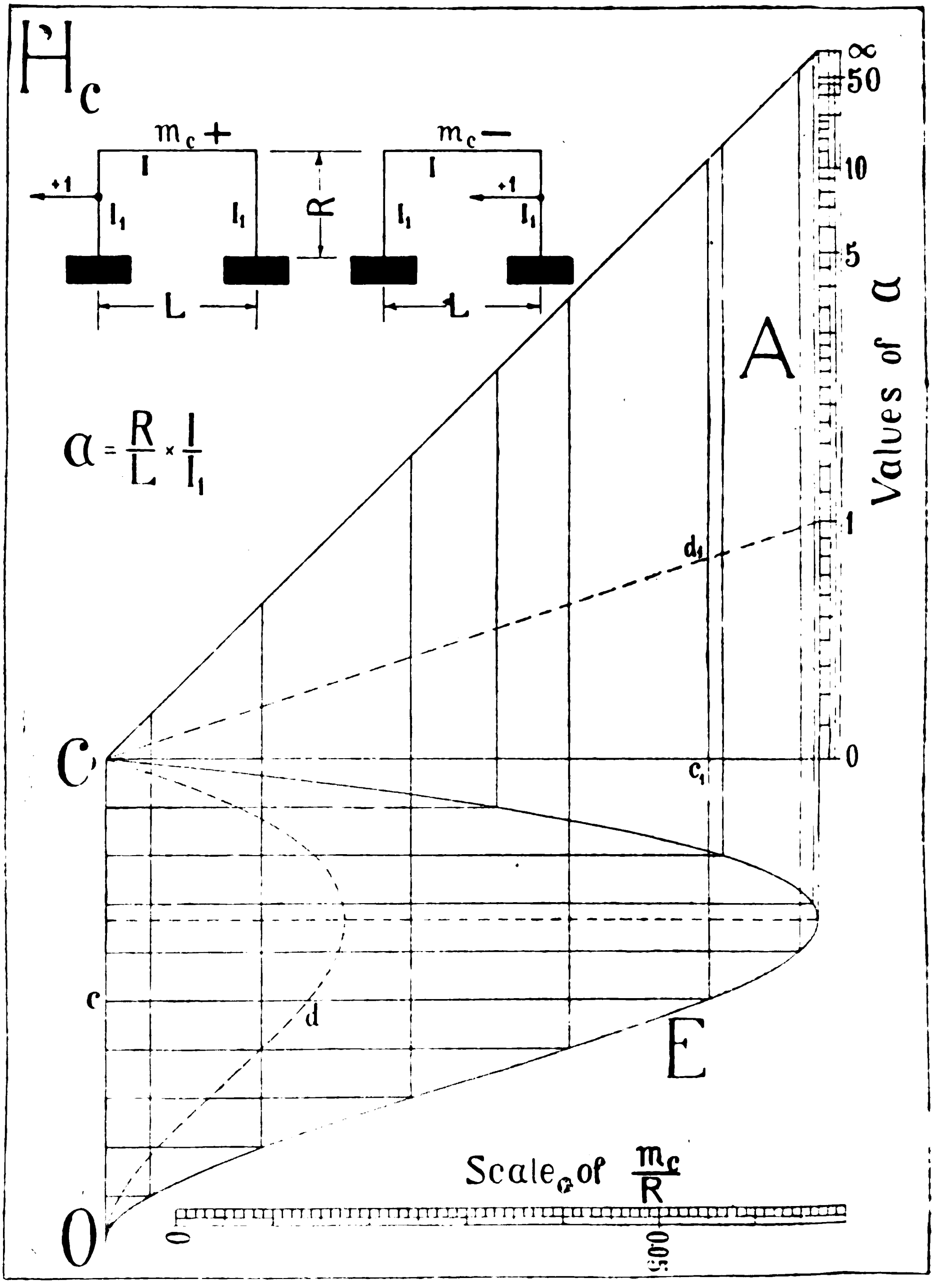
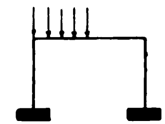
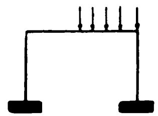
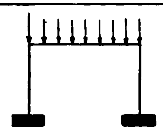
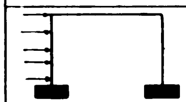
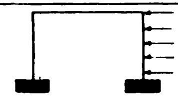
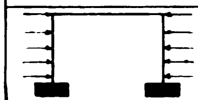


TABLE I (p = LOAD PER UNIT LENGTH)

·LOADING	P_0	Q_0	M_0	M_1	M_c
	$\frac{13+72a}{32(1+6a)}pL$	$\frac{L}{8(2+a)R}pL$	$\frac{2+45a}{192(2+a)(1+6a)}pL^2$	$-\frac{11(2+9a)}{192(2+a)(1+6a)}pL^2$	$\frac{2+3a}{48(2+a)}pL^2$
	$\frac{3+24a}{32(1+6a)}pL$	$\frac{L}{8(2+a)R}pL$	$\frac{14+51a}{192(2+a)(1+6a)}pL^2$	$\frac{10+93a}{192(2+a)(1+6a)}pL^2$	$\frac{2+3a}{48(2+a)}pL^2$
	$\frac{1}{2}pL$	$\frac{L}{4(2+a)R}pL$	$\frac{1}{12(2+a)}pL^2$	$-\frac{1}{6(2+a)}pL^2$	$\frac{2+3a}{24(2+a)}pL^2$
	$-\frac{aR}{(1+6a)L}pR$	$-\frac{13+6a}{8(2+a)}pR$	$-\frac{15+73a+30a^2}{24(2+a)(1+6a)}pR^2$	$\frac{a(23+6a)}{24(2+a)(1+6a)}pR^2$	$-\frac{a}{24(2+a)}pR^2$
	$\frac{aR}{(1+6a)L}pR$	$\frac{3+2a}{8(2+a)}pR$	$\frac{9+35a+18a^2}{24(2+a)(1+6a)}pR^2$	$-\frac{a(25+18a)}{24(2+a)(1+6a)}pR^2$	$-\frac{a}{24(2+a)}pR^2$
	0	$-\frac{5+2a}{4(2+a)}pR$	$-\frac{a+3}{12(2+a)}pR^2$	$-\frac{a}{12(a+2)}pR^2$	$-\frac{a}{12(2+a)}pR^2$

y = the ordinates of the arch line above the horizontal line through the haunches.
I = the Inertia Moment of the cross section at any point of the arch line.
z = the ordinates of the arch line with reference to a horizontal line through the elastic centre, so that

$$z = \rho - y$$

ds = the element of arch line.

The three values of P_0, Q_0 and M_0 being known the bending moment at any point of the arch is found by simply applying ordinary Statics.

Vertical Forces moving from 1 *to* 2.

If the special case of the structure forming the subject of this article is considered, and if the load consists of a unit vertical force applied at any point K (*Fig.* 1) between 1 and 2, the values of P_0, Q_0 and M_0 given by formulæ (1) become the ordinates p_0, q_0 and m_0 of the three corresponding Influence Lines, and the value of M becomes:—

$M = 0$ from 0 to 1 and from 1 to K;

$M = -(x_d - x_K)$ at any point d between K and 2;

$M = -\left(\frac{L}{2} - x_K\right)$ from 2 to 3;

moreover, (2) gives:—

$$\rho = \frac{1+a}{1+2a} R$$

These values substituted in equations (1) give, after some purely algebraic calculations which it would be of no interest to reproduce,

$$\left.\begin{aligned} p_0 &= \frac{4t^2 - 3(1+4a)}{2(1+6a)} \times t + \frac{1}{2} \left(\text{with } t = \frac{x_K}{L}\right) \\ q_0 &= \frac{L}{2R} \times \frac{3}{a+2} \times \left(\frac{1}{4} - t^2\right) \\ \frac{m_0}{L} &= \frac{3+7a}{8(a+2)(1+6a)} \times (1-4t^2) - \frac{t^3 - \frac{t^2}{2} - \frac{t}{4} + \frac{1}{8}}{1+6a} \end{aligned}\right\} \quad (3)$$

These formulæ immediately give:—

$$\left.\begin{aligned} \frac{m_1}{L} &= -\frac{11a}{8(a+2)(1+6a)} \times (1-4t^2) - \frac{t^3 - \frac{t^2}{2} - \frac{t}{4} + \frac{1}{8}}{1+6a} \\ \frac{m_c}{L} &= \frac{4t^2 - 2(a+2)t + a + 1}{4(a+2)} \end{aligned}\right\} \quad (4)$$

The second formula (4) is only applicable for positive values of t, but it is obvious that the corresponding Influence Line is symmetrical about the centre.

It will be easily seen that the three V diagrams are direct applications of these formulæ (3) and (4).

Horizontal Forces moving from 0 *to* 1.

If a unit horizontal force is applied at any point K (*Fig.* 2) between 0 and 1, the values of P_0, Q_0 and M_0 given by (1) become the ordinates p_0, q_0 and m_0 of the corresponding Influence Lines, and the value of M becomes:—

$M = 0$ between 0 and K.

$M = y_d - y_K$ at any point d between K and 1.

$M = R - y_K$ from 1 to 2.

$M = y_d - y_K$ at any point d between 2 and 3.

These values substituted in equations (1) give:—

$$\left.\begin{aligned} p_0 &= \frac{R}{L} \times \frac{3a}{1+6a} t^2, \left(\text{with } t = \frac{y_K}{R}\right) \\ q_0 &= 1 - \frac{t^2}{2(a+2)}\Big[3(1+a) - (1+2a)t\Big] \\ \frac{m_0}{R} &= t^2\left[\frac{(a+1)t}{2(a+2)} - \frac{15a^2+26a+3}{2(1+6a)\,(a+2)}\right] + t \end{aligned}\right\} \quad (5)$$

From these equations is found immediately

$$\left.\begin{aligned} \frac{m_1}{R} &= t^2\left[-\frac{at}{2\,(a+2)} + \frac{a\,(3a-5)}{2\,(1+6a)\,(a+2)}\right] \\ \frac{m_c}{R} &= \frac{a}{2\,(a+2)} t^2\,(1-t) \end{aligned}\right\} \quad (6)$$

Horizontal Forces moving from 2 to 3.

If the point K were between the points 2 and 3 in *Fig.* 2, the values of M would be:—

$M=0$ from 0 to 1, from 1 to 2 and from 2 to K.

$M=-(y_K-y_d)$ at any point d between K and 3 and the Influence Lines would be given by (always applying equations (1)):

$$\left.\begin{aligned} p_0 &= \frac{R}{L} \times \frac{3a}{1+6a} t^2, \left(\text{with } t = \frac{y_K}{R}\right) \\ q_0 &= \frac{t^2}{2\,(a+2)}\Big[3\,(1+a) - (1+2a)t\Big] \\ \frac{m_0}{R} &= t^2\left[-\frac{(a+1)t}{2\,(a+2)} + \frac{9a^2+14a+3}{2\,(1+6a)\,(a+2)}\right] \end{aligned}\right\} \quad (7)$$

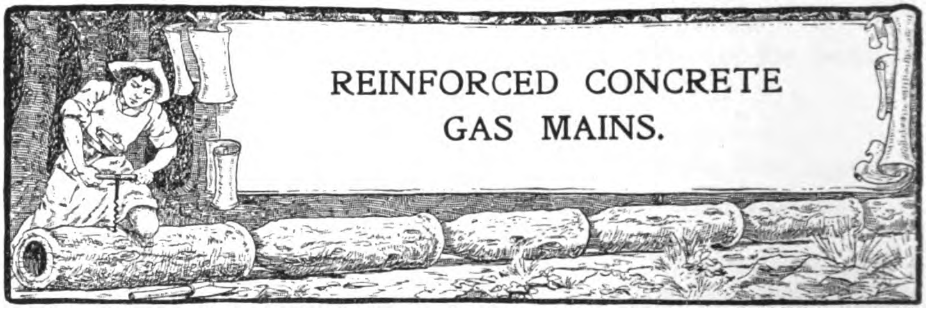
and further

$$\left.\begin{aligned} \frac{m_1}{R} &= t^2\left[\frac{at}{2\,(a+2)} - \frac{a\,(9a+7)}{2\,(1+6a)\,(a+2)}\right] \\ \frac{m_c}{R} &= -\frac{a}{2\,(a+2)} t^2\,(1-t) \end{aligned}\right\} \quad (8)$$

The H diagrams explained above are direct applications of the formulæ (5) to (8).

Effect of Uniformly Distributed Loads.

It has been explained in the beginning of this article how the areas of the Influence Lines are a measure of the bending moments due to uniformly distributed loads. Having the Influence Lines it is easy to find their areas, which are given in the results summarised in Table I. They will prove very useful in practice.

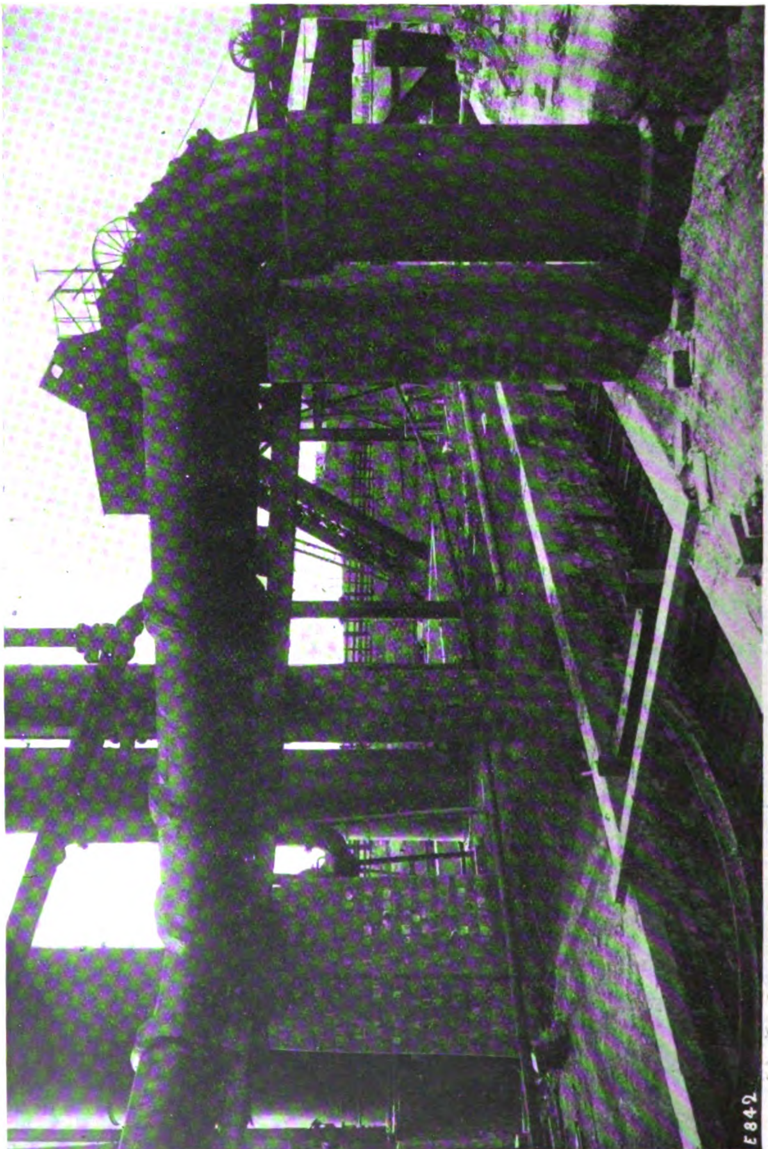


In the following article some particulars are given of what appears to be a new development of reinforced concrete—namely, its application to gas mains. All concerned in this particular subject will, no doubt, watch this new experiment with considerable interest.—ED.

WE reproduce herewith some interesting photographs of a new application of reinforced concrete for the manufacture of gas mains. The high cost of steel and cast iron mains, which hitherto have been exclusively used for the transmission of gas, has rendered it advisable, and even imperative, to have recourse to other materials and methods of construction. Reinforced concrete, having been largely used for water mains, naturally presented itself as a possible substitute. Up till now, although gas engineers and specialists in reinforced concrete work have frequently admitted the possibility of using reinforced concrete pipes for the distribution of gas, they have been reluctant to commit themselves to the experiment. The principal difficulties which had to be overcome were the porosity of the concrete and the difficulty of finding a suitable gas-tight joint. It is therefore to the credit of Messrs. Edmond Coignet, Ltd., the well-known reinforced concrete specialists, and to their clients, The Barnsley Smokeless Fuel Co., Ltd., that they have acted as pioneers in this matter, the former company having designed, while the Barnsley Company have constructed, the first reinforced concrete gas main in this country at the latter's new works at Barugh, Yorkshire. The gas mains were designed and constructed in accordance with the general indications and requirements of Mr. Stephen Wellington, A.M.I.E.E., F.C.S., the consulting engineer of the new works, and it is mainly due to his enterprise that reinforced concrete was adopted for this purpose.

The first question that presented itself was whether it would be preferable to make the pipes on the site of the works or in some particular spot away from the works, whence they would ultimately have to be transported. Upon careful consideration it proved more convenient to deliver all the materials and the moulds for making the pipes on the actual site of the works, where there was plenty of space available, especially as the difficulties of transport were very considerable. After investigation it was found that the most suitable length to make the pipes for this purpose was 6 ft., their diameters being respectively 14 in. internal dia. and 24 in. external dia. The smaller pipes have a thickness of only $1\frac{3}{4}$ in., and the larger ones of 2 in., and they are reinforced by means of a meshwork of expanded metal. Special steel collapsible moulds were devised for the purpose of making the pipes on the

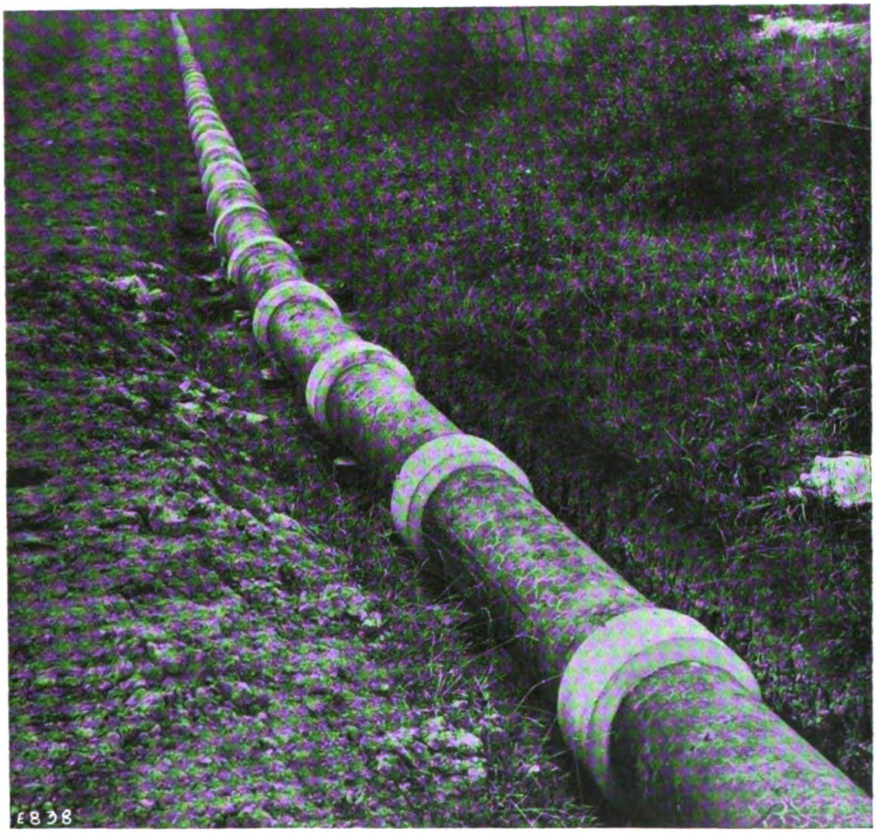
A 24-in. Reinforced Concrete Gas Main.



A 24-in. Reinforced Concrete Gas Main, showing Bend in Cast Iron with Manhole.

site, and this method has turned out to be both rapid and practical. The collars for the joints between consecutive pipes were also made in reinforced concrete in a similar manner to the pipes, and in small moulds made for the purpose.

Practically the whole of the operations of concreting these pipes has been carried out by women. The concrete was suitably graded and of a proper mixture to ensure both strength and density, and the pipes were very carefully



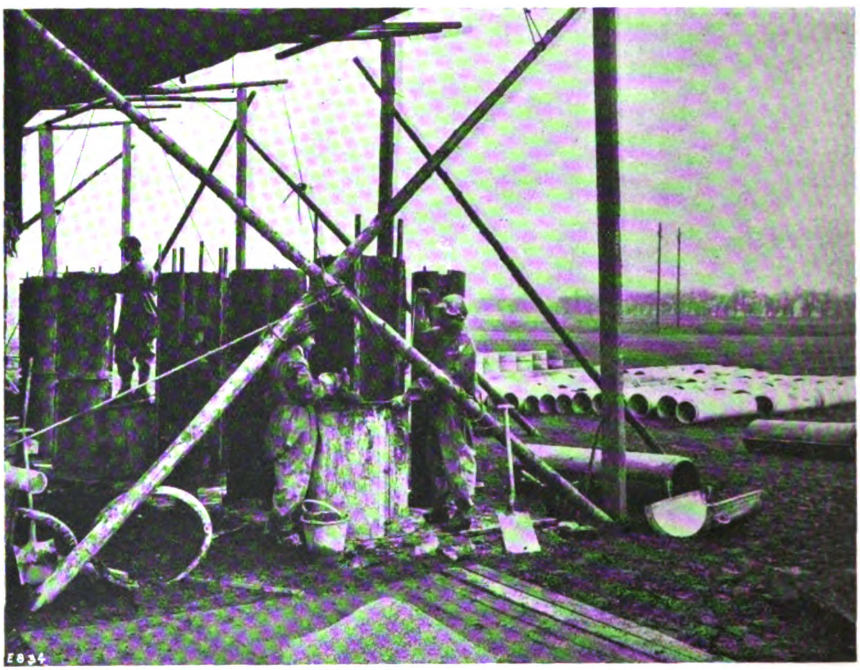
14-IN. DIA. REINFORCED CONCRETE GAS MAINS FOR THE BARNSLEY SMOKELESS FUEL CO.

made, in order to prevent all possibility of air bubbles or cavities. After they were cast and matured they were plunged in a bath of tar of a sufficient temperature to make it thoroughly liquid, so that the pipes should be permeated in every pore by this substance. This extra precaution was for the purpose of filling up any small cavity or pinhole which might have remained undetected. The pipes were then laid in the trench in the same manner as cast iron mains, and their ends were jointed by means first of a special joint of tow treated with pitch and cement.

Obviously, the success of making and laying pipes of this description requires that particular attention should be given to a number of important details both in the construction and in the laying and jointing of the pipes.

From the point of view of economy the advantage of reinforced concrete over cast iron mains is very considerable.

Messrs. Edmond Coignet, Ltd., express the hope that this new application of reinforced concrete will be found as economical and practical after the war is over, and that a new industry for reinforced concrete will thereby be created.



REINFORCED CONCRETE GAS MAINS—WOMEN CONCRETING THE PIPES.

REINFORCED CONCRETE PIGGERY AT SPRINGHILL, DUNDEE.

By J. H. LANGLANDS, Architect and Civil Engineer.

The following particulars and illustrations should be of interest to all who have charge of the erection of agricultural buildings. Reinforced Concrete is a material which can be used to the greatest advantage on buildings of this description.—ED.

THE recent scarcity of foodstuffs in this country, together with the somewhat inadequacy of agricultural buildings for feeding purposes, has given many designers food for thought as to which type of construction would most suitably fulfil the requirements in these times.

In the case in question the author was instructed to erect suitable housing for as many pigs as possible on the ground available and to do whatever was practicable to keep down expense.

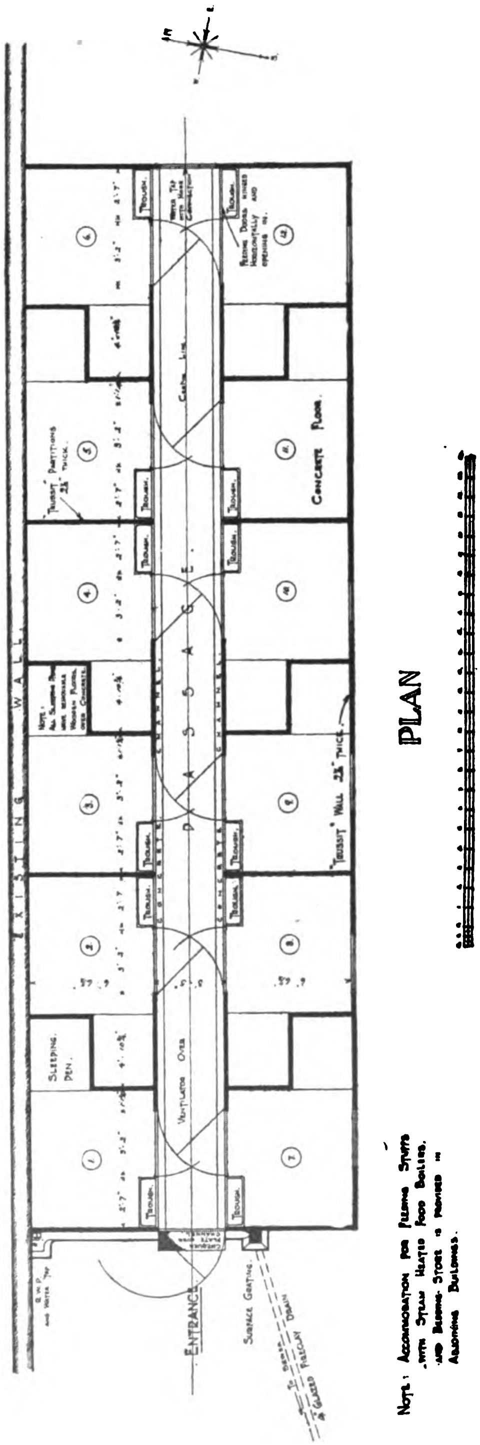
The site for the building is in near proximity to dwelling houses, both of tenements and self-contained villas, and it was consequently essential that the sanitary conditions of the building should in no way impair the amenities of the locality.

I may state that I had visions of the impending difficulties with the authorities as to whether they would permit such a structure to be erected in that vicinity, a petition having been lodged, signed by the inhabitants of the district, against granting permission for the erection of piggeries, and it was not before it was stated that it was intended to construct the building of monolithic and vermin-proof reinforced concrete that the plans were approved by the authorities.

The building, which is rectangular in shape, was erected against an existing wall of some 9 ft. in height.

The total length of building is 55 ft. and the breadth 16 ft. All access to the building is obtained through the doorway, 3 ft. 6 in. wide, at the west end, which gives direct access to the central feeding passage. This passage is formed in cement, with a slight camber forming a run to the open channels on either side. These channels drain all liquid from the central passage and adjoining pens. Water taps and hose connections are provided both in and outside the building, and it is the duty of the attendant to flush pens and passages with water each day, and no conditions exist which would be likely to encourage insanitation.

All external and internal angles have been carefully rounded off and finished smooth.



A Reinforced Concrete Piggery, Springhill, Dundee.

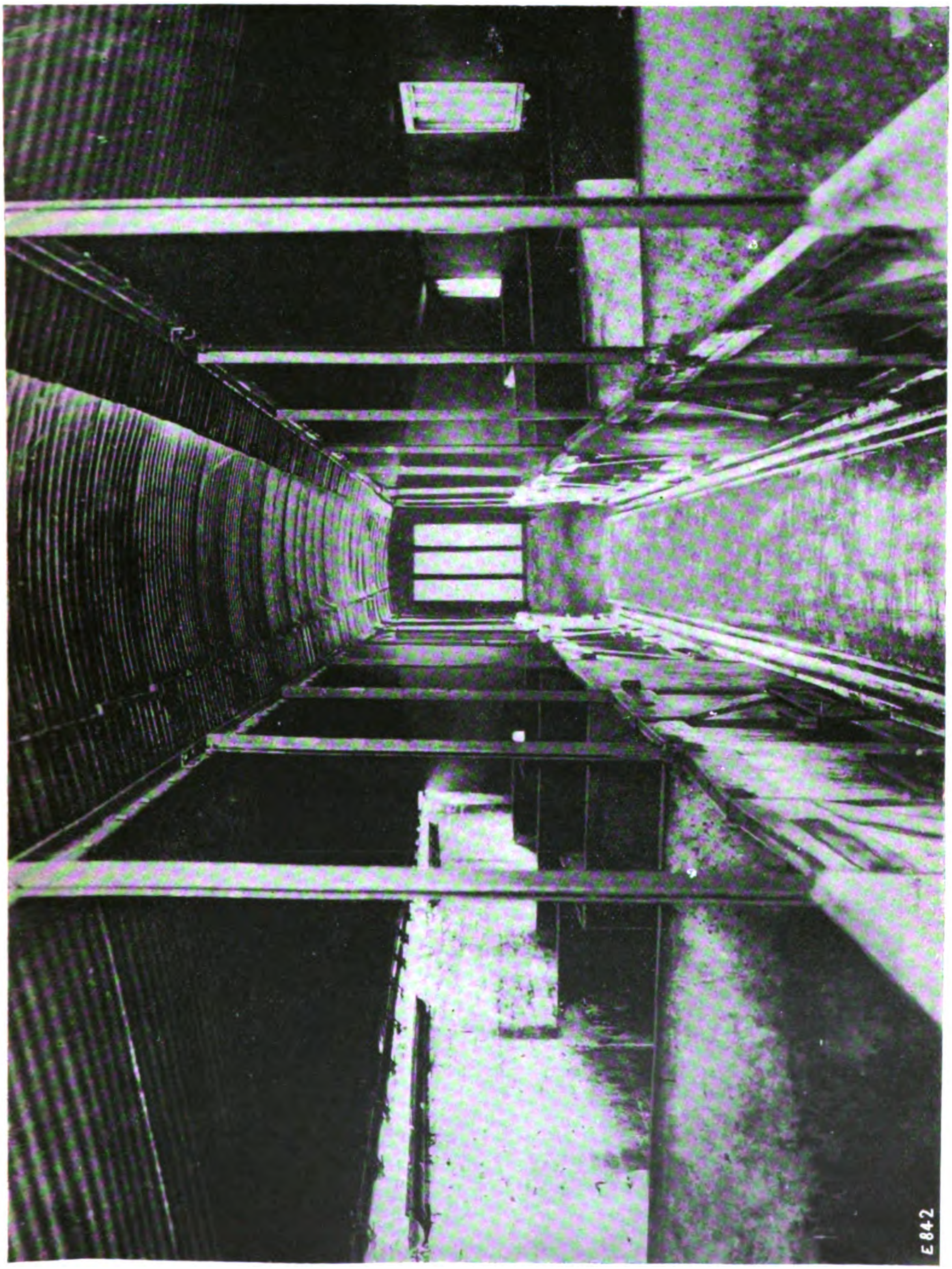
There are twelve pens in all, six on either side of the central passage, and each capable of accommodating two full-grown pigs or three younger, as required.

Pens are arranged so that the sleeping portions, measuring, approximately, 4 ft. by 3 ft., zigzag into each other to economise space, the floor of these portions being covered with portable wood floors, slightly raised, over concrete, in order to keep the bedding dry. The alternate straight and zigzag partitions are 2½ in. thick and 3 ft. high.

There is also a series of 1¼ in. by 1¼ in. by ¼ in. steel angles at both sides of the passage, which rise to a height of 8 ft. from the floor. These carry steel purlins of similar section, which in turn carry the corrugated sheeting of the roof. As all windows are dead sashes, suitable ventilation was provided at the ridge of the roof.

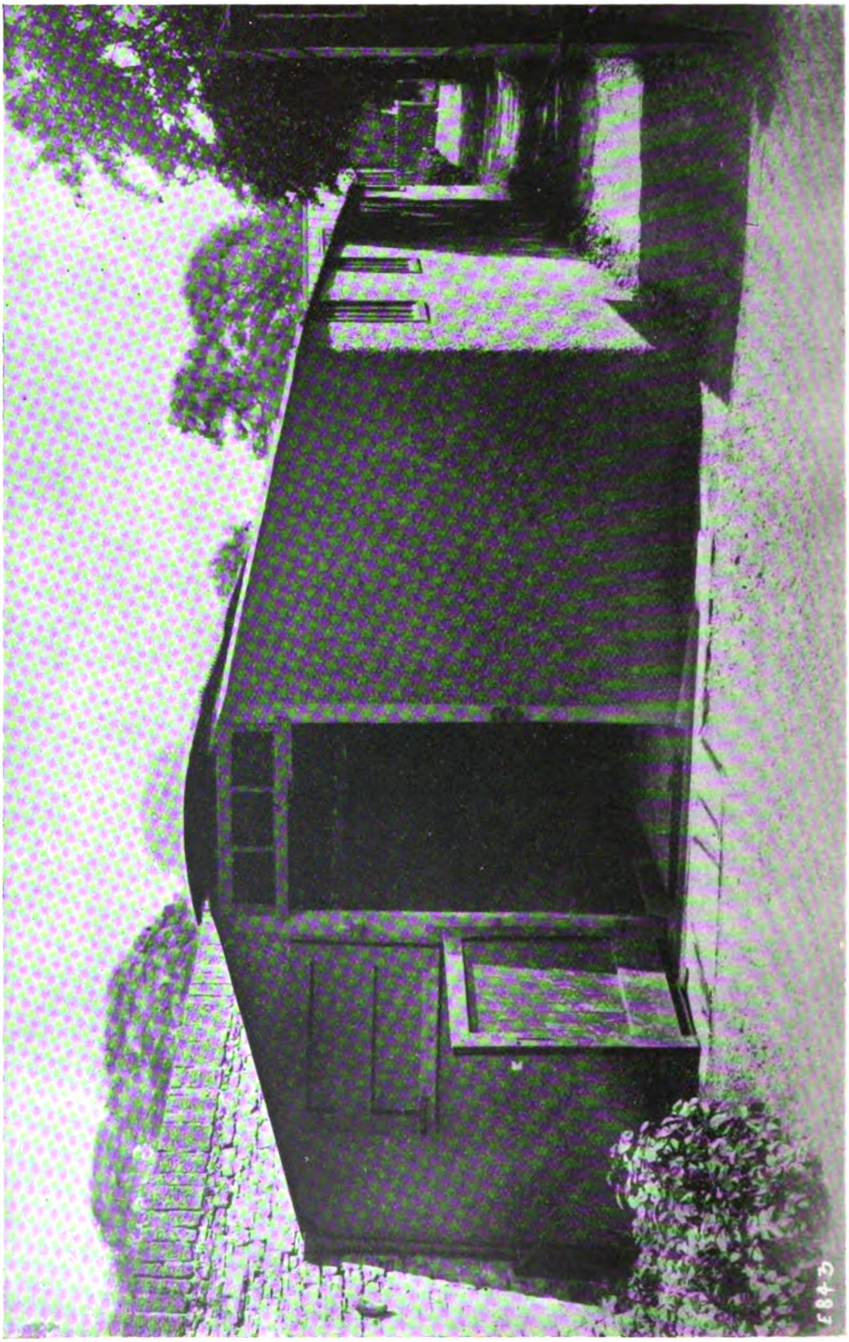
The specification included that all outside walls and internal divisions should be reinforced with "Trussit" expanded metal, as supplied by the General Fireproof Building Products Co., 7, Ward Road, Dundee, who were responsible for all the reinforced concrete and steel work.

The great advantage in using "Trussit" is that it eliminated the necessity of having permanent supports at close intervals. Steel angles were erected at convenient intervals averaging about 6 ft., and previous to the erecting of the expanded metal all window frames were secured in position.



Interior View.

Reinforced Concrete Piggery, Springhill, Dundee.



Exterior View.
REINFORCED CONCRETE PIGGERY, SPRINGHILL, DUNDEE.

It may be of interest that the outside walls were plastered on the outside only before the internal divisions were erected and the floor laid. This enabled all the structure to be thoroughly bonded together, and the temporary supports were removed before the inside cement mortar coat was applied.

As the structure was exposed to a somewhat strong sunshine, it was deemed advisable to erect the corrugated iron roof before any concrete work should be done, and this was accordingly carried out. This, of course, did not obviate the necessity for frequent watering of all cement work; but I am convinced it went a long way in enabling us to procure the building as it is to-day.

It is now a considerable time since the cement was finished, and in no part of the building is a crack visible.

In order that no unsightly hair cracks should appear, only well-aged cement was used for the finishing coat.

Another interesting feature of the design is that the doors to the pens on each side of the passage are the exact size of the central passage, thus forming a most convenient barrier when the pigs are being driven in or being transferred from one pen to another.

Access to all feeding-troughs is obtained through doors hinged horizontally along the side of the passage. Previous to the food being barrowed in, these doors over the troughs are all bolted back, thus exposing the trough to the passage side and at the same time keeping the pigs back.

The building was finished by a coat of rough cast (Harl) on the outside. Chips of rather larger size than usual were used, and the effect given is much more pleasing than is obtained with smaller material.

To obviate any undue vibration in the concrete, all hinges and security bolts were fixed to the "Trussit" expanded metal and were securely cemented in during plastering operations.

A glance at the photographs will show that the building is a good permanent structure and is likely to need little attention in the way of repairs.

The total cost of the building was £202 14s. 10d., which includes all drainage and water connections, this working out at about £16 17s. per pen.

With these figures in view one cannot over-estimate the value of the new materials for reinforcing concrete, for in this case, as in many others, the writer was enabled to erect this building at a very reasonable cost.

The plan does not show accommodation for food stores and steam cooking apparatus, these having been provided for in an existing building almost adjoining.

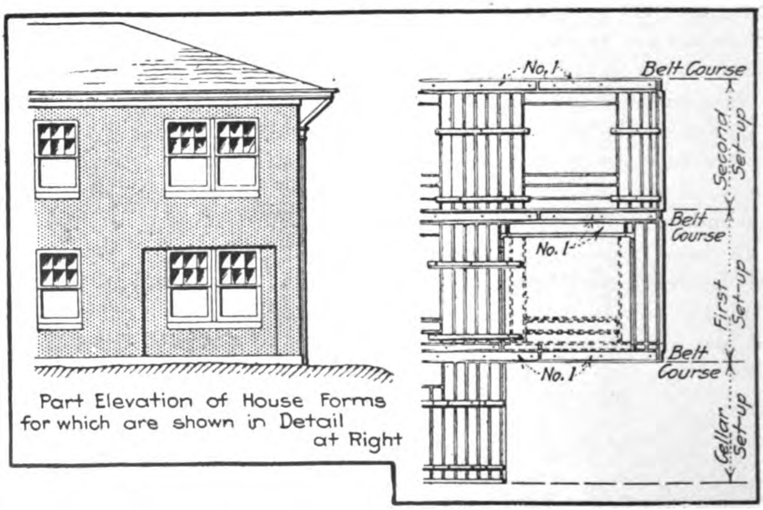
A SCHEME OF ONE HUNDRED SMALL CONCRETE DWELLINGS UNDER ONE CONTRACT IN U.S.A.

The following particulars of a scheme devised in America for erecting cheap concrete dwellings in large numbers may be of interest at the present time, when the question of small houses is receiving so much attention and consideration. It cannot be said that the houses have any special architectural merit, but on the other hand possibly some of the methods adopted here of standardising certain parts may be of assistance where a very large number of dwellings are needed. Our particulars and illustrations are taken from the "Engineering News-Record."—ED.

In Donora, Penn., the Aberthaw Construction Company, of Boston, Mass., is completing for the American Steel and Wire Company a group of cheap concrete dwellings.

EIGHT TYPES OF HOUSES ALL SOMEWHAT ALIKE.

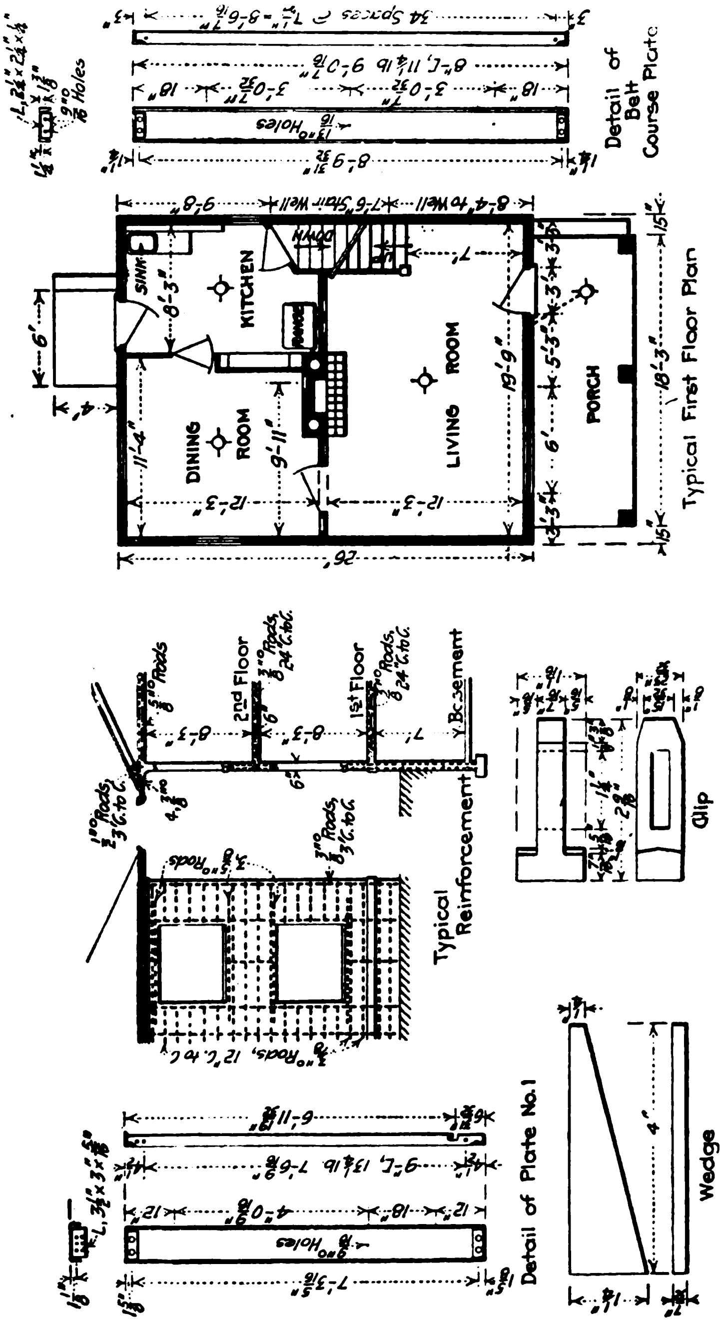
The site of the development is about 40 miles outside of Pittsburgh and is located on a steep hill above the Monongahela River. The property has



Concrete Dwellings Scheme in U.S.A.

been laid out into 156 lots, of which 100 are now being built upon and the remainder will follow next year. Grading was done and streets laid out by the American Steel and Wire Company concurrently with the house building. The streets will all be paved with concrete, and granolithic side-walks will be laid.

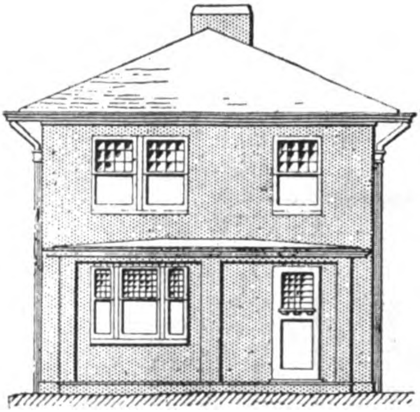
The houses were designed by the Lambie Concrete House Corporation, of Boston, Mass. Eight different styles of houses are being built, containing some four, some five, and some six rooms, all with a bath and cellar. Of



Some details showing how the houses were reinforced and how the steel forms were applied.
CONCRETE DWELLINGS SCHEME IN U.S.A.

these, a few are being built in pairs with party walls, and the rest are all detached. The contract prices for a house complete range from $2,000 to

$3,300, but such costs are based on prices of some time ago and can hardly be used for present comparison. The costs include gas furnaces and cooking ranges, electric lighting and the usual improved kitchen and bathroom equipment. The average floor area is 26 by 26 ft.



Typical Elevation

CONCRETE DWELLINGS SCHEME IN U.S.A.

Typical house layouts are shown, They are all of the box type with 6-in. solid concrete walls reinforced vertically on both faces and horizontally on the outer face with straight rods, with an intermediate partition wall cutting down the floor spans to 12 to 15 ft. The floors are of the ribbed reinforced concrete type, with the ribs or beams spanning between the outer and interior walls. These ribs are left exposed in the cellar, but in the other floors plaster board is nailed to strips left in the concrete and a finish plaster coat made. The buildings are finished at the top with a reinforced concrete cornice in which a gutter is formed, and on top of the concrete ceilings a roof is built up of spruce framing covered with asbestos slate, so that the whole of the exterior of the building, with the exception of this frame, the wooden window and door frames, and wood stairs, is fire-resisting.

SPECIAL STEEL FORMS USED.

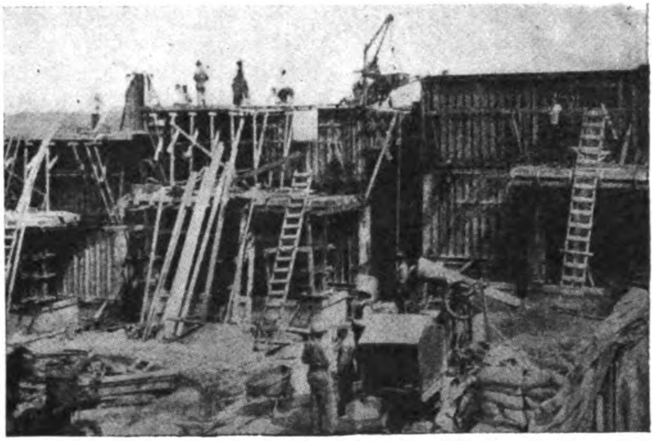
An important factor in the effectiveness of the work is the forms. These are of a patented special steel channel type. They consist of 9-in. channels set up vertically and connected together with clips and wedges passed through slotted holes in the flanges of the channels. At the corner of the building a 4 by 4-in. steel angle is set up, and the forms are lined up longitudinally by means of a steel channel used to form a belt course. This not only fastens the forms of the lower floor, but is bolted into the floor reinforcement and remains in place for a support for the second-storey forms, and is only stripped at the last when all the concrete is poured. The steel wall forms also support the floor forms, which are steel domes, arrangement being made by which the steel channels on which the domes are laid are bolted to the inner side of the steel wall forms. The cornice has to be built inside special wood forms supported, as shown in some of the views, by wooden struts reaching down to the belt-course channel form.

The cellars were excavated with a steam shovel which went down a street, taking out a strip the depth of the houses. The space between the walls of the houses is backfilled after the cellar walls are placed. The digging was in hardpan with some shale, but all of it was taken out by the steam shovel.

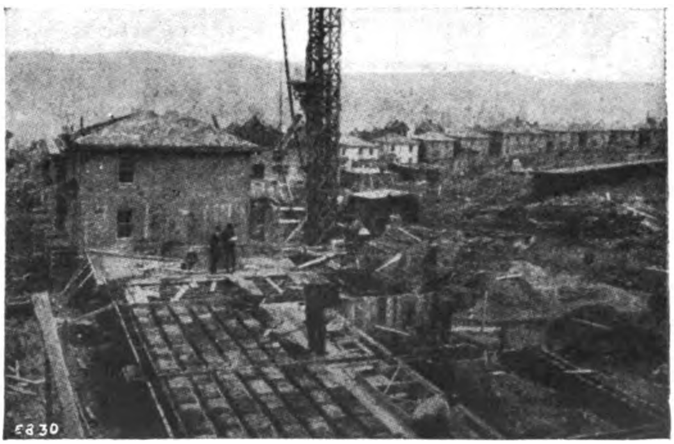
FORMS MOVED FROM ONE HOUSE TO NEXT.

The construction of the houses proper is done in groups, to fit the number of sets of forms, which are taken down as soon as possible and moved on to the next group.

The usual method is to set the forms for one storey—walls and floor together—and then to pour the concrete for this section all at once. The progress of the job is limited by the setting of the concrete. To form, pour and strip each storey takes about seven days. Working at this rate, the house of two floors and cellar is completely concreted in three weeks, and with the twelve sets of forms on the job, twelve houses are concreted in this period. After this the plumbing, heating, plastering, roofing, and finish are done, which take



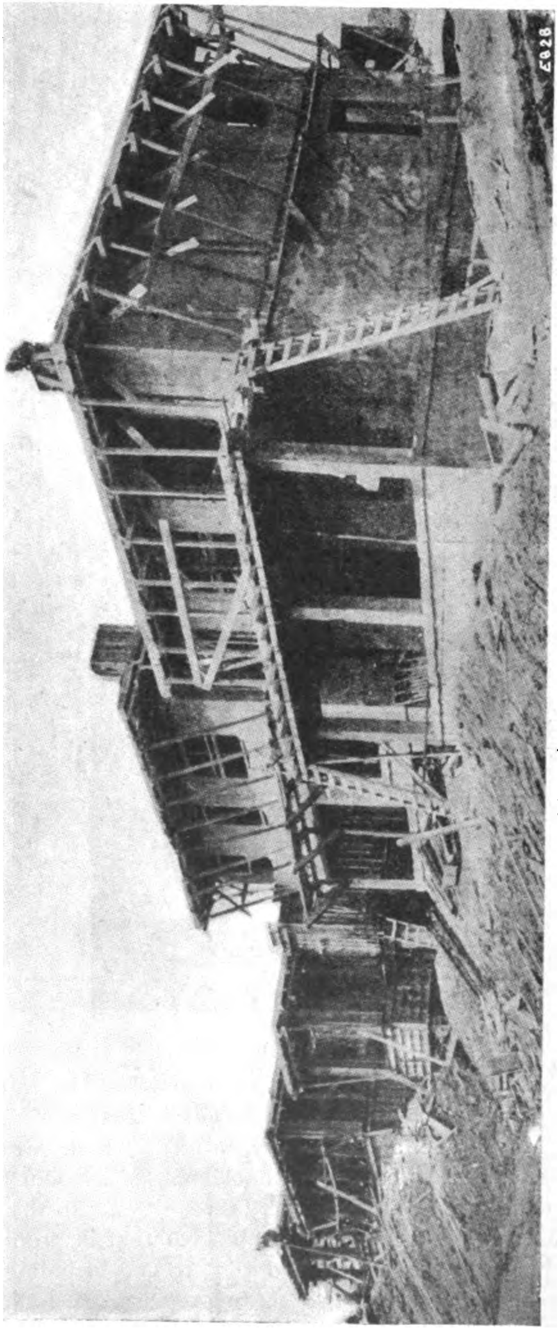
Lifting concrete barrows by derrick on house form.



Method of spouting concrete from tower.
Concrete Dwellings Scheme in U.S.A.

about five weeks more, so that the houses are being completed at the rate of twelve in the first eight weeks and twelve every three weeks thereafter.

During the months of May, June and July the progress made was as follows: Twenty-eight complete houses (counting double houses as one) were concreted in 12½ weeks, or at the rate of a house every three days. In the last month quite a number of houses were concreted very quickly—that is, from the day starting erecting basement wall forms on the footings, to and including the day the roofs were concreted. The last houses have gone up as follows: Two in 13 calendar days, 2 in 14 days, 5 in 15 days, 2 in 16 days, 2 in 17 days, 3 in 19 days, 1 in 20 days, and one in 21 days. Under ordinary conditions these houses could have been built with one set of forms.



View showing how forms were used.
CONCRETE DWELLINGS SCHEME IN U.S.A

CONCRETE TOWER REPLACED BY SMALL HOISTS.

In the original contract for the houses concrete was placed from a high stationary tower with a chute. This proved inefficient, because of the number of moves that had to be made to control the whole housing area. There is so small an amount of concrete in each house—125 cu. yd. on the average—and the houses are so scattered that the cost per yard of concrete was materially increased by the cost of the tower erection and construction. After a long study of different methods the Aberthaw Company decided on small mobile concrete mixers, which could be placed alongside each house during concrete placing, and small hoists on each building.

The plant consists of three Koehring "Dandie" one-bag gasoline-driven mixers, two of which are equipped with side loaders; three Sasgen circle swing derricks; two Novo gasoline-driven hoists, which control derrick and mixer. The slag aggregate and sand, as well as the cement, are delivered to the mixer by means of a truck.

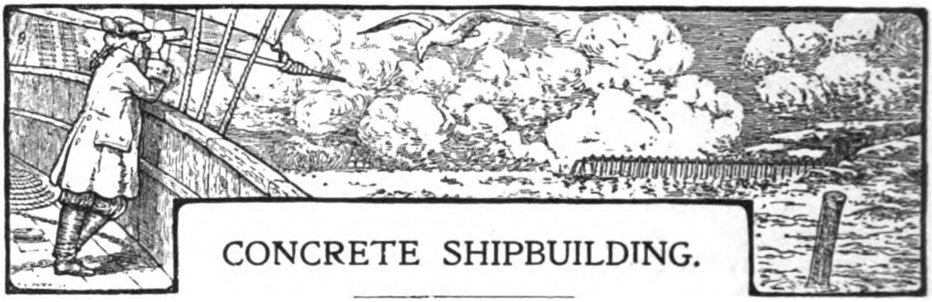
The Sasgen derrick is not used for pouring the basement and first floor, but is used for all concreting above that. It is bolted securely to the best course on one corner of the building, and the concrete is hoisted in concrete buggies or wheelbarrows. Better results have been obtained with the buggies than with the wheelbarrows. Each wheelbarrow has a hook bolted to the front end and is lifted by the derrick by means of three steel arms with rings on the ends, two of which hitch to the handles and the third into the hook on the barrow, so that it is lifted completely and level on to the floor.

DETAIL OF COSTS.

The steel reinforcement varies from 1½ tons in the smallest type of single houses to 3 tons in the largest type of double houses. The labour on wall steel has cost to date $11.90 a ton and the floor steel or beam steel $7.50 a ton. The cost of labour on wall forms to date has been $4.30 a hundred sq. ft., and the stripping has been $2.10. This does not include the moving of forms on to the lots, which has cost about $55 per house, or about $1.25 per 100 sq. ft. of wall.

The quantities of concrete per house vary from 145 cu. yd. for the largest double house down to 85 for the smaller single houses. This includes all walls and floors, footings, pavings, porches, and chimneys. At the present time it is costing about $2.25 per cu. yd. to place the concrete in the first- and second-storey walls, which are 6-in. walls, and it costs the same for the floor slabs. The smaller houses have about 15 cu. yd. of concrete in the first- or second-storey walls, and 6 cu. yd. of concrete in the first and second floors. The roof, including the cornice, has about 10 cu. yd. The cost of erecting the form-work, including handling, stripping, and cleaning, is averaging about 50c. per sq. ft. As no lumber is required for the wall forms, this is doubtless considerably cheaper than work of this class could be done in wood.

Some of the houses nearly completed.
CONCRETE DWELLINGS SCHEME IN U.S.A.



CONCRETE SHIPBUILDING.

THE Portland Cement Association, U.S.A., has recently issued a small pamphlet in which they give an illustrated summary of what has been accomplished in concrete shipbuilding, including details and photographs of some of the earliest concrete boats built.

The following are a few extracts from the pamphlet relating to some of the later developments of this industry, and not previously illustrated in this journal.

Concrete Shipbuilding in America.—*Fig.* 1 shows some of the finished pontoons in use on the Panama Canal. These barges were built in 1911. In this case concrete was selected as the construction material because no skilled labour for steel or wood ship construction was available, nor were the necessary materials for such construction easily at hand. Concreting materials, however, were easily obtainable in large quantity.

The design of these barges called for a structure 64 ft. long by 24 ft. wide, with a depth ranging from 5 ft. 4 in. to 5 ft. 8 in. The walls were made $2\frac{1}{2}$ in. thick because the barges were intended for use merely as floats to carry suction pumps and engines. The only bracing of the hull consisted of two 3-in. bulkheads extending from bow to stern. The reinforcement consisted of $\frac{1}{2}$-in. square deformed bars covered with $\frac{1}{2}$-in. No. 12 wire mesh. Reinforcing was suspended in place from wooden beams and properly located by constructing a wooden platform placed at an elevation corresponding to the bottom of the barges. Bars were placed on 9-in. centres lengthwise and 12-in. centres crosswise, after which the platform was removed and the network of the reinforcing covered with wire mesh. A $\frac{1}{2}$-in. coat of cement mortar was then applied to the wire mesh.

Success with concrete barges on the Panama Canal in 1911 led to the selection of this material for other barges or pontoons for use as landing stages for boats up to 65 ft. long. (See *Figs.* 2 and 3.) These later barges or pontoons are 120 ft. long by 28 ft. wide and 8 ft. deep. Work on two of these was started in July and August, 1913, and completed in April and May of 1914. Four additional barges of this kind were finished in 1916.

The *Panama Canal Record,* October 25th, 1916, contains the following paragraph regarding some severe treatment which two of these barges successfully withstood:—

> At the time of the blowing up of the cofferdam behind which the pontoons were built the surface of the water in the entrance basin was about 15 ft. below the mean tide level. The gap made by the explosion did not allow the water to

pour in from the sea until the tide rose. The stream which broke over the dam at high tide cut an increasing channel in the earth, resulting in a strong inrushing current sufficient to make the barges part their moorings and circle about the basin. In so doing one of them struck a fender pile and broke it at a point about 20 ft. below the butt, where its diameter was about 12 in. The barge groaned under the impact, and one of the end timbers was sheared off, dragging its anchor bolts through the concrete and causing it to crack. This damage was above the water line. In other respects the pontoon was uninjured. The two pontoons collided once in their course around the basin, but this did no damage to either.

The drawings, *Fig.* 4, show a design for reinforced concrete barges as proposed by Mr. Allen Hoar, C.E., of California, and published in *Marine Engineering* in July of this year.

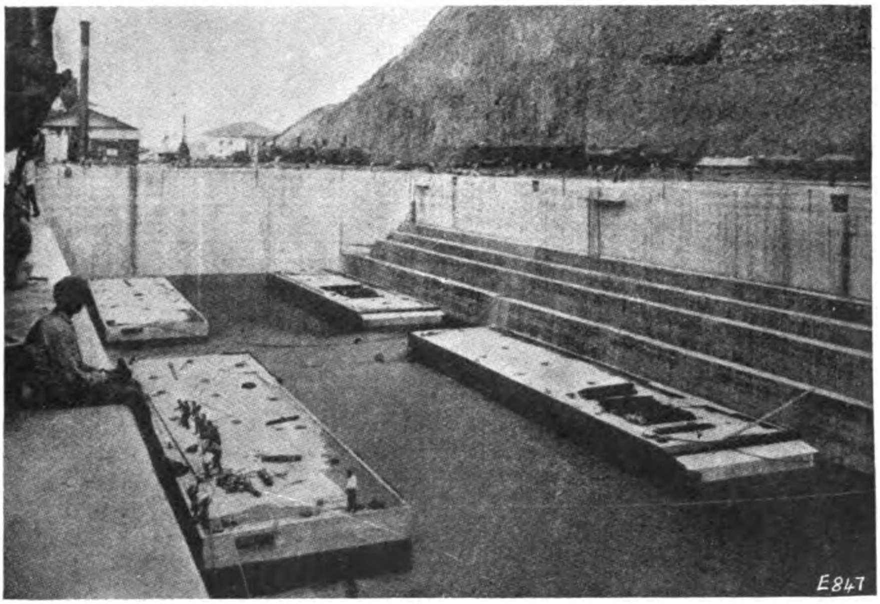


FIG. 1. FINISHED CONCRETE PONTOONS ON PANAMA CANAL.

The author of this design has in contemplation a fleet of concrete barges, each 120 ft. by 28 ft. by 8 ft., capable of carrying 400 tons of cargo between various bay and river points around San Francisco. Loaded light, the draught of these barges will be 2 ft. 7 in. and the displacement 258 tons. The hull will be divided into watertight compartments by longitudinal and transverse bulkheads, while wood timbers will serve as guards to protect the barge from injury by collision.

In the issue of *Marine Engineering* referred to above the following table of comparisons appeared :—

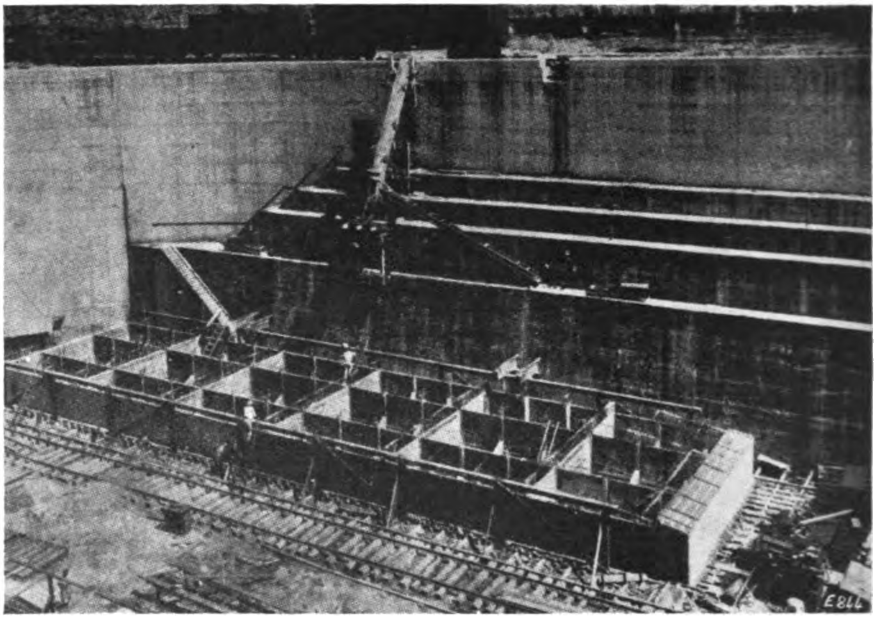


FIG. 2. CONCRETE PONTOONS IN COURSE OF CONSTRUCTION. TO BE USED AS A LANDING STAGE ON PANAMA CANAL
This shows one of the Pontoons directly forms had been removed.

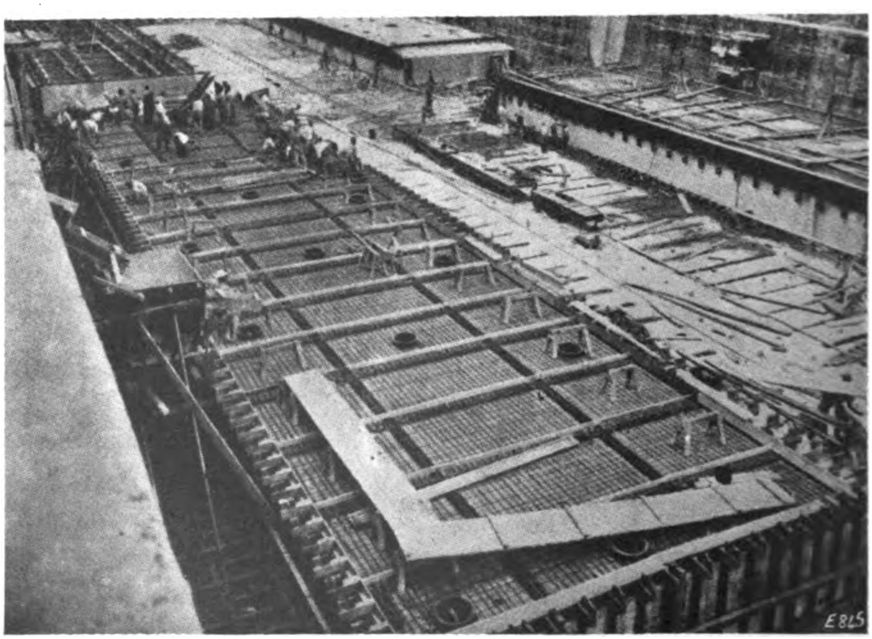


FIG. 3. GENERAL VIEW OF REINFORCEMENT IN PLACE FOR CONSTRUCTING DECK OF CONCRETE PONTOONS ON PANAMA CANAL.

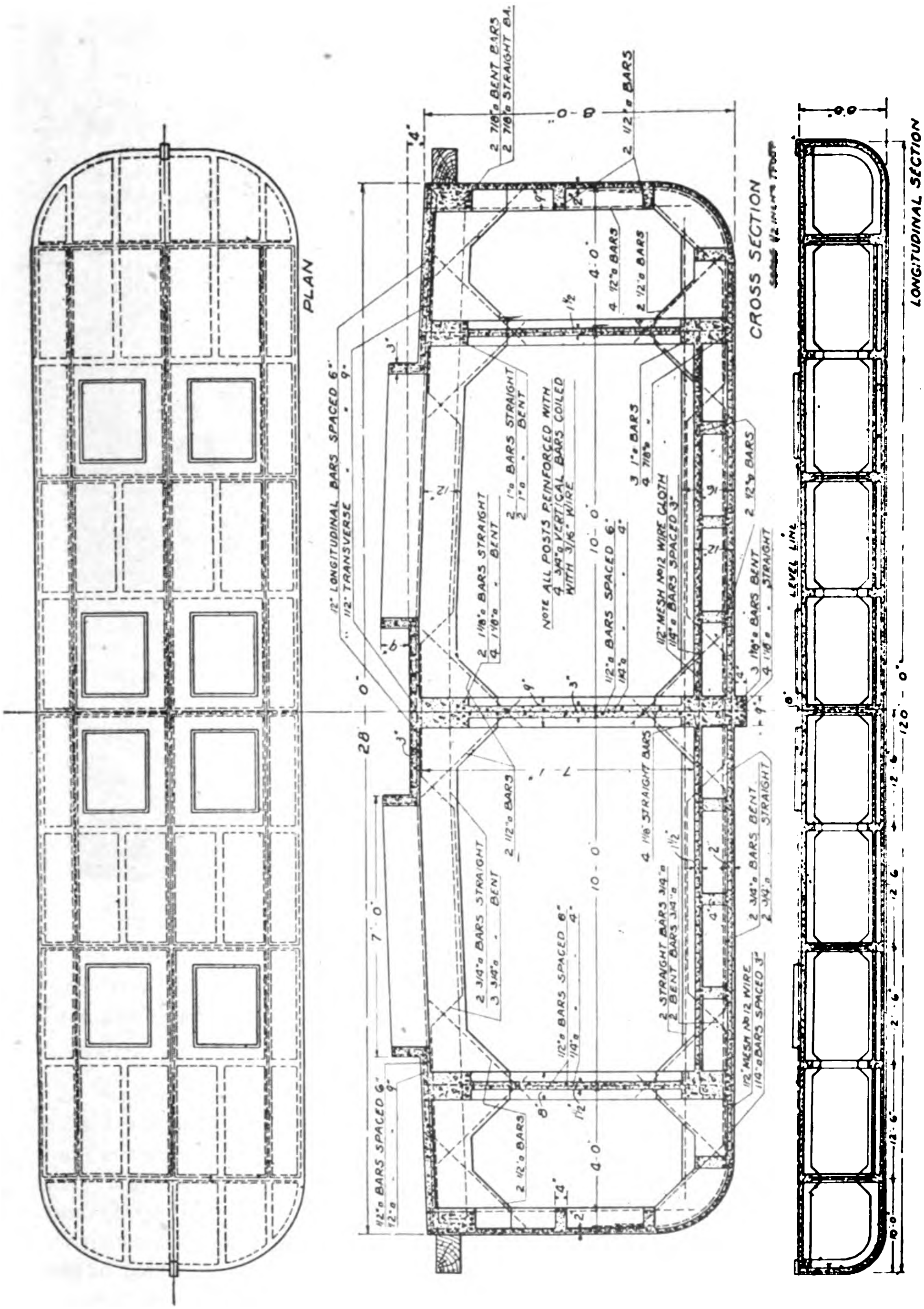


Fig. 4. Design for Reinforced Concrete Barge Proposed by Mr. Allen Hoar, C.E.

	Reinforced Concrete	Wood	Steel
Estimated life	35	15	25
Displacement (light), tons	259	135	151
Pounds per cubic foot capacity	19·25	10	11·2
Cost per cubic foot	·318	·304	·687
First cost	$8,547	$8,171	$18,466
Total cost of repairs	855	2,432	1,847
Interest on first cost at 5 per cent.	15,000	6,128	23,082
Interest on repair cost at 5 per cent.	750	912	1,154
Total cost	$25,152	$17,643	$44,549
Total annual cost	$718·63	$1,176·20	$1,781·96

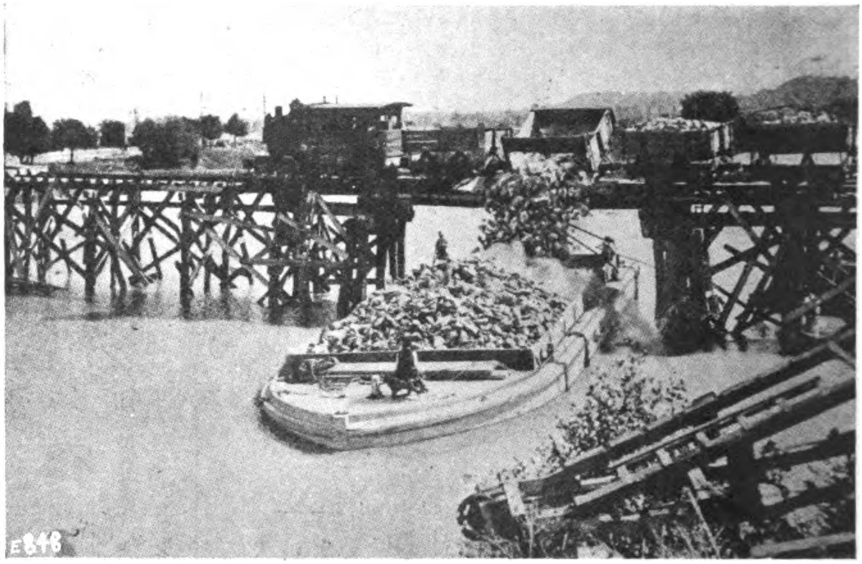
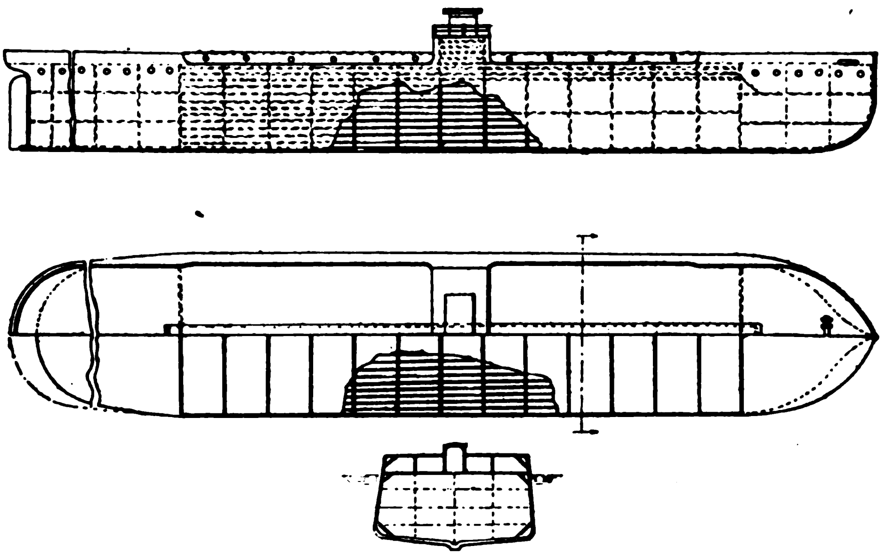
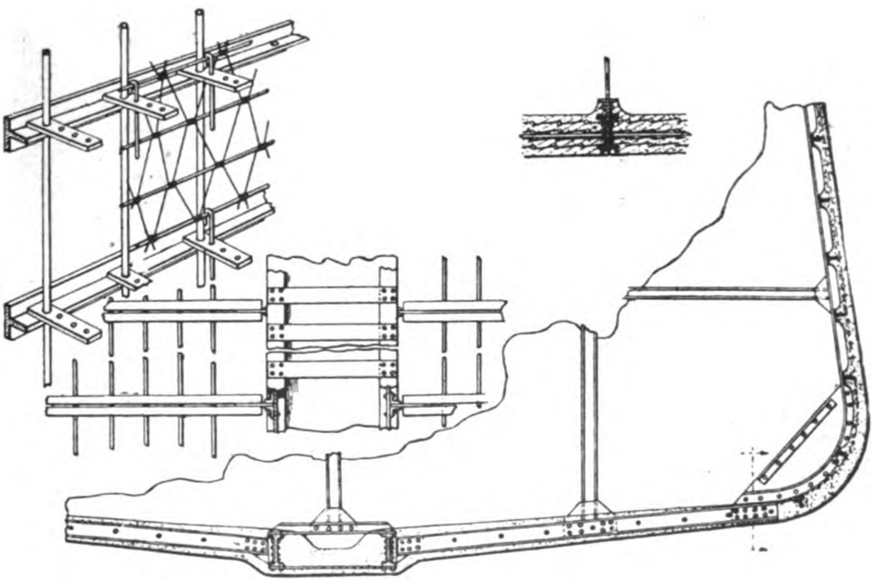


FIG. 5. THE CONCRETE BARGE "PIONEER" IN USE ON THE WELLAND SHIP CANAL.

One of the barges in use on the Welland Ship Canal is illustrated in *Fig.* 5. This barge was launched in November, 1910, and has been in use ever since, principally for carrying stone. The barge measures 80 ft. by 24 ft., and has a draught of 7 ft.

In an earlier number of this magazine we made a short reference to a design taken out by Mr. Carl Weber, of the Cement Gun Construction Co., of Chicago. The pamphlet from which we are quoting in this article gives some plans and details of Mr. Weber's system, which are reproduced in *Figs.* 6 and 7. It will be recalled that the author's idea is to use a concrete or steel framework and cover this with a number of layers of reinforced concrete, which will be placed by his "Tector" process by means of a machine which applies concrete by air pressure somewhat similar to the cement gun, except that in this method the hydration process is divided into two distinct stages, resulting in the elimination of sand pockets in the hull and in a more uniform and denser





Figs. 6 & 7. Plans and Details of Design of Mr. Carl Weber.

concrete. He also employs a special mixing process, in which the mixture is thoroughly kneaded after pre-hydration, by which he claims to obtain a high-grade waterproof concrete. It is said that the building method proposed by Mr. Weber eliminates form work and adapts itself to the requirements of different types of construction. The hull will be built by a series of laminations varying in number and thickness according to the pressures developed at the different depths, and also according to the purpose for which the vessel is to be used.

The design, *Fig.* 9, is that of Mr. E. Lee Heidenreich, a consulting engineer in Kansas City. The following is his description of the design, which he states is only tentative :—

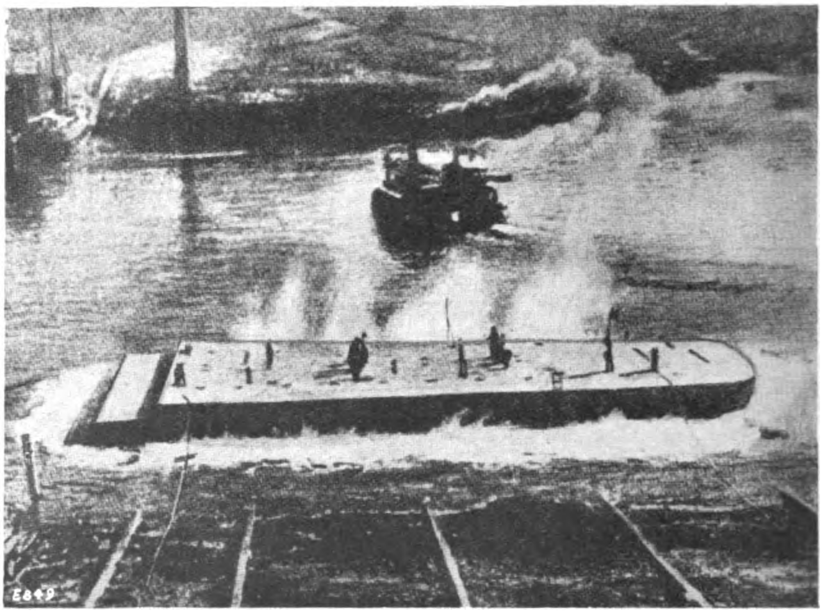


FIG. 8. PONTOON IN N.S.W.

The hull is composed of five vertical longitudinal trusses, three horizontal trusses consisting of one deck and two floor trusses, and in addition a series of transverse bulkheads, which may be pierced by small or large openings as desired. It will be seen that stresses in this construction are determinable, and the resisting moments are largely met by T-beam constructions to take care of the primary stresses and their recoil.

If a hull like this be considered satisfactory for a 5,000-ton transport it would require some 3,000 c. yds. of reinforced concrete, which, for a number of vessels, could be readily produced at 20 dollars per cubic yard or 60,000 dollars for the hull.

It goes without saying that some of the transverse bulkheads can be reduced to strengthening ribs along the vertical hull and centre longitudinal bulkhead as well as act as deck beams. It is maintained by the author that with some modification

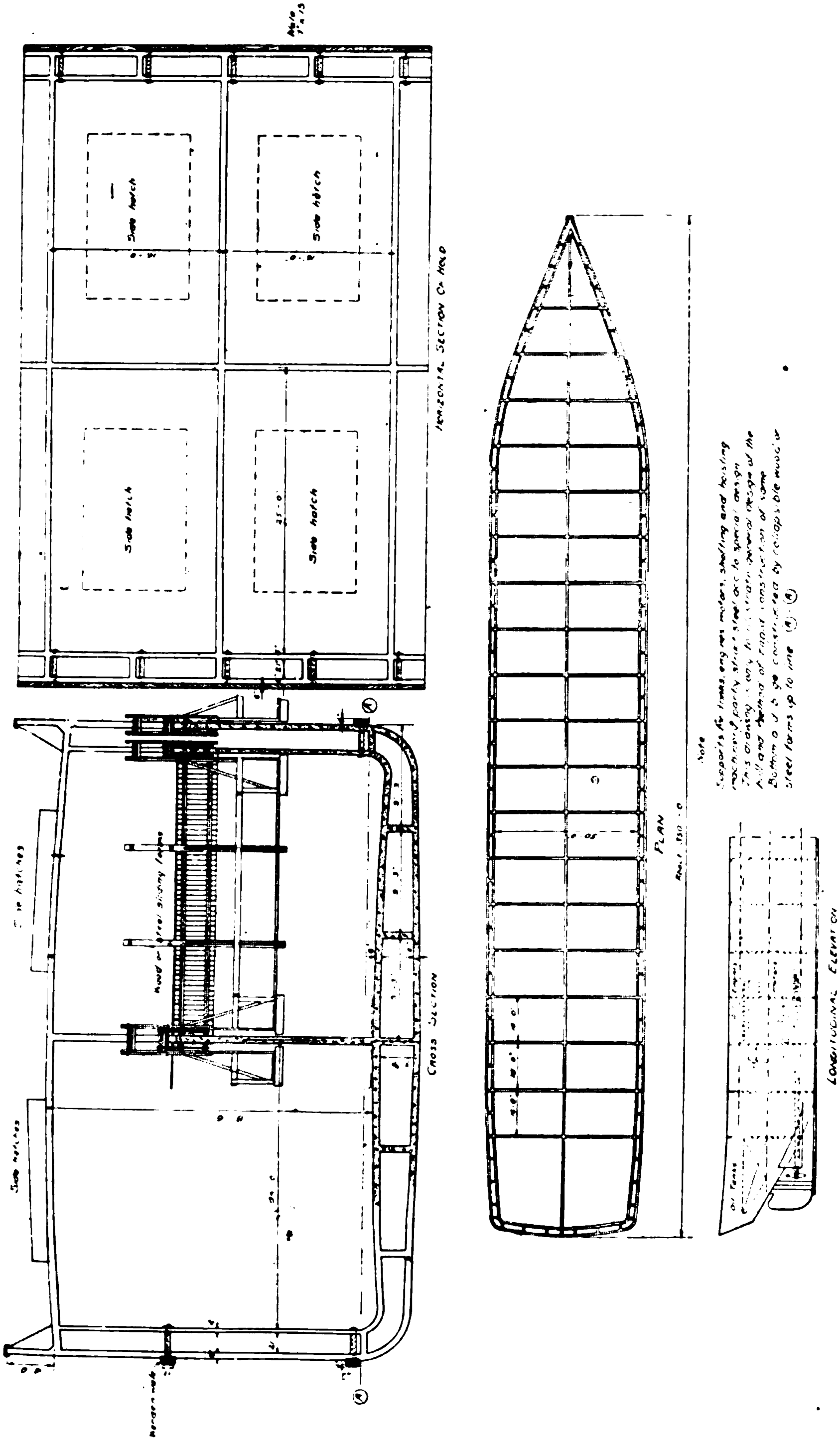


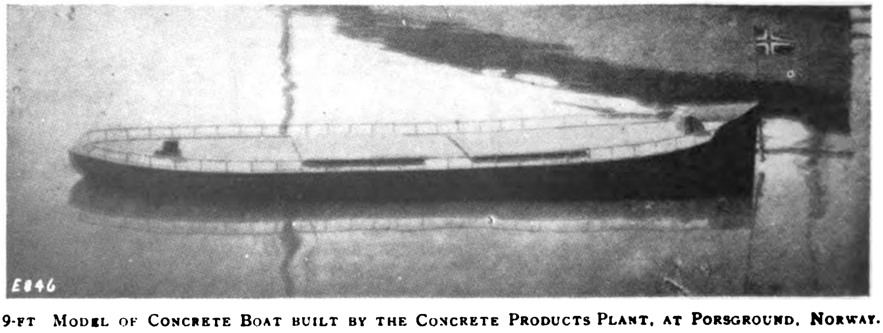
Fig. 9. Sketch for Reinforced Concrete Transports, proposed by Mr. E. Lee Heidenrech, Kansas City, Mo.

of the lines of the hull required, the same can be built in reinforced concrete by means of sliding forms with great economy in costs and time of construction.

Australia.—New South Wales.—In 1914 the Sydney Harbour Trust decided to build a pontoon for use in Circular Quay, Sydney, N.S.W. After investigating various available methods of construction it was decided to use reinforced concrete, as it seemed likely this material would eventually prove cheapest because of durability and low maintenance. The pontoon, of which an illustration is shown in *Fig.* 8, is 110 ft. long, 53 ft. 3 in. wide at the bow, 67 ft. 7 in. at the stern, and has a draught of 7 ft. 9 in., and a deck area of 6,000 sq. ft. The total displacement is 783 tons. Three hundred and forty-two cu. yd. of concrete and forty-three tons of reinforcing steel were used in its construction. The bottom of the barge is 5 in. thick. Bulkheads, 4 in. thick, divide the whole into forty-four compartments, which support an 8-in. concrete floor or deck.

Concrete Ships in Holland.—The first concrete boat in Holland was built in 1887 by the Fabrick van Cement-Ijzer Werken. This firm first built barges up to eleven tons capacity, which proved so successful that plans were elaborated resulting in the building of barges 64 ft. long and 14 ft. beam, of fifty-five tons capacity. The system they adopted was that of building longitudinal and transverse bulkheads, spaced approximately on 6-ft. centres, thus providing a cellular construction which, they claim, makes the ship practically unsinkable. Another firm in Holland who have carried out shipbuilding in concrete are Messrs. R. Last Sons, who built a motor boat in which a framework of steel ribs and longitudinal rods to which wire mesh was attached was covered with a coat of mortar. This finished shell was only ½ in. thick. The boat had room for six or eight people and was propelled by a motor which drove it at moderate speed. This boat was, however, only intended for pleasure purposes.

Norway.—In conclusion, we show an illustration of a 9-ft. model of a concrete boat built in Norway, which was handed over to the United States Bureau of Standards in July of this year to enable it to study methods of construction. Fuller details of one of the ships recently launched in Norway are being held over for a separate article.



9-FT MODEL OF CONCRETE BOAT BUILT BY THE CONCRETE PRODUCTS PLANT, AT PORSGROUND, NORWAY.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.—ED.

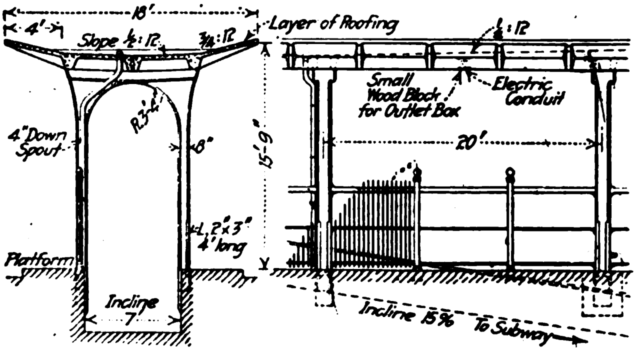
THE AMERICAN CONCRETE INSTITUTE.

UNIT CONSTRUCTION IN CONCRETE.

By JOHN E. CONZELMAN, Civil Engineer, St. Louis, Mo.

The following paper was read at the last meeting of the above Institute, and may be of use to those of our readers who are interested in what is known as the "Unit" construction of concrete, for which the author claims certain advantages, especially in connection with the erection of small dwellings on a large scale.

We are facing a crucial period in the development of concrete construction During the past twenty years we have been so occupied in developing and constructing that we have had little time for sober second thought and investigation. Fortunately, the last two or three years have witnessed a change, and most of us have paused to analyse the results thus far accomplished.



Section through Incline   Elevation

FIG. 1. CONCRETE PLATFORM SHELTER WITH TWO-POST BENTS SPANNING INCLINE APPROACH

We realise now more fully than we used to that concrete is not permanent unless it has been made of carefully selected materials which have been properly proportioned and thoroughly mixed for a reasonable length of time. We have known that the water content exerts a marked influence on the strength and permanence of concrete, and most of us have been guilty of varying this factor to suit the requirements of our spouting and conveying systems. It is well for the art that we have reached this transitional stage and are profiting by our past experiences. Practical experience combined with the analyses and investigations that have been made have not only pointed out the defects, but have fortunately shown the causes and indicated, at least to a considerable extent, the remedies.

In this period of reformation there are few engineers or constructors who are not feeling the spirit of the times, and who are not applying what they have learned to the improving of the product. This is a healthy condition for any industry, and one that will lead to large results.

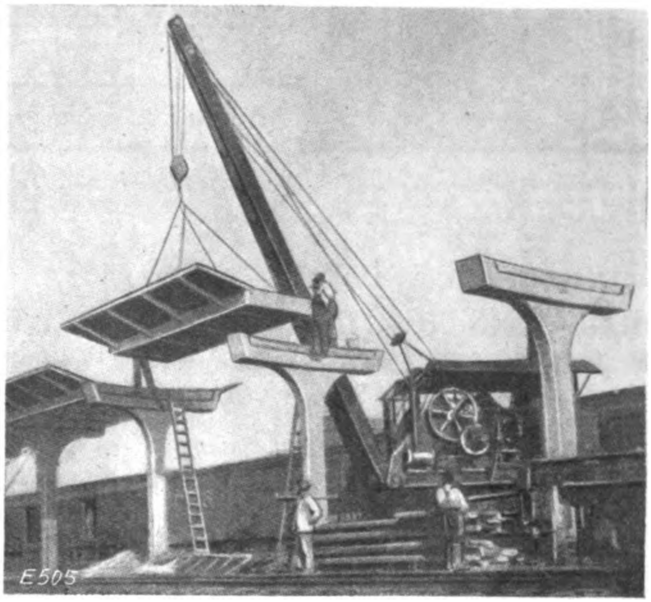


FIG. 2. PLACING ROOF SLABS OF PLATFORM SHELTERS AT LOS ANGELES.

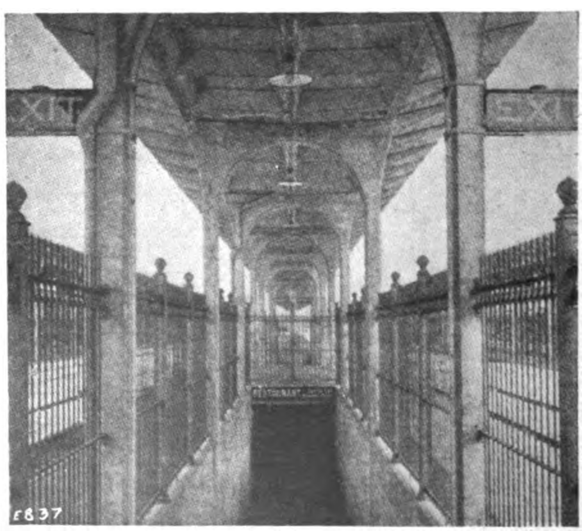


FIG. 3. SUBWAY ENTRANCE TO ARCADE DEPOT, LOS ANGELES, CAL.

We have not only learned that we have been neglectful of these precautions that affect the permanence and uniformity of the concrete produced, but we have further realised that these same precautions would have resulted in a great increase in the strength of the concrete. We have not been using the materials to the best advantage, and this has acted to retard progress. When we use mixers that will work the materials together instead of merely agitating them we will have gone a long way in the right direction. Proper selection of aggregates and thorough mixing should result in concrete of such reliable and uniform strength that a saving of 30 per cent.

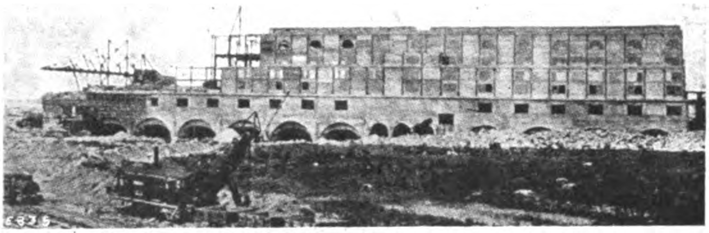


FIG. 4. DOWN-STREAM SIDE OF POWER HOUSE, CEDARS RAPIDS, CANADA.

of materials could be accomplished. This statement is, of course, predicated on the assumption that the concrete will be properly protected during the curing period.

It may be said, therefore, that careful selection of aggregates, skilful proportioning (including water), long mixing and proper handling and placing, combined with reasonable protection after the concrete is in the forms, are the basis of successful, economical, and permanent construction.

By unit methods concrete is mixed and placed under what may be called factory conditions, and because it is possible, and necessary for economical operations, to pour

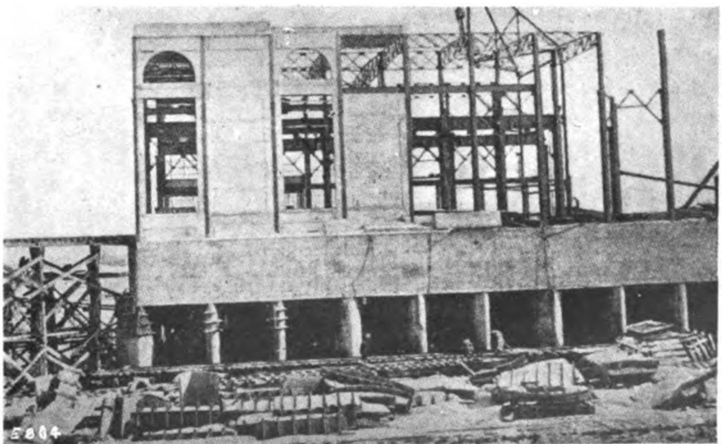


FIG. 5. VIEW OF POWER HOUSE, CEDARS RAPIDS, IN COURSE OF ERECTION.

each day, there is no tendency to rush concreting at certain periods; system and orderly procedure result in a better product in this case as elsewhere.

As a result of these advantages the use of unit methods has increased more extensively than is generally known. The construction has been extensively used for practically all structures ordinarily built of reinforced concrete, and in addition to this has opened up entirely new fields for the application of this material.

FOR RAILROADS.

Railroad work offers a wonderful field for the development of the unit method. If it were possible to standardise such structures as engine houses, freight sheds, snow sheds, train sheds, and small stations, the construction of these by the unit method on a factory basis at central locations would effect economies that would be surprising. This method would also ensure permanent and reliable structures.

In my judgment, such methods would produce a saving of 30 or 40 per cent. of the concrete that would be required if the construction were carried out in the usual way. There is no reason why such standardised buildings cannot be carried in stock

FIG. 6. CLASSING SHEDS FOR THE GALVESTON COTTON COMPRESS AND WAREHOUSE CO.

and shipped out as required. The erection could be done in a surprisingly quick time. What is true of railroad structures applies with equal force to commercial buildings, manufacturing centres, and housing developments.

Unit methods have been developed by the railroad companies mainly in the direction of heavy slabs for bridge and trestle work, and at various times engineers have devised unit methods in carrying out particular problems. This is especially true of the construction of sea walls, caissons, and similar structures.

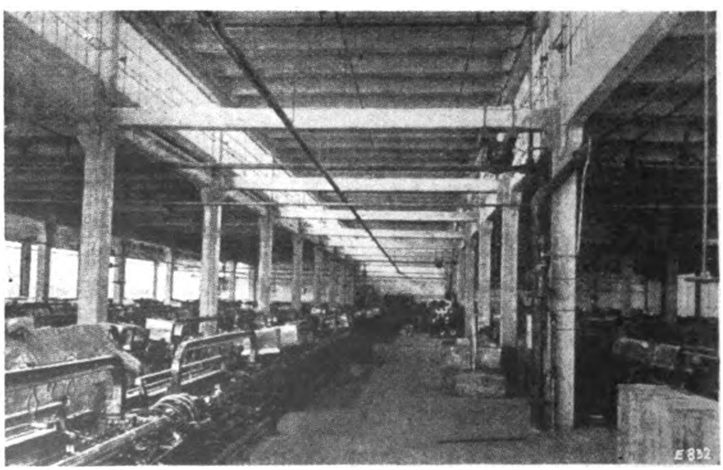


FIG. 7. INTERIOR OF A MILL BUILDING, POSTEX MILLS, TEXAS.

The pursuit of the unit idea to its logical development has been mainly carried out by two or three individuals and companies. These parties have expended a great deal of time and a large amount of money in working out their ideas to a practical basis, and some have felt it necessary to take out patents for the purpose of protecting their investments. For example, the company with which the speaker is connected has spent perhaps $300,000 on the development of the unit idea. Other individuals have spent large amounts. When it is remembered that most of this development work was carried out under adverse criticism from practically all supposed authorities is it not but just that the work of these companies shouid be recognised, and that their rights to the methods developed should be respected by all?

When the time comes, as it soon will, when units are made in permanent factories by improved methods of manufacture and curing, a perfectly reliable structural material will be obtained, and perhaps 50 per cent. of the concrete that is now used will be saved.

I wish to call special attention to the construction used for the power house for the Cedars Rapids Manufacturing and Power Co. in Canada. The combination of structural steel and concrete as used there produced a building of low cost and yet one that should be practically permanent. With a very little additional expense a hollow wall construction was secured which is a desirable feature in that climate. The possibilities of this combination for the construction of piers, power houses and factory buildings of permanent character make a very strong appeal to the imagination.

WORKING MEN'S HOMES.

The economic construction of sanitary, permanent and fire-resisting homes by unit methods for working men and others is a demonstrated possibility. In no other

Fig. 8. Car Barn of the Philadelphia Rapid Transit Co., showing Construction of Reinforced Concrete Skylights.

field of constructional endeavour are the possibilities of economic results of such universal advantage.

The construction of homes, especially the low-priced house, has not received the intelligent, thoughtful and scientific planning that is used for larger developments such as manufacturing plants or office buildings. In this case, also, it has been found impossible to use scientific construction methods on account of the limited costs. In this case, as in most others, the poorer man who needs it most is prohibited by circumstances from utilising the best methods and the efficient organisations devoted to building construction.

The construction of working men's homes has in many cities been left to the speculative builder, whose aim has been to produce the most for the money with little regard to quality. The result is poor construction and continual repairs—repairs often being justified by the statement that the labouring man, or mechanic, likes to have something to do around the house. This, of course, is a false policy.

At the present time in practically all of our manufacturing centres there is a great lack of housing accommodation; skilled working men receiving high wages find it impossible to secure satisfactory or even decent accommodation. This condition can only result in a lack of effectiveness.

The problem has, however, an entirely different aspect when we come to the consideration of working men's colonies. In this case if the development comprises a sufficient number of houses, the total cost becomes an item sufficient to attract services of the highest class and justifies the use of equipment on a large scale. This step at once brings to the construction of working men's homes the same architectural, engineering and constructional skill ordinarily used in the construction of large building operations.

It is, in fact, the one method by which the greatest economy can be obtained in the construction of individual homes. It is, also, the one method by which the ornamentation of one house can be omitted and attractiveness obtained by the arrangement of entire blocks. The same principles of economy and rapid construction apply in this field as in the railroad construction field heretofore mentioned.

The standardisation of parts and construction by factory methods mean the same economies in building construction as have been obtained in manufacturing operations of all kinds. The possibilities of constructing houses by the use of standardised units, even when the development is not carried out on a large scale, has been demonstrated. Mr. Grosvenor Atterbury, of New York, has constructed sixteen or eighteen houses with standard sections in which the walls, floors and roofs are of reinforced concrete. Fourteen of these buildings were constructed under the direction of the Sage Foundation at Forest Hills, Long Island.

These houses, which have now been in use for several years, and which are rented to a high-class of tenants, have proved entirely satisfactory. In these houses the walls are constructed of hollow standardised sections or units and act as supports to the unit concrete floors.

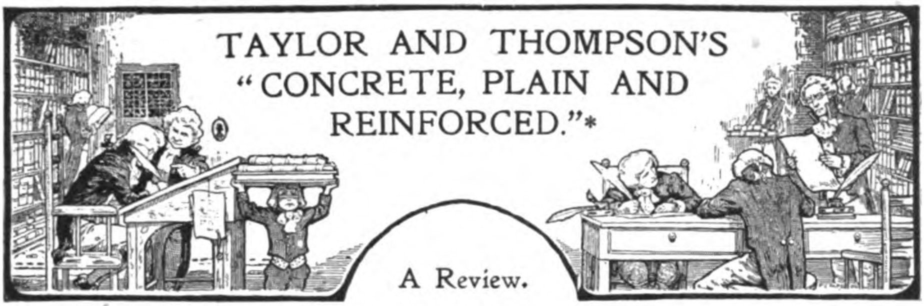
The speaker took up the question of the study of working men's homes about eight months ago, and in this time has developed several methods for the economical and rapid construction of working men's colonies. None of these colonies have as yet been constructed, but tenders have been submitted on the construction of approximately 4,000 houses. With the experience gained in the construction of a large number of manufacturing plants and other structures by unit methods the costs of these houses are figured with reasonable exactness. The estimates show that if the construction of these houses can be carried on as a continuing operation the cost of the reinforced concrete portions can be kept down to a surprisingly low figure.

It is my belief that under such conditions these houses, which will be sanitary, fireproof and permanent, consisting of reinforced-concrete walls, floors and roofs, can be constructed at a cost to compete successfully with the usual construction as ordinarily carried out. These conclusions are the results of investigations made in reporting on various houses prospects.

MEMORANDUM.

Concrete Pit Props.—In view of the shortage of timber for pit props, and the resultant high prices, the question of using concrete for that purpose came up at the annual meeting of the Midland Counties' Institution of Engineers, at Nottingham. A paper was read entitled, "A New System of Reinforcement, and Some Uses of Concrete and Cement in Mines." The paper was read by Mr. W. Marriott, M.Inst.C.E., of Melton Constable. Mr. Marriott, after personally visiting a Nottinghamshire colliery, said he came to the conclusion that if it were necessary to have yielding props, concrete props could be made so, by placing one end in a simple container, made of concrete, cast iron, or even steel, filled with clay, the latter to be made to exude, under pressure, through a small hole, or holes, in the base of the pedestal. The rate of shrinkage would be regulated by the size of the hole. He gave the results of a series of experiments.

An interesting discussion ensued, Mr. W. H. Hepplewhite, His Majesty's Inspector of Mines; Mr. G. Spencer, West Hallam, president of the institution; Mr. G. J. Bins, Duffield, and others taking part.



(Concluded from p. 583, October issue.)

By EWART S. ANDREWS, B.Sc.Eng., M.C.I.

FOLLOWING the chapter on "Strength and Composition of Cement Mortars," we have one upon "Proportioning Concrete," written by Mr. William B. Fuller, which does not appear to differ materially from the corresponding chapter in previous editions and still forms about the best treatment on the subject; this chapter is followed by chapters upon "Tables of Quantities of Materials for Concrete and Mortar," "Preparation of Materials for Concrete," "Mixing Concrete," and "Depositing Concrete."

An important chapter upon "Effect of Sea Water upon Concrete and Mortar" follows from the pen of M. R. Feret, whose principal conclusions are as follows:—

(1) No cement or other hydraulic product has yet been found which presents absolute security against the decomposing action of sea water.

(2) The most injurious compound of sea water is the acids of the dissolved sulphates.

(3) Portland cement for sea water should be low in aluminium and lime.

(4) Puzzolanic material is a valuable addition to cement for sea water construction.

(5) As little gypsum as possible should be used for regulating setting time.

(6) Sand containing a large proportion of fine grains must not be used.

(7) The cement and aggregate should be proportioned to give a dense and impervious concrete.

Following this we have three chapters on "Laying Concrete and Mortar in Cold or Freezing Weather," "Destructive Agencies," and "Water-tightness," respectively, these leading up to a chapter on the "Strength of Concrete."

Chapters of this type require a great amount of skill in preparation as they consist practically of the digest of a very large number of experiments extending over a wide ambit, and it is not at all easy to obtain the correct perspective on a large range of experimental results and to avoid dogmatising upon matters for which sufficient experimental evidence does not exist. We

* 885 pp. Published by Chapman and Hall, Ltd., London. Price 23s. net.

feel, somehow, that the authors of this book do tend a little to impress their own opinions upon the experimental facts, but they have given us plenty of the evidence so that we may draw our own conclusions if we wish. The question of water content of the concrete is receiving considerable attention now; from the authors' experiments it appears that 7 to 10 per cent. water content gives the best concrete for permeability and compressive strength. In dealing with the question of gravel *versus* broken stone concrete, the authors quote the usual experiments to show that the stone concrete is stronger than gravel concrete for the same proportions by volume. Mr. Johnson, of University College, Cork, has, however, shown that in 1 : 2 : 4 gravel concrete there is less cement than in the corresponding mix of stone concrete, so that the usual comparison is hardly fair on the gravel concrete.

The next chapter deals with the "Theory of Reinforced Concrete," and follows the ordinary lines of adapting the ordinary beam formulæ to the special conditions; the question of shear reinforcement we have already dealt with. Considerable stress is laid on the fact that "the elastic limit of the steel corresponds to the ultimate strength of the beam in tension." This, of course, is true in a general sense, but it requires some qualification. In many reinforced concrete beams there is a reserve of strength after the elastic limit, or, rather, the yield point of the steel has been passed and failure does not occur suddenly; this is one of the great advantages of the use of ductile steel as the reinforcement. In the theory of the stresses in chimneys the treatment developed by Messrs. Taylor, Glenday, and Faber, is followed.

A very important chapter on "Tests on Reinforced Concrete" follows, which contains a large amount of very useful test results and references to other authorities for more detailed information. We have previously acknowedged the difficulty in writing a chapter of this kind and think that the authors have succeeded very well. The information on pp. 446, 447 as to the width of slab over which concentrated loads may be regarded as spread, will be found of great assistance to practical designers. Prof. Morris's tests show that these widths are considerably greater than have commonly been allowed for, and can be expressed by effective width in feet $= \cdot 6$ span in feet $+ 1\cdot 7$. Useful information is next given on the analogous problem of the distribution of a load placed over one beam to parallel beams in the floor system.

The question of reinforced concrete design is next dealt with in a long chapter extending over 130 pages. This chapter we find rather disappointing when viewed from the point of view of the practical engineer who has actually to execute the design and superintend the preparation of the working drawings; it seems more like an extension of the chapter on theory of reinforced concrete and is written more from the point of view of calculations, such as might be given in a course of lectures at a college than from that of the actual difficulties arising in the drawing office. The slab formulæ on p. 487 should, we think, be further explained as to derivation or authority. On the question of double reinforcement an approximate method devised by Mr. Edward Smulski is given which certainly has the merit of simplicity, but which does not differ materially from the simplified methods which many designers have been in the habit of using; we do not find, however, any explanation of the fact that in many cases the application of these formulæ results in more steel being apparently required on the compression than on the tension side. Without any explanation of the fact that if the ordinary formulæ, based upon the compressive strength of the concrete, give this result, the whole of the bending moment can be resisted by the steel above, the inexperienced designer would soon be in difficulties. In the very scanty treatment on haunching the ends of beams to provide increased resistance to the reverse bending moments, no warning is given that the effective slope of the haunch for increasing the depth of the beam must not be taken as more than about thirty degrees, since the formulæ are based upon the assumption that there is no abrupt change in section or—to express it in more practical but less scientific terms—the stresses cannot work round a sharp corner. We would like also to see some note as to the fact that the cusp in the reverse bending moment diagram for a continuous beam becomes considerably rounded off if the supporting pillar or beam is a wide one.

Building construction is dealt with in the next chapter in a manner that is quite satisfactory, especially considering the authors have reached p. 606 before this chapter starts, and there are other matters demanding treatment.

The remaining chapters in the book deal with "Foundations and Piers," "Beam Bridges," "Arches," "Dams and Retaining Walls," "Conduits and Tunnels," "Concrete Pavements and Sidewalks," "Cement Manufacture," "Miscellaneous Structures," and "References to Concrete Literature."

In conclusion we would like to repeat that the book is an excellent one—so excellent that no structural engineer should be without it. Its very excellence has made us ask for more, and we have therefore made some criticisms in the hope of making the book better still. As Englishmen we admire the great amount of work that American engineers have done in developing the use of reinforced concrete and of attempting to place its design upon a scientific footing. We hope that the authors will not take amiss our suggestion that British engineers have also done something, and that some of their results and opinions might be given greater prominence in a book that has already established a strong position upon the bookshelves of British engineers.

CORRESPONDENCE.

Under this heading we invite correspondence.

COTTAGE BUILDING AFTER THE WAR. CONDENSATION ON CONCRETE, etc.

To the Editor, CONCRETE AND CONSTRUCTIONAL ENGINEERING.

SIR,—In a recent issue of CONCRETE the following phrase occurs in discussing the suitability of concrete for cottage building :—

" *Concrete, if made properly, is dense and non-porous, with the result that if it is used without proper provision for either insulation against changes of temperature or the absorption of moisture condensed upon the walls there will be objection on the part of the tenants.*"

This is a point which I find is overlooked by some users of concrete, for I have received many letters from architects and others asking my advice with regard to curing damp concrete or cemented walls, especially when situated in basements.

The writers have been puzzled because they cannot imagine how the walls can be damp in their various positions, and upon examination I have often found that condensation upon a cold surface, such as a cement surface, has been the sole reason for the moisture collecting on the surface of the wall and sometimes on the cement floor.

I have never found the following treatments to fail or to prevent condensation or sweating on interior walls :—

The use of a wood float if a cement finish is desired. This gives a granular surface. However, it is much better to plaster over the cement with lime-mortar, and this also prevents the alkali which exists in all cement from injuring the wall paper. The following specification is recommended :—

Float to a fair face with ordinary plasterer's lime and sand mortar (about three of sand to one of lime) lightly keyed (scratched) in the usual manner to receive the final setting coat. This to be left a day or two until strong pressure from the thumb leaves no impression, although it would be better if it were left seven to ten days. The finishing coat of lime putty, sand and plaster of Paris may then be applied with safety. The proportions depend on the quality of the lime, which varies in different districts. In some localities the following skimming is used. It gives a good finish, sets well, and works quickly :—

2 parts of lime putty or chalk lime.
1 part of washed sand.
1 part of plaster of Paris.

Existing cement work requires hacking and treating with spirits of salts to form a key and to give suction before applying the above.

With regard to a cement block being dense and non-porous, much depends on what the aggregate is composed of. If it is made of broken common red brick or coke breeze it will be very porous, but if it is made of granite chippings it will be practically non-porous, but not dependably damp-proof.

If I were making concrete blocks for cottage walls, and could use any aggregate I wished for, I would fill the concreting mould half full of a very porous aggregate, such as coke breeze or porous brick, and then I would finish with a non-porous aggregate and skim off with ¼ in. of Pudloed cement.

I should thus get a perfectly smooth face without ornamental irregularities, which hold rain and frost, and a dense outside thickness of concrete; while the inside of the block would be extremely porous. This porosity is of great benefit in two ways.

(1) It prevents condensation on the interior face of the wall.

(2) It gives a warmer room, because the warm air from the fire and the bodily heat given off by the occupants penetrates the minute interstices of the porous concrete, and is retained there for a considerable length of time.

Such heat easily penetrates the usual lime plaster with which these blocks are faced, but practically no heat generated in a house will penetrate a cement rendering or a non-porous cement block.

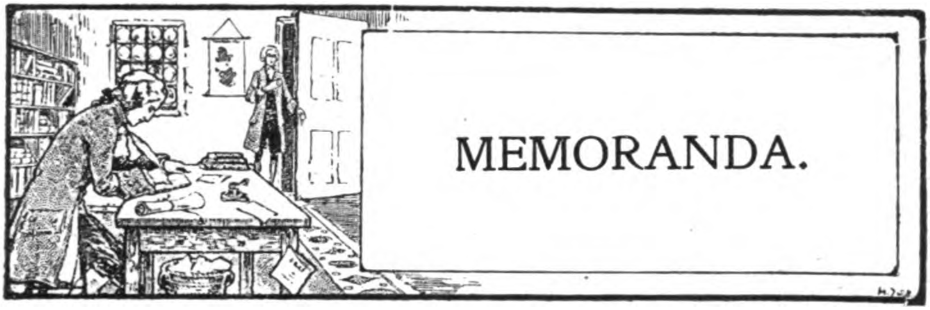
If great care is not taken in the building of concrete cottages there will be trouble with condensation, and that would be a pity, because the aggregate is so easily obtained from demolished buildings, and such houses are certainly made more weather-proof, hygienic and dry than any other kind of structure.

I have made and am making experiments at considerable expense with this end in view.

Yours faithfully,

King's Lynn.

J. H. KERNER-GREENWOOD.



Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

The Concrete Institute.—We have pleasure in giving below the programme of the Concrete Institute for its tenth session (1917-18), and when we remember how difficult it is to arrange meetings at the present time we think the Institute is to be especially congratulated on the interesting series of lectures that has been arranged for. As far as can be stated at the moment, the arrangements for the coming session are as follows:—

November 22nd, 1917 (*Thursday*), 5.30 p.m., eighth Annual General Meeting (seventy-fifth Ordinary General Meeting): Paper by Mr. J. N. Friend, D.Sc., on "The Corrosion of Iron and Steel, with special reference to Reinforced Concrete" (Lantern).—*December 20th* (*Thursday*), 5.30 p.m., seventy-sixth Ordinary General Meeting and Joint Meeting with British Fire Prevention Committee: "The Effects of Fire on Reinforced Concrete Buildings, as Demonstrated by some Recent Examples," by Mr. H. Kempton Dyson and Mr. Ellis Marsland (Lantern).—*January 24th*, 1918 (*Thursday*), 5.30 p.m., seventy-seventh Ordinary General Meeting: Paper by Mr. E. A. W. Phillips, M.Inst.C.E., etc., on "British Trade and the Metric System."—*February 28th* (*Thursday*), 5.30 p.m., seventy-eighth Ordinary General Meeting: Paper by Charles F. Marsh, M.Inst.C.E., etc., on "Criticisms of the London County Council Regulations Relating to Reinforced Concrete."—*March 21st* (*Thursday*), 5.30 p.m., seventy-ninth Ordinary General Meeting: Paper by Mr. H. L. Barraclough, on "Some Practical Points in the Design and Construction of Partitions."—*April 25th* (*Thursday*), 5.30 p.m., eightieth Ordinary General Meeting: Paper by Mr. J. H. Deane, M Inst.C.E., on "The Charterhouse Street Cold Stores of the Port of London Authority" (Lantern).

The meetings will be held in the Lecture Hall at Denison House, 296, Vauxhall Bridge Road (close to Victoria Station), Westminster, S.W.1.

The British Fire Prevention Committee (Winter Session).—The British Fire Prevention Committee commenced its Winter Session during October and has planned a certain number of testing operations for the coming spring, and the usual issue of its publications during the winter.

It has issued some of its usual Red Books on recent American fires, but some of the reports on fire preventive questions of the Committee that were prepared earlier in the year for the use of the authorities cannot be made available to the public during the war.

The Committee's service of fire "warnings" continues to be extended and there have been numerous re-issues during the past quarter, especially on matters relating to air raids, conservation of farm produce, hospital safeguards, and small petrol fires. New issues of notices have also been made in respect of storage of coal in bulk and on the treatment of burns under an up-to-date non-proprietary treatment.

Housing Problems After the War.—A course of six lectures is being given on the above subject by Professor S. D. Adshead, M.A., on Tuesdays, at 5 p.m., at University College. The first lecture was given on November 6th. Admission to the lectures will be by ticket only, to be obtained on application (enclosing a stamped addressed envelope), addressed to the Secretary, University College, London (Gower Street, W.C.1.).

Concrete Utilities Bureau.—A useful series of six pamphlets, dealing with concrete, has recently been issued by the Concrete Utilities Bureau, 6, Lloyd's Avenue, E.C.3. The bureau intends to publish other similar pamphlets from time to time, which may be obtained post free on application to the bureau. The first six booklets are entitled:—1. "Concrete: A Unique Building Material." 2. "Concrete: How it is Made." 3. "Concrete Tanks and Cisterns." 4. "Concrete Paths and Pavements, Kerbs and Gutters." 5. "Concrete Fence Posts." 6. "Concrete Floors, Feeding Floors and Footpaths." 7. "Concrete Poultry Houses and Piggeries."

Concrete Roads in Sheffield.—We have received a report from the City Surveyor's Department of the City of Sheffield for the year ended March, 1917, dealing with the work done by the Highway and Sewerage Committee. Referring to concrete roads the report states that:—

> The question of constructing roads with concrete surfaces is again being widely discussed, and thoroughfares of this character in other districts have been inspected.
>
> Considerable knowledge has been gained, but there is so far no convincing evidence that concrete roads pure and simple would be suitable for wide use in Sheffield.
>
> *In view of probable restrictions upon the use of other road-making materials, however, it may be necessary to adopt this system to a greater extent than otherwise would be thought advisable.*
>
> *Many of the asphaltic roads already laid in the City are practically of reinforced concrete,* depending for their strength entirely upon the concrete, but having a thin wearing surface of asphalte.

In a table appended to the report it is stated that some 14,546 super yards of asphaltic paving were laid during 1914, 1915, and part of 1916, and most of this was laid either on reinforced concrete or concrete, only a small proportion being laid on old macadam or on old granite sets.

A Concrete Boat in Scotland.—A London daily paper reports that a concrete boat, believed to be the first in Scotland, has been designed and built by Mr. James Bowman, plasterer, North Street, Montrose. It is 12 ft. long, 4 ft. 3 in. wide, and 2 ft. 8 in. deep. After the launch the boat, named *Excelsior*, was put on trial in the dock at Montrose.

A Reinforced Concrete Arched Keel Block—An arched keel block has been specially designed and patented by the Ayrshire Dockyard Company, Ltd., Irvine, N.B., with the object of overcoming the great difficulty experienced at present of obtaining wooden keel blocks. It is made of concrete, iron, whinstone, and sand, or other suitable material. The advantages claimed for it are as follows:—(1) Facility of construction. (2) Cheapness of construction. (3) Great strength. (4) Durability. With regard to facility of construction, all that is required is a wooden box of similar design to the block, so as to contain the proper mixture of cement, iron, sand, etc. The block can be made by one man in about an hour, and after being allowed to harden for several days, is ready for use. One of the chief advantages of the arched keel block is that it can be made for about one-third of the cost of wood. Even allowing for the present high price of cement, it is estimated that three arched keel blocks would not exceed the cost of one set of wooden blocks of similar height. Another feature of the design is that it combines great strength with lightness of weight. Particular attention has been given to the matter of strength, and a block has been tested to 90 tons without showing any sign of weakness. Further advantages of the arched keel block are that it will not deteriorate, is not affected by weather, and with care will stand for a long number of years.—*Engineer.*

An Appeal to Motor Lorry Owners.—A special appeal has been issued by the Earl of Cottenham, on behalf of the Motor Transport Volunteers, for motor lorries for conveying troops passing through London on leave. The Motor Transport Volunteer Corps was founded in February, 1916, by Sir John Lister Kaye and Commandant C. R. Freemantle, and some 500,000 troops have been assisted. The Army authorities supply the petrol, and all the officers and drivers of the Corps give their services. Offers of assistance should be addressed:—31, Walbrook, E.C.4.

PROPOSED WORKS.

Dublin.—Tenders have been invited during the month by the directors of the Midland Great Western Railway Co., of Ireland, for the complete renewal in reinforced concrete and steel of Newcomen and Summerhill Bridges, Dublin.

Southport.—The borough surveyor has prepared plans for a low retaining wall to surround the sea bathing lake and for the extension of the concrete bottom of the lake.

South Africa.—During the financial year ending March 31st next the South African Government intends spending £185,040 on harbour improvements.

British Guiana.—The Public Works Department, Georgetown, Demerara, contemplates the following new works, viz:—(1) The construction of 9,700 lineal ft. of reinforced concrete-faced earth dams, 3,000 ft. of reinforced concrete groynes, forming "koker" runs, and 750 lineal ft. of reinforced concrete groynes, required for the East Coast Demerara sea defence works. (2) Construction of 4,000 lineal ft. of reinforced concrete-faced earth dams, 2,250 lineal ft. of reinforced concrete groynes, and 3,000 lineal ft. of reinforced concrete groynes, forming "koker" runs for the West Coast sea defence works. (3) Construction of 1,650 lineal ft. of reinforced concrete-faced earth dams; 10,630 lineal ft. of reinforced concrete groynes forming "koker" runs, and 14,590 lineal ft. of reinforced concrete groynes for the Essequibo sea defence works.

Loddon Bridge.—The working of strengthening and widening Loddon Bridge near Reading (built in 1754), has just been completed by Messrs. Collier and Catley, of Reading, for the Berks County Council. The bars for the reinforced concrete were supplied by the Indented Bar Company.

Japan.—According to some notes which have been furnished by the British Consul at Tokio a company has been organised in Japan for the manufacture of concrete for reinforced concrete buildings and telegraph poles.

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DECEMBER 1917. VOL. XII. No. 12.

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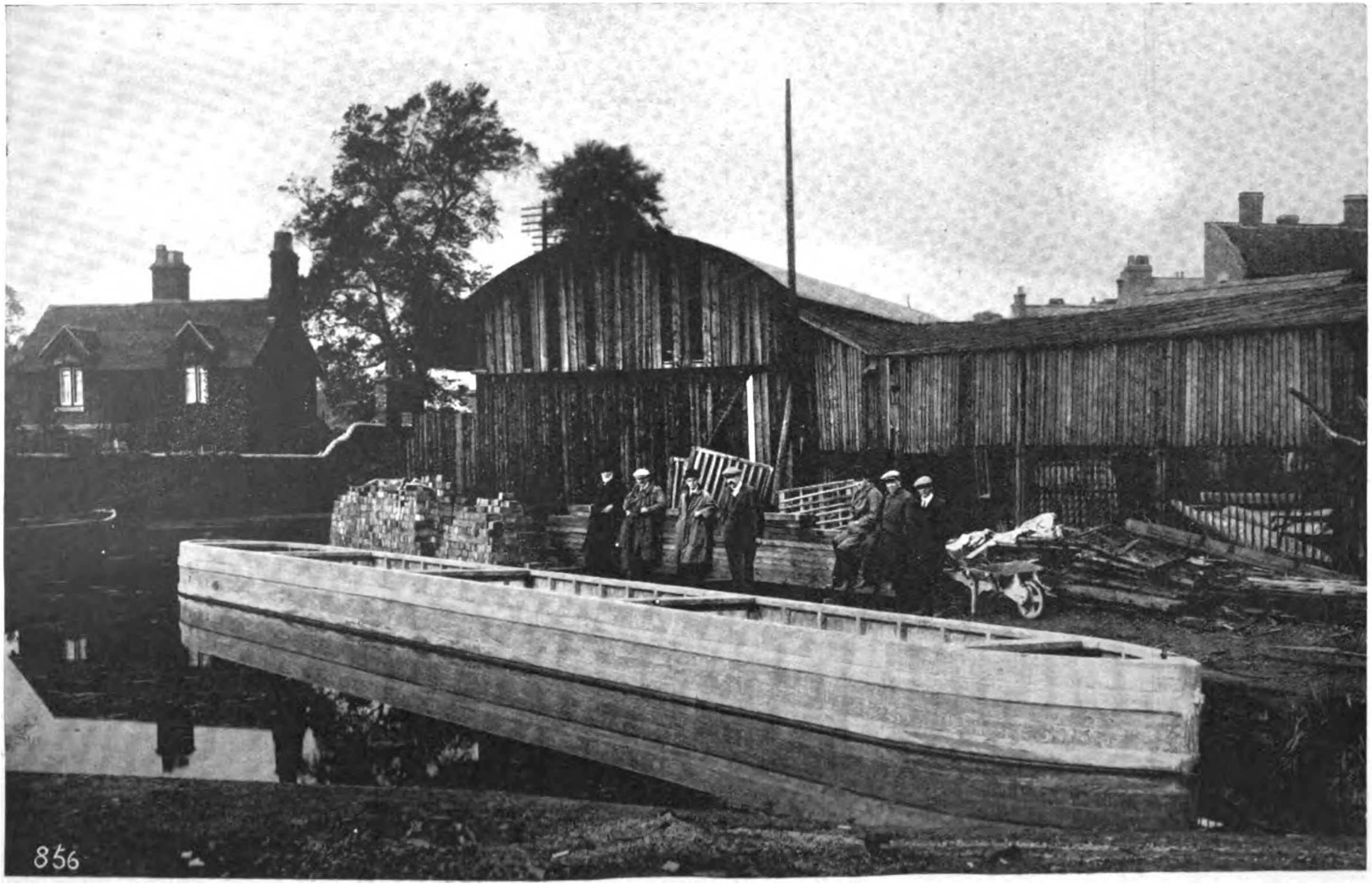


A Reinforced Concrete Barge.

(See p. 674 for description.)

CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume XII. No. 12. LONDON, DECEMBER, 1917.

EDITORIAL NOTES.

HOUSING OF THE WORKING CLASSES COMPETITION.

THE importance of providing suitable cottages for the working classes has now been fully realised by the Government, and steps are being taken as regards finance and general organisation which will facilitate erection on a large scale when conditions are favourable. A competition has been arranged by the Royal Institute of British Architects, who are acting for the Local Government Board, although we should have thought the competitions organised by various parties, including ourselves, would have sufficed for the provision of ideas. Substantial premiums are being offered for various types of cottage design, as will be seen on page 681 of this issue. The competitors are allowed a great deal of license, as one clause states that no regard need be paid to existing by-laws or local Act provisions, and this, if not "overdone," should be helpful as indicating what can be done if some of the existing restrictions are removed. As the Local Government Board are acting in conjunction with the Royal Institute of British Architects, we assume that this clause indicates a revision of the present by-laws at an early date if a good case can be made out against them, and we hope that this may be the outcome of the competition.

Another most important clause states that local materials, if reasonably obtainable, should be specified, but, owing to the serious shortage that at present exists in certain materials, competitors should consider and suggest the substitution of others with a view to facilitating and cheapening construction.

PLANNING.

The general arrangement and planning of any cottage is obviously a matter which is of primary importance, as the success of the scheme will be entirely dependent on this as far as the comfort and convenience of the occupants is concerned, apart from the fact that the initial cost will be greatly affected by the type of plan adopted. The essential points are: (*a*) Simplicity, (*b*) convenience from the housewife's point of view, (*c*) no waste space, and (*d*) due regard to the constructional possibilities of the materials to be used. These items are so obvious that there is no need to go into any detail with regard to them except in the case of the last mentioned, and in this item we mean that the walls should be arranged to give economical spans, chimney breasts should be planned with due regard to the supports below, openings and solids must be planned to give bearing for weight-carrying portions, and similar details must be properly considered if the plan is to be such as to allow of real economy in execution.

CONSTRUCTION.

The question of construction will be one which must entail much careful thought on the part of the competitor who conscientiously endeavours to give effect to the clause in the conditions which deals with the use of local materials and the question of substitution when necessary to facilitate and cheapen the work. There has been considerable discussion in the past as to the relative costs and suitability of various materials for cottage building, and the use of concrete has been steadily gaining in favour owing to its suitability and low cost, and although there were many advantages to be gained by its use in pre-war times, there are now even more striking features in its favour, which must result in its more extensive adoption. Let us consider for a moment some of the common materials used, in conjunction with the conditions which now prevail and which will continue for some considerable time after the war.

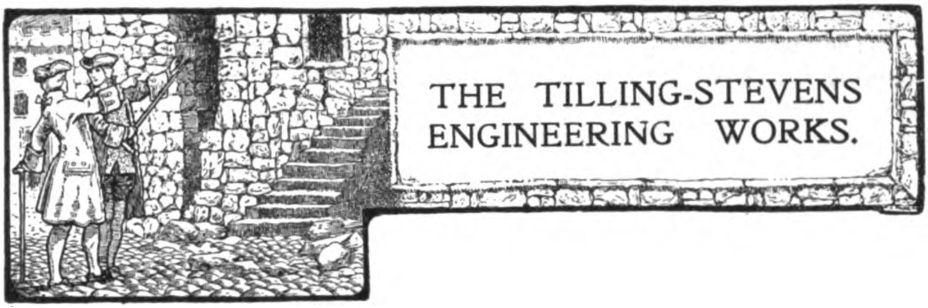
Timber has been extensively employed in the past, but its use on a large scale is now quite impossible in an economical structure. It is very expensive, the supplies are so limited as to render it almost impossible to obtain, it is of a poor quality, a large percentage being home-grown and unseasoned, and only small sections are available.

Ordinary clay bricks may be adopted to a certain extent, but it must be borne in mind that there is only a limited supply of these at the present time. Previous to the war many examples of cottage work were carried out in which it was definitely proved that a saving was effected by the use of concrete blocks as compared with brickwork, and as the cost of bricks has increased to a greater extent than in the case of concrete it will be obvious that the latter material has an additional advantage at the present time, where economy is of primary importance.

The remarks in connection with bricks will apply to a certain extent to clay tiles also, and concrete tiles can be used to give an effective roof at very low cost.

Steel and iron should be avoided in the construction generally, as it is quite unnecessary when the loads are light. A limited amount can sometimes be advantageously used for reinforcing floors where concrete is adopted in place of timber joists.

Concrete.—The last and most important material to be considered is concrete, and here we find none of the disadvantages which obtain with the other materials referred to. In the first instance the bulk of the materials required for its manufacture can be obtained locally, and thus transport avoided, and there is no question of the supply being limited, as coarse aggregate and sand can be got in abundance, while Portland cement manufacturers are capable of meeting all demands. The best type of construction for the walls is that consisting of two leaves of concrete blocks each 4½ in. thick, built with a 2-in. cavity, as this ensures a dry dwelling, and no trouble will be experienced with condensation of moisture on the inside surfaces. Concrete floors, steps, sills, lintels, tiles, and gateposts can all be used with the minimum of expense and the maximum durability, and by the extensive application of one material in that manner full advantage can be taken of machines and plant installed in connection with the wall construction, and thus reducing the initial cost to a minimum. Delay will be avoided by the use of concrete, and every competitor is urged to seriously consider its possibilities when specifying the method of construction.



THE TILLING-STEVENS ENGINEERING WORKS.

By ERNEST G. W. SOUSTER, A.R.I.B.A.

THE chief activity of the building trade during the war has been expended in the erection of factories and temporary buildings for war purposes; and concerning the former it may be said that the whole question of factories and industrial buildings has been approached from a new point of view.

Previous to 1914, with very few exceptions, any structure of four walls pierced with a few openings for windows was considered good enough, and the provision of canteens, medical and rest rooms, etc., were Utopian considerations, very interesting to be discussed by extensions lecturers or settlement workers, but having little effect on the employer of labour.

To-day this is changed, and every factory of any standing is installing welfare departments, and the building owner is consigning his old-fashioned ideas to the scrap heap.

He is beginning to realise that the cost of providing sufficient artificial light, and the muddle due to defective organisation, due to out-of-date buildings, must have added a considerable percentage to the cost of the goods turned out, and the speeding up of production and the increase of accommodation caused by the huge orders placed by various Government Departments is forcing him to see that modern buildings are a necessity.

Externally, also, the modern factory is a great advance on the old, for when money was spent on the elevations it was generally wasted on useless, fussy, or so-called architectural details. A factory should not appear pretty; its appearance should convey its use; it should be well proportioned and pleasing to the eyes. An architect who is a good designer obtains the architectural effects by proper treatment of the requirements, not by misplaced ornamental detail.

The factory here illustrated is a worthy example of the modern manner, for all the main lines arise naturally from the constructions, and by concentrating on the supporting piers of the structure an astylar architectural character has been given to the whole composition. (See *Fig.* 6.)

Figs. 1 and 2 show the general lay-out of the whole building, from which it will be seen that it is planned on the unit system. As will be readily realised, great economy of construction is effected by keeping all bays similar, and in the future use of the works all shafting can be standardised and made interchangeable.

The building stands on a site between the public road and a river, thus allowing the possibility of using both land and water transport. A roadway passing over a weighbridge runs along one side to the whart at rear, and a large bay is provided for unloading, abutting upon the receiving department.

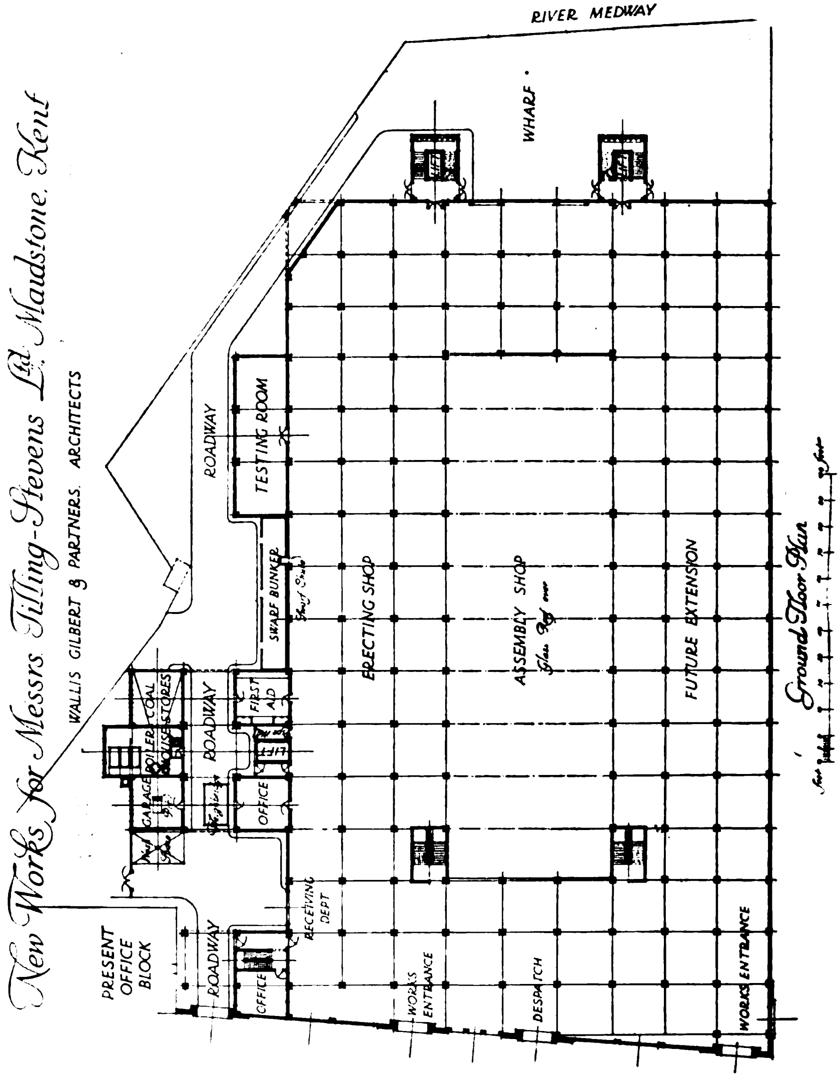


Fig. 1.

The coal stores, boiler house, and a private garage are placed at one side of this roadway, and offices, lift, etc., on the side abutting the factory. On the first floor these, together with the roadway, are carried up as adjuncts to the main block, and on alternate floors serve as first aid rooms, rest rooms for women, and lavatories for both sexes.

The general disposition of the factory block is as follows:—

Ground Floor.—Receiving, testing, and despatch departments, with time-keeper's offices, etc. These take but a small proportion of the whole, and the remainder is occupied by assembly shop.

First Floor.—Fitting shop and lavatory annexe.

Second Floor.—Partial assembly shop, appropriated stores, etc.

Third Floor.—Machine shop and lavatory annexe.

Fourth Floor.—Machine shop and mess rooms.

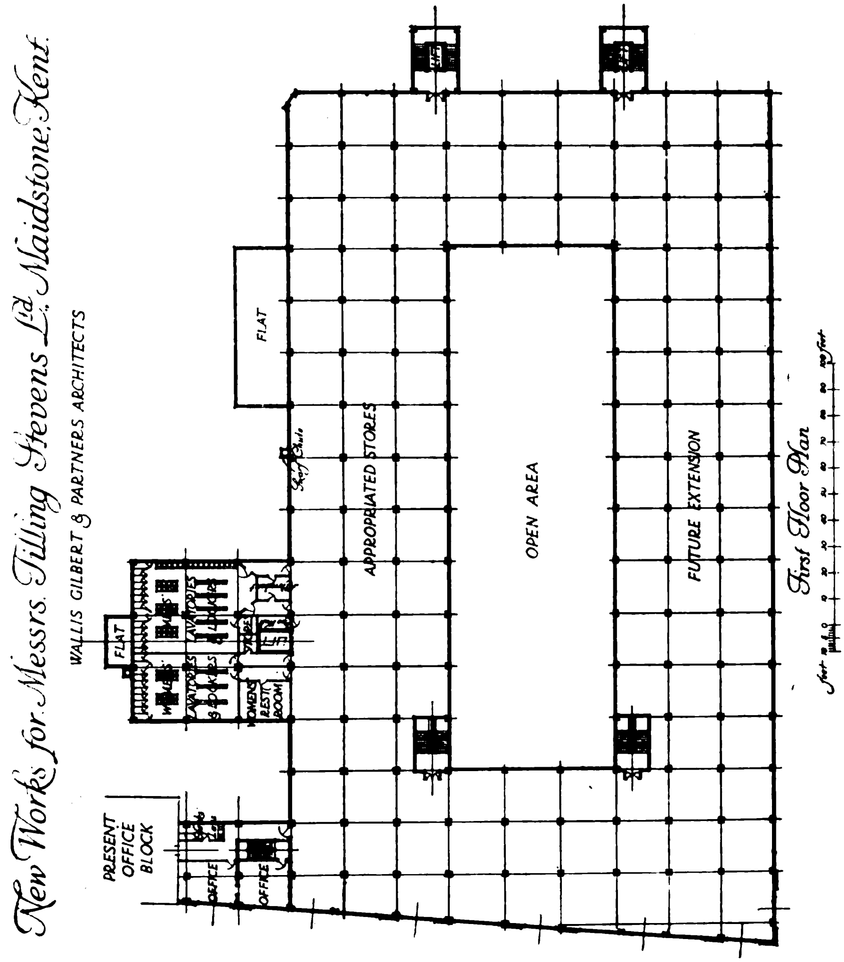


FIG. 2.

In all floors shafting brackets have been formed during the reinforced construction, and beams have been arranged so that the pulley wheels are close up to the underside of the floors, in order to give as much clear headroom as possible.

The heating is on the low-pressure hot-water system, by Messrs. Norris and Co., St. Andrew's Hill, Queen Victoria Street, E.C. All pipes run in a duct formed of reinforced concrete below finished surface of floor. These pipes are connected at each floor level with the rising mains, which run up to the pipe shaft next to the main lift.

A reference to the elevation shows that the maximum daylight lighting has been provided, and whatever artificial light is required will be by electricity.

Ample staircases are provided, and, as will be seen from the plan, the employees have three alternative means of escape should a fire break out at any point in the building.

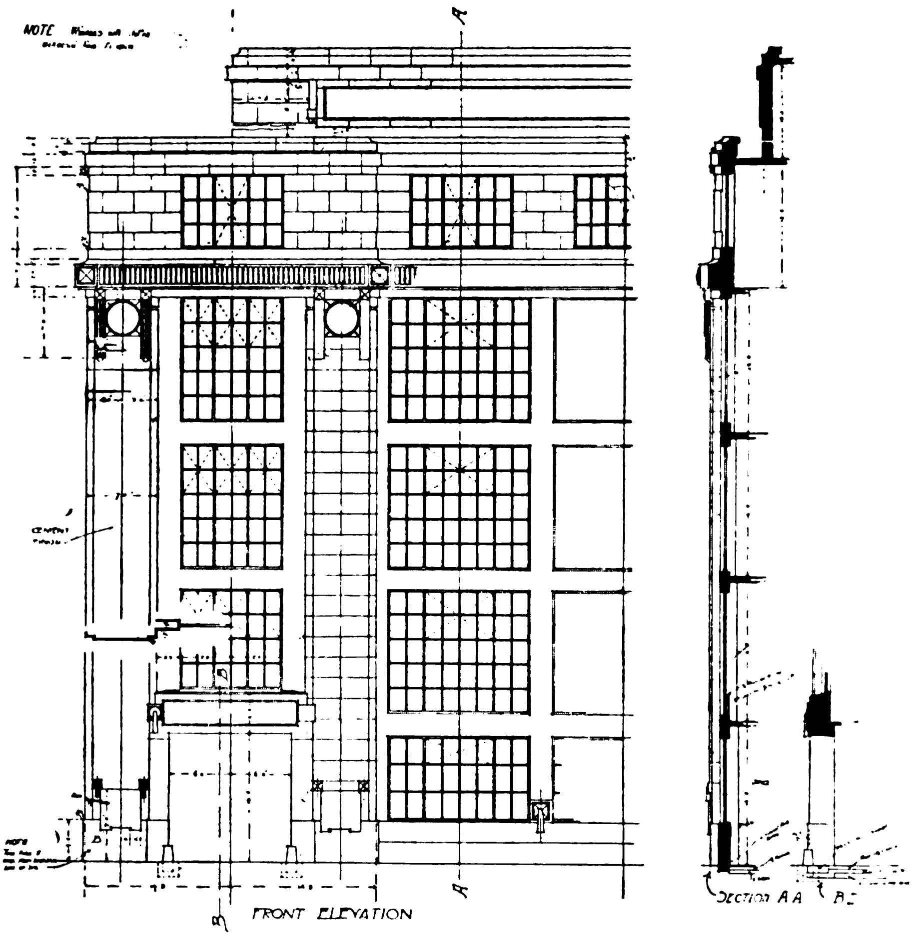
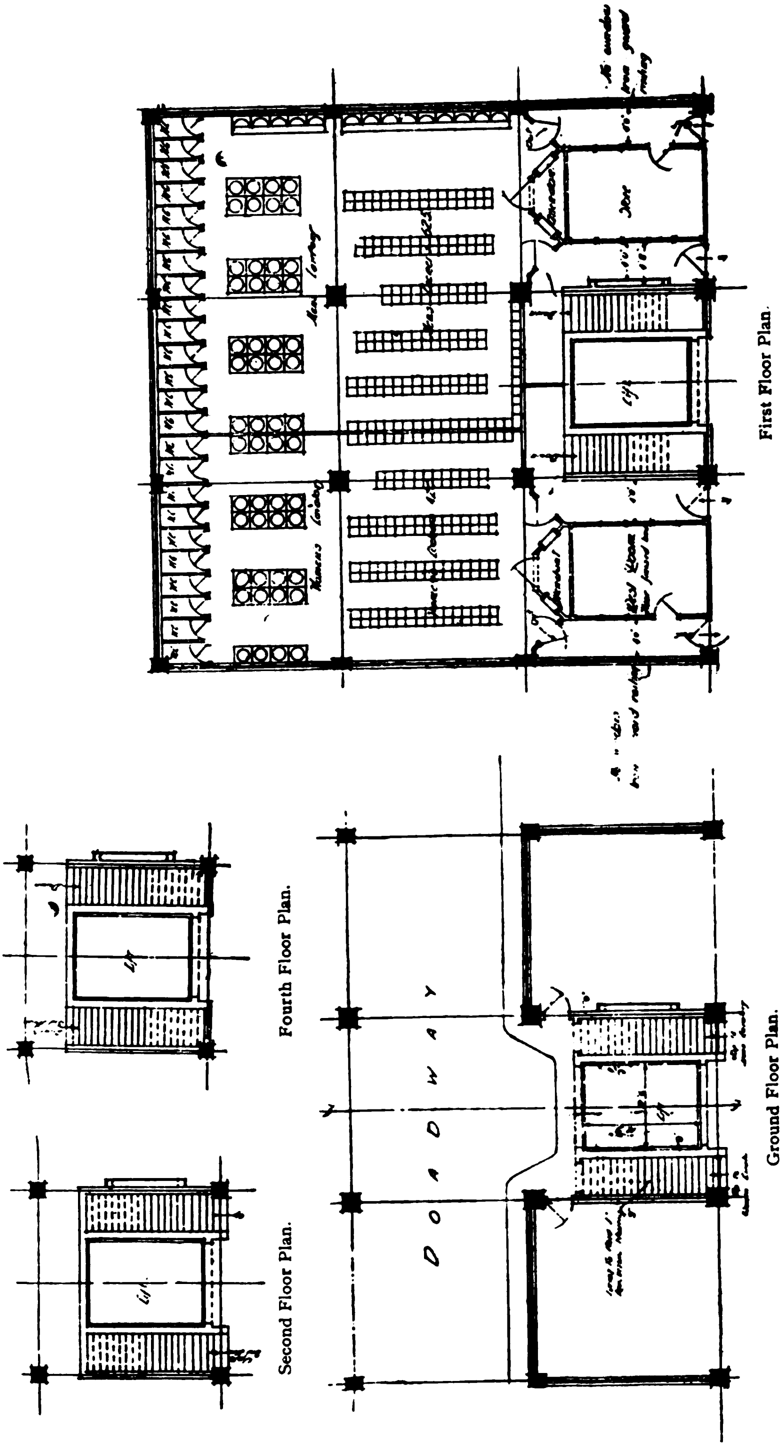


FIG. 3. THE TILLING-STEVENS ENGINEERING WORKS.

All lavatory walls are covered with white glazed tiles, and great care has been taken to make the sanitary arrangement scientifically up to date. Messrs. Dent and Hellyer, of 35, Red Lion Square, London, are the contractors for this work.

The cost of the portion of the building now erected works out at but 6d. per foot cube, this figure including heating, lighting, and everything necessary for completion.



First Floor Plan.

Fourth Floor Plan.

Second Floor Plan.

Ground Floor Plan.

Fig. 4. Plans of Lavatory Bay, The Tilling-Stevens Engineering Works.

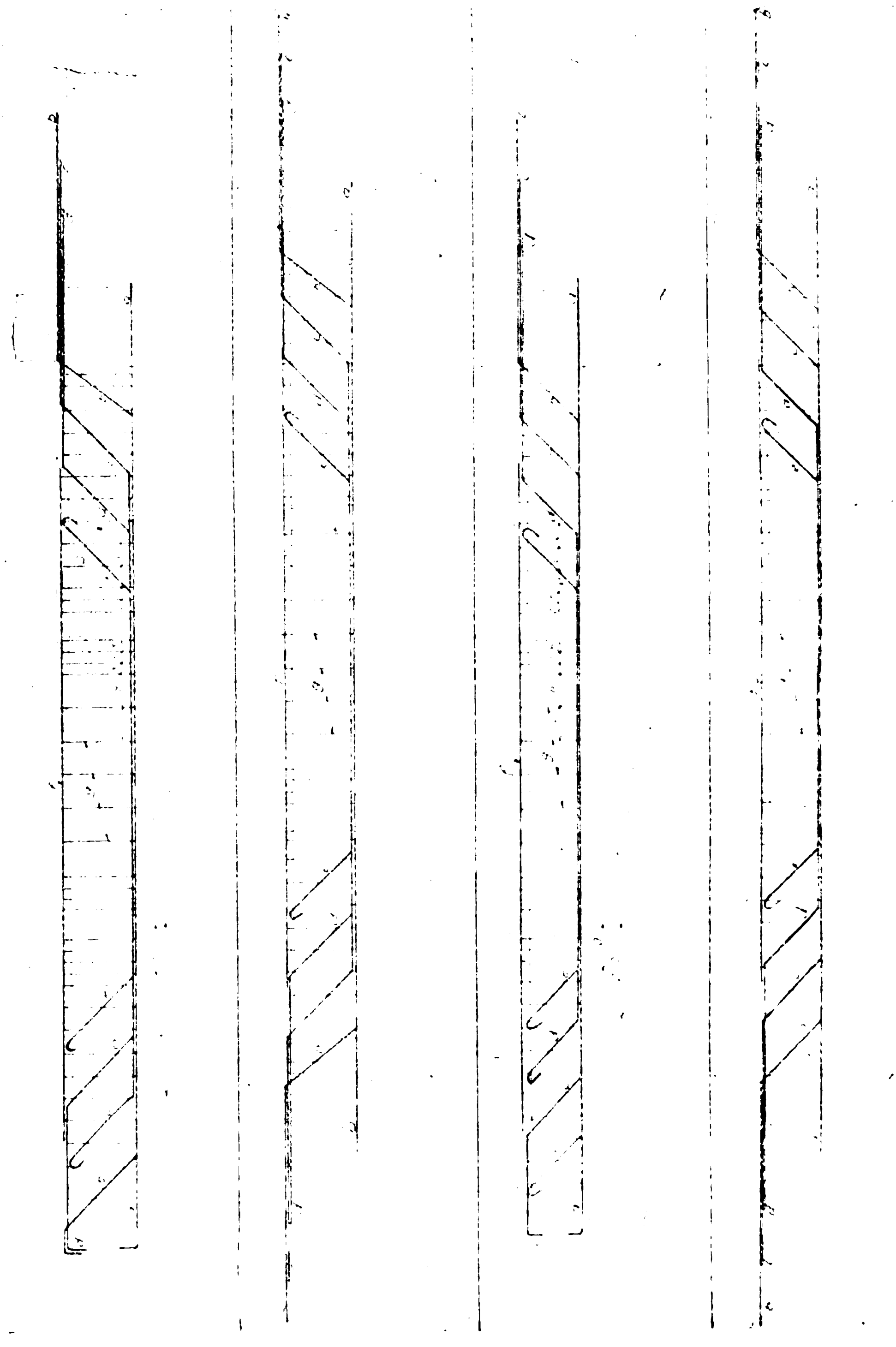


Fig. 5. Details of Beams.
The T[illegible] Engineering Works.

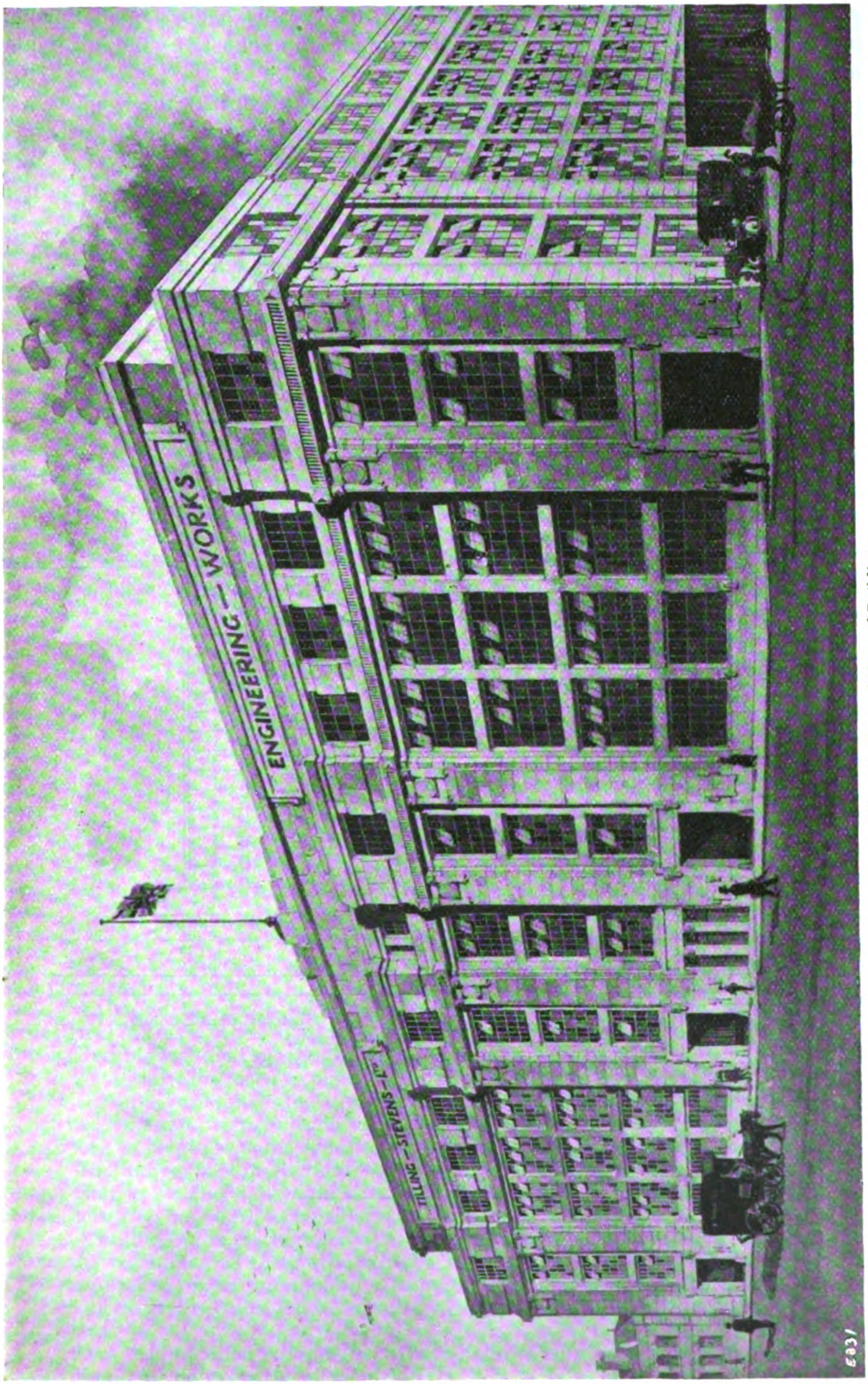
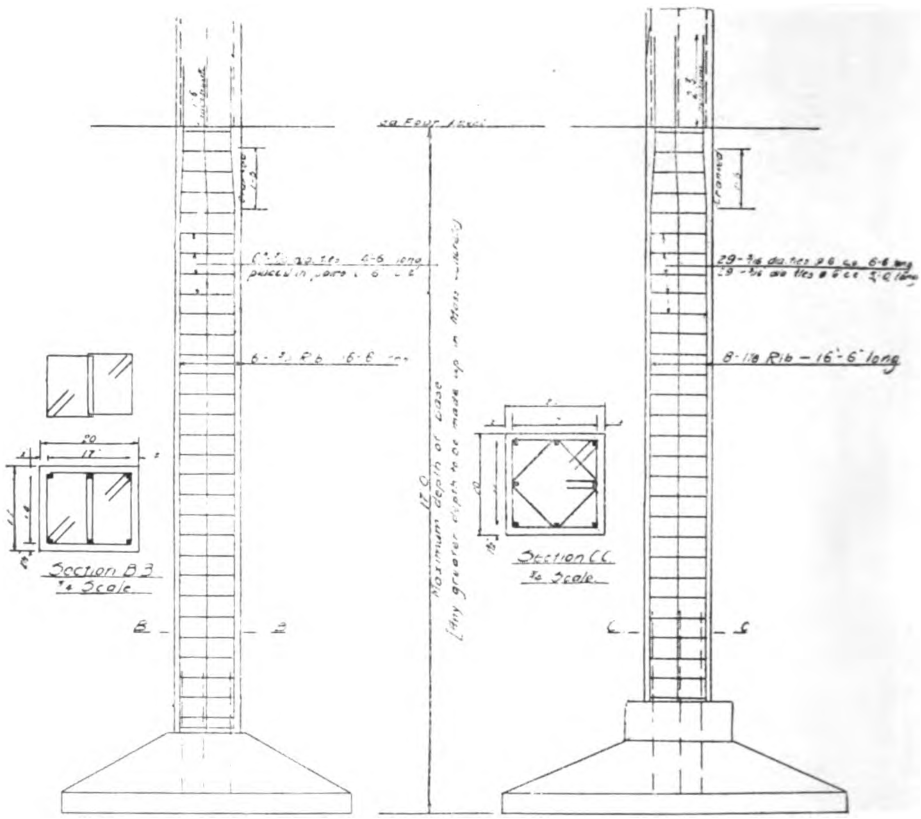


Fig. 6. General View of Building.
THE TILLING-STEVENS ENGINEERING WORKS.

The architects for the building are Messrs. Wallis, Gilbert, and Partners, of Caxton House, Westminster, who have made an exhaustive study of modern industrial buildings.

The Trussed Concrete Steel Co., Ltd., have designed the whole of the reinforced concrete construction, and the general contractors for the works are Messrs. Patman and Fotheringham, Park Street, Islington, N.1.



External Column. Internal Corner Column

Fig. 7. Typical Details of Columns.

THE TILLING-STEVENS ENGINEERING WORKS.

RESEARCHES ON REINFORCED CONCRETE BEAMS

With New Formulæ for Resistance to Shear.

By OSCAR FABER, D.Sc., A.M.Inst.C.E., etc.

Continued from September issue, p. 516.—ED.

PART V.

(*Concluded.*)

(*e*) *Results and Conclusions.*

Comparing the observed ultimate loads from *Figs.* 68-83 with the safe loads as calculated by R.I.B.A. rules we have—

Beam Number.	Safe Shear R.I.B.A.	Safe Load.	Ultimate Load.	Factor of Safety.
1a	960	1,920	6,635	3·5
b	,,	,,	8,630	4·5
2a	2,130	4,260	11,220	2·6
b	,,	,,	11,640	2·7
3a	1,650	3,300	10,620	3·2
b	,,	,,	14,220	4·3
4a	2,820	5,640	—	—
b	,,	,,	19,620	3·5
5a	960	1,920	8,635	4·5
b	,,	,,	13,610	7·1
6a	2,130	4,260	14,730	3·5
b	,,	,,	20,730	4·9
7a	2,240	4,480	10,030	2·3
b	,,	,,	20,730	4·6
8a	3,410	6,820	16,730	2·4
b	,,	,,	23,815	3·5

It will be noticed that there is considerable variation in the factor, the limits being 2·3 and 7·1.

Although the mean factor is about what it should be, some beams if designed in this way are distinctly dangerous (2*a*, 2*b*, 7*a*, 8*a*), while 5*b* involves considerable waste of material.

As has already been explained, the agreement, such as it is, is due to the fact that the resistance due to diagonal tension of the concrete assumed to act in all beams, though actually not existing at rupture in most of them, happens to be of the same order as the resistance to inclined compression.

The danger lies in the fact that for longer beams this would not be so, and that in 7*a* and 8*a*, where the inclined compression has to be neglected, the factor 60 *ba* is still assumed to act.

A failing of the method is that it gives no value to the haunch for increasing the resistance to shear (though the R.I.B.A. would take it into account in calculating reverse moments), although it is obvious from the tests that they have great value, the *b* results always being much higher than the *a* results.

Only the inclined compression theory shows why this is so, and enables this factor to be properly allowed for.

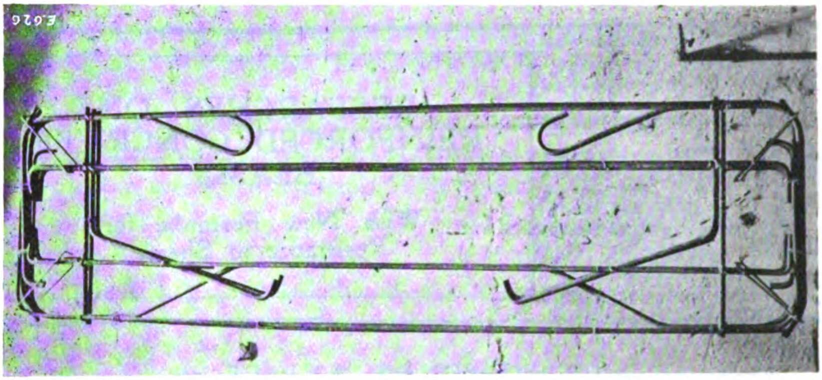


Fig. 84

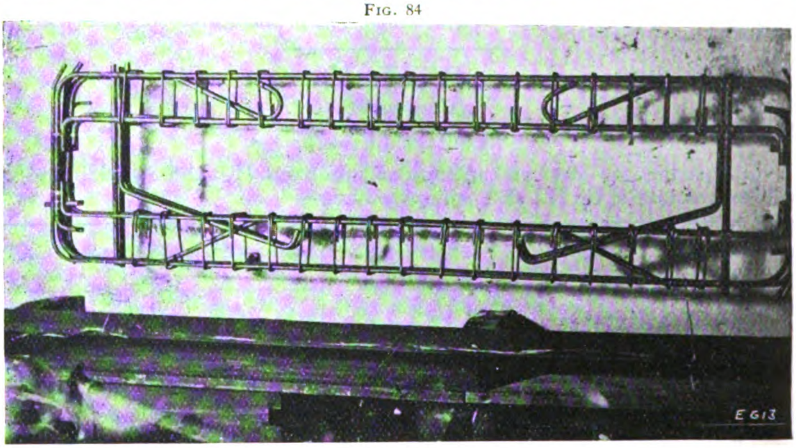


Fig. 85.

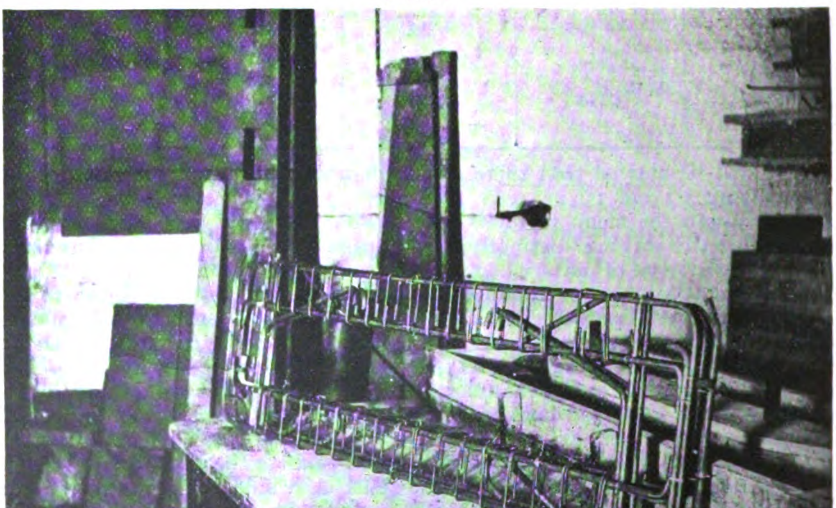


Fig. 86.
Researches on Concrete Beams.

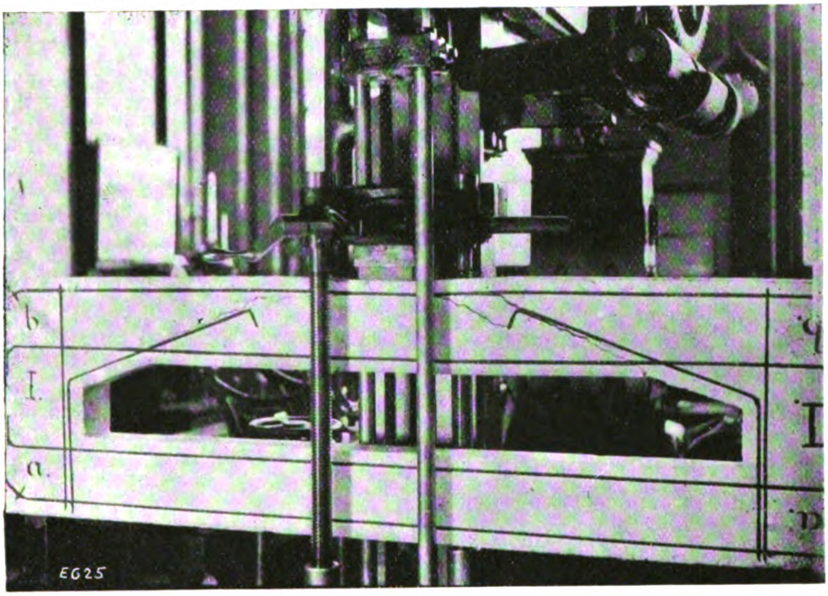


Fig. 87.

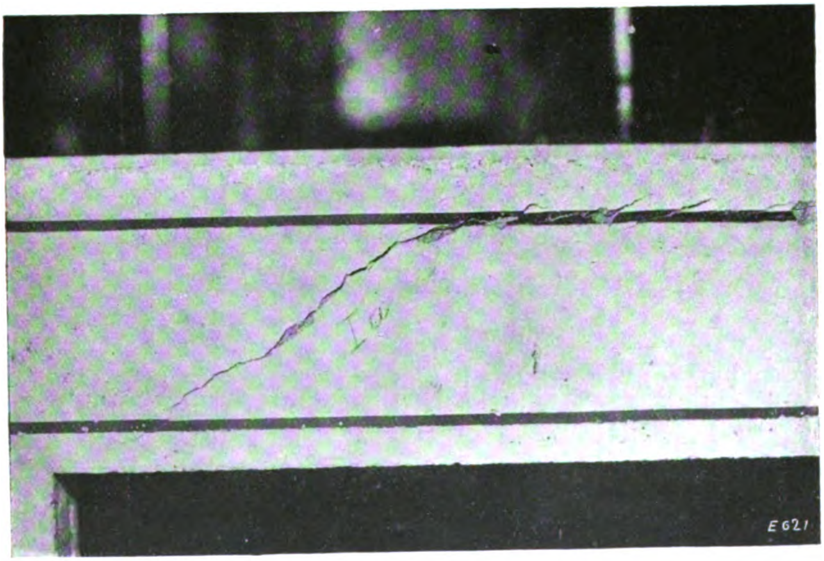


Fig. 88. Beam 1*a*.

Researches on Concrete Beams.

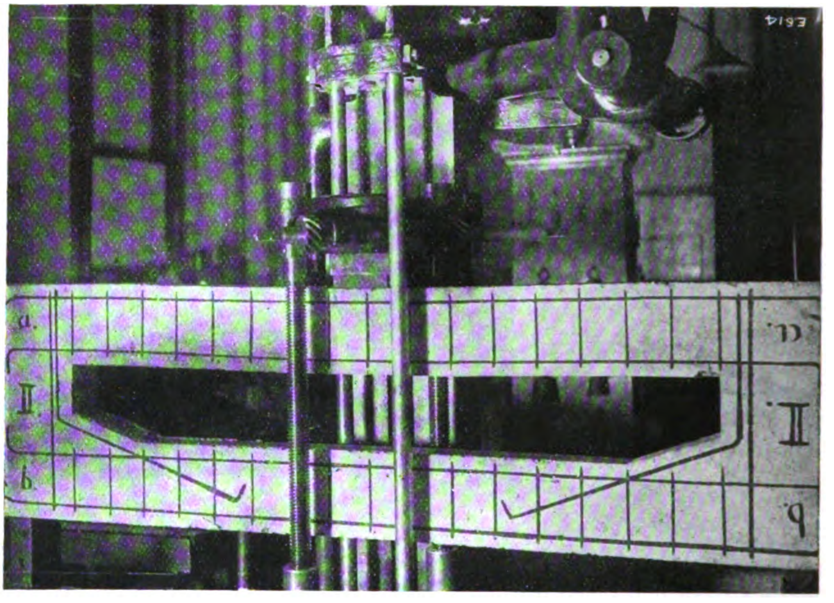


FIG. 89. BEAM 2*a*.

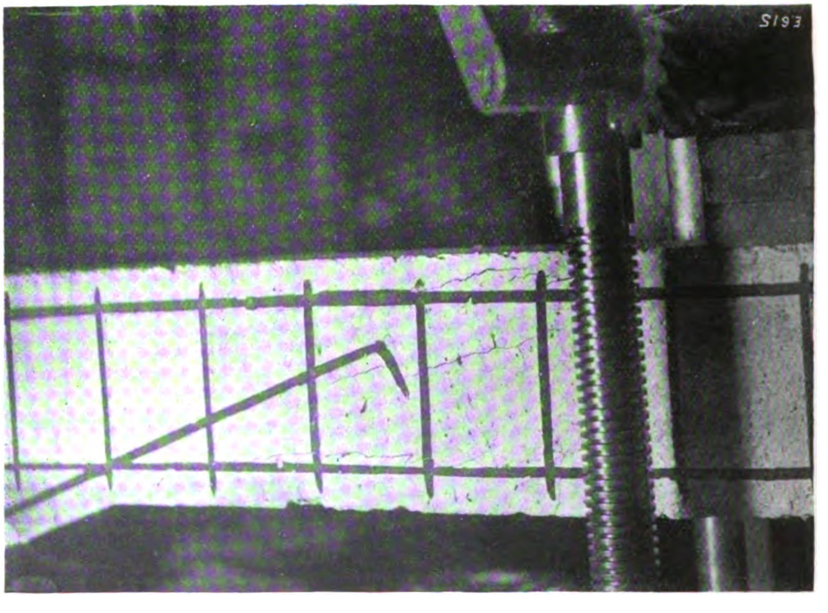


FIG. 90. BEAM 2*b*.

RESEARCHES ON CONCRETE BEAMS.

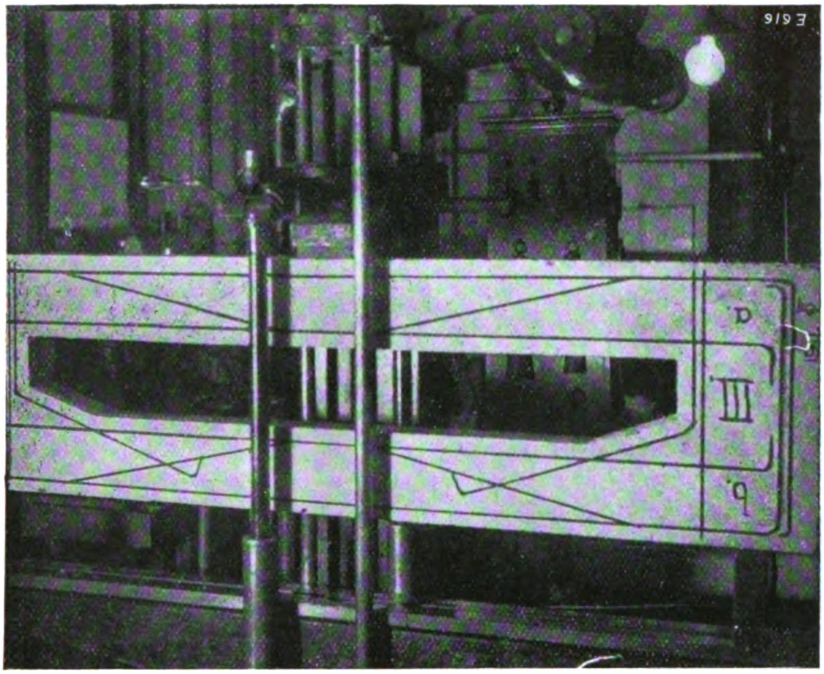


FIG. 91. BEAM 3*a*.

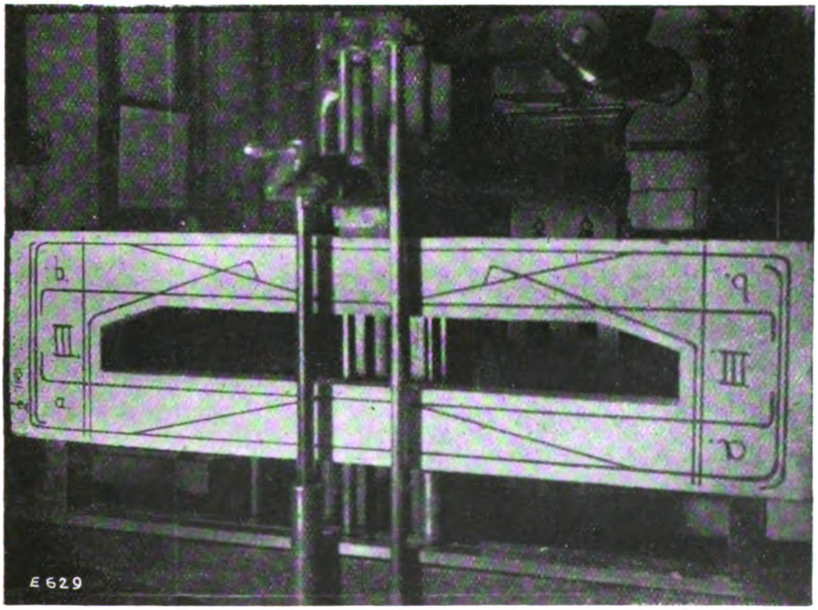


FIG. 92. BEAM 3*b*.
RESEARCHES ON CONCRETE BEAMS.

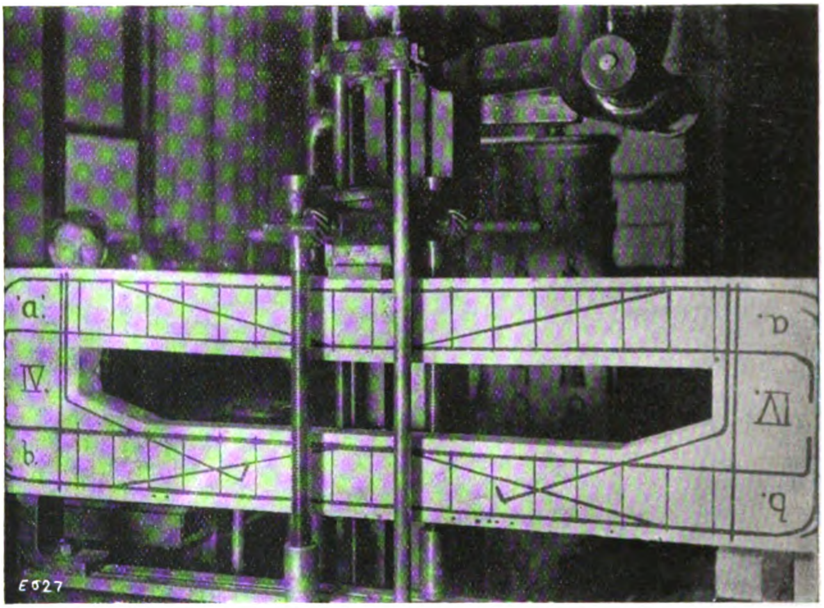


FIG. 93. BEAM 4*a*.

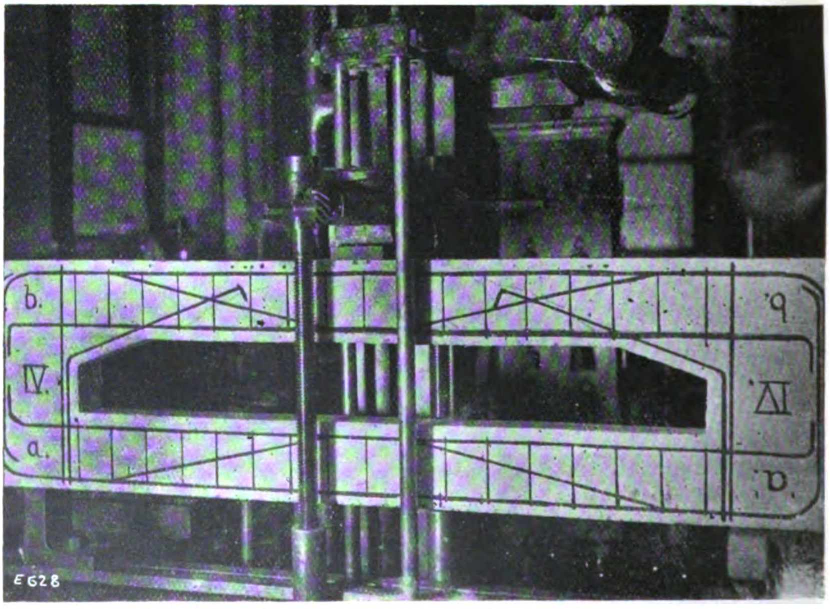


FIG. 94. BEAM 4*b*.

RESEARCHES ON CONCRETE BEAMS.

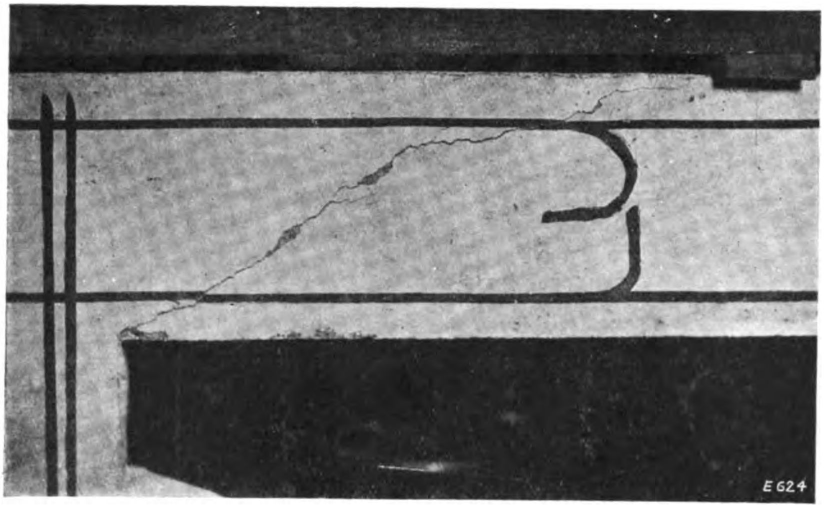


FIG. 95. BEAM 5*a*.

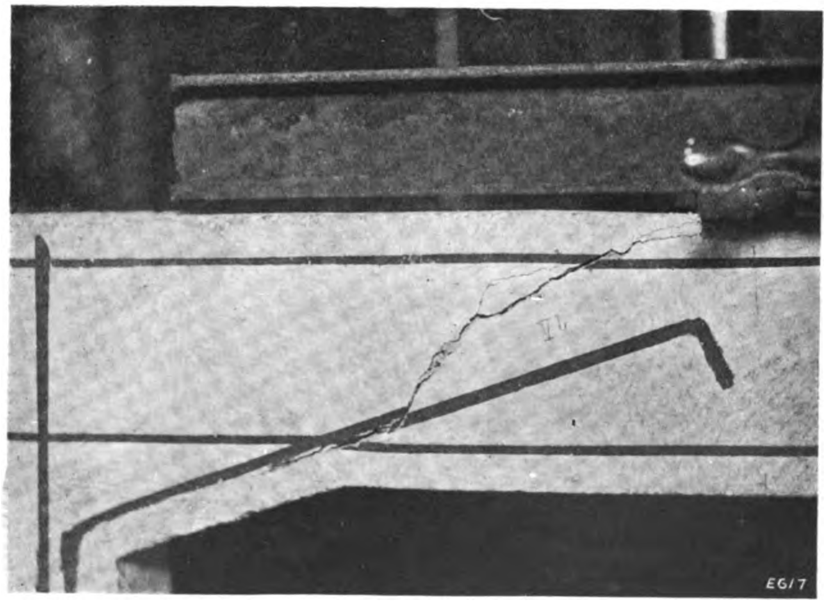


FIG. 96. BEAM 5*b*.

RESEARCHES ON CONCRETE BEAMS.

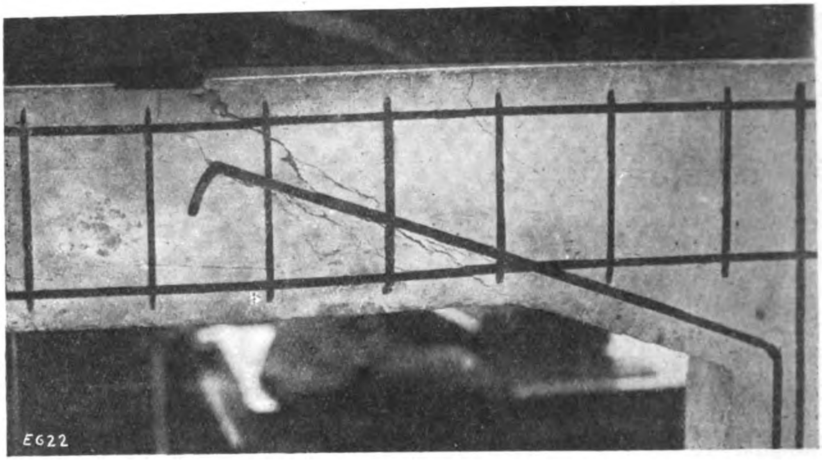


FIG. 97. BEAM 6*b*.

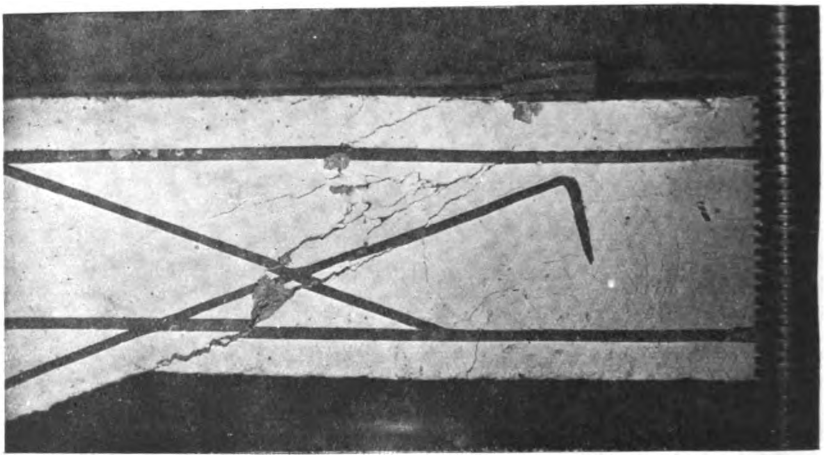


FIG. 98. BEAM 7*b*.

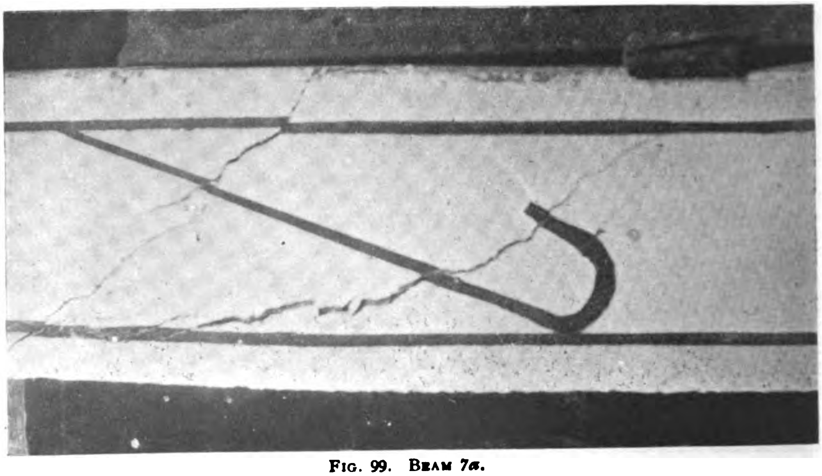


FIG. 99. BEAM 7*a*.
RESEARCHES ON CONCRETE BEAMS.

Comparing now the observed ultimate loads with the safe loads as calculated by L.C.C. rules we have—

B am Number.	Safe Shear L.C.C.	Safe Load.	Ultimate Load.	Factor of Safety.
1a	960	1,920	6,635	3·46
b	,,	,,	8,630	4·50
2a	1,170	2,340	11,220	4·8
b	,,	,,	11,640	5·0
3a	960	1,920	10,620	5·53
b	,,	,,	14,220	7·40
4a	1,860	3,720	—	—
b	,,	,,	19,620	5·3
5a	960	1,920	8,635	4·5
b	,,	,,	13,610	7·1
6a	1,170	2,340	14,730	6·3
b	,,	,,	20,730	8·8
7a	1,280	2,560	10,030	3·9
b	,,	,,	20,730	8·1
8a	2,450	4,900	16,730	3·4
b	,,	,,	23,815	4·8

It will be seen that while all the beams give a good factor if calculated by the rules, they very often lead to a great waste of material, factors of 7·4, etc., being quite unreasonable and wasteful.

Comparing now the observed ultimate loads with the safe loads, as calculated by the writer's inclined compression theory, we have—

Beam Number.	Inclined Compression		Ultimate Load.	Factor of Safety.
	Safe Shear.	Safe Load.		
1a	675	1,350	6,635	4·9
b	900	1,800	8,630	4·8
2a	1,680	3,360	11,220	3·3
b	1,850	3,700	11,640	3·2
3a	1,285	2,570	10,620	4·1
b	1,490	2,980	14,220	4·8
4a	2,293	2,586	—	—
b	2,440	4,880	19,620	4·0
5a	1,080	2,160	8,635	4·0
b	1,800	3,600	13,610	3·8
6a	1,988	3,976	14,730	3·7
b	2,530	5,060	20,730	4·1
7a	1,280	2,560	10,030	4.0
b	2,700	5,400	20,730	3·8
8a	2,130	4,260	16,730	3·9
b	3,430	6,860	23,815	3·5

It will be seen that the factors are sensibly constant, the limits being 3·2 and 4·9, and are of the right magnitude, the average being 4·0.

None of the beams calculated by this method are either wasteful or dangerous, although as great variation of reinforcement occurs as could ever be met with in practice.

It will be noticed also that exactly the correct value is given to haunches, since the factors of the *b* beams are the same as those of the *a* beams, both for single loading (Beams 1-4) and for two point loading (Beams 5-8).

It will be seen that the theory gives exactly the correct value to the inclined bars of 7*a* and 8*a*, which are not properly dealt with by any other analysis.

Both the results of the tests and the inclined compression theory show how desirable it is that inclined bars should be continued along the beam, the theory indicating that this is particularly the case when inclined to a small angle with the horizontal.

ANNUAL GENERAL MEETING.

The following is an Abstract from the Annual Report of the Concrete Institute presented at its Annual General Meeting, which was held on November 22nd.—ED.

A SUMMARY OF THE REPORT OF THE COUNCIL.

THE present membership of the Concrete Institute is 978.

The decrease in membership is attributable to the war; a considerable number of members of the Institute are serving with the Forces.

The finances of the Institute are shown in the balance-sheet which accompanied the Report.

Owing to War conditions the number of general meetings has been reduced, and the educational lectures and the informal meetings of junior members have again been abandoned for the Session. Such educational work will be resumed as soon as it is possible to do so.

Award of the Institute Bronze Medal.—As the result of a ballot among members of the Council, the bronze medal for the best paper read in 1915-16 Session was awarded to Dr. Oscar Faber, D.Sc., etc., for his paper entitled, "Shearing Resistance of Reinforced Concrete Beams."

Scientific Research.—In the previous Annual Report it was stated that the Institute, in response to a request from the Advisory Council appointed by the Committee of the Privy Council on Scientific and Industrial Research (now established as the Department of Scientific and Industrial Research), had submitted a scheme of Research on Concrete and associated materials, and that a number of meetings of the Committees of the Institute had been held in connection therewith, and that deputations had waited upon the officers of the Research Council to place details before them.

A scheme was eventually formulated for the undertaking of tests on the properties of various local sands and coarse materials and concretes made therefrom. A Joint Committee was appointed consisting of the Science Standing Committee of the Institute and representatives of the various technical institutions, who were willing to co-operate by undertaking tests in their laboratories and with their staffs. The Committee has been further strengthened by the addition of the following representatives of various Government Departments and Societies:—

War Office—Major-General Sir G. K. Scott-Moncrieff, K.C.B.; *H.M. Office of Works*—Mr. J. H. Markham; *Institute of Builders*—Mr. G. M. Burt.

A programme was duly drawn up, and an application was made for a grant for the first year's work. The Institute has undertaken to bear the cost of printing the results of the research, and the management of the scheme is in the hands of the Science Committee acting under the Council of the Institute. The Institute expressed its willingness to appeal to the technical public for contributions to the research fund, but thought it best to defer such appeal until after the war. The

Research Council agreed with this, and has made a grant of the £830 required for the first year's work. Some delay in starting was caused by the difficulty of obtaining the necessary apparatus owing to the war, but a number of laboratories have now begun work.

Full details of the scheme will be published when the results of the research are reported to the members, but briefly the scheme is as follows:—Concretes will be made from a variety of aggregates mixed in the familiar proportions of 1 : 1½ : 3 and 1 : 2 : 4. Others will be made equally rich in cement, but with the proportions of sand to stones varied. These concretes will be tested for strength, permeability and other properties. In this way it is hoped to discover not only the relative value of various aggregates, but also the most advantageous way of using them.

The following were appointed as delegates on a special Commission formed by the British Fire Prevention Committee to conduct an inquiry into the fire resistance of certain structural materials:—Mr. D. B. Butler and Mr. H. D. Searles-Wood.

The Architect and the Reinforced Concrete Specialist.—The Special Committee which was appointed to consider and report on the relations between the architect and the reinforced concrete specialist and structural engineer made a report to the Council, which was forwarded to the Royal Institute of British Architects.

Examinations.—The first examination of the Concrete Institute has been deferred until after the war.

Educational Facilities for British Prisoners of War.—Professor Henry Adams, the Superintending Examiner of the Institute, has been appointed to represent the Institute at a Conference of Examining Bodies, held at the Board of Education, to deal with educational facilities for British Prisoners of War. The Conference has drafted the following statement:—

"Realising that many British Prisoners of War abroad have made great efforts to pursue systematic courses of study, and that arrangements are in existence for recording the work done by them and in some cases for examining them, the following bodies are prepared to recognise in a liberal spirit any work done or examinations passed by such prisoners while in captivity, and also, in cases where such prisoners on their return home may apply for examination, to arrange so far as practicable and consistent with educational effectiveness to examine them without delay and in a manner suited to their circumstances." The Council has stated that the Concrete Institute is willing to act in the manner suggested.

Steel Frame Buildings.—The Conference which was convened by the District Surveyors' Association to consider the interpretation of the L.C.C. (General Powers) Act, 1909, with reference to steel frame buildings, and on which the Institute has representatives, has held a number of meetings in the past year and is engaged in drafting a report.

The Institute's Publications.—With a view to promoting the educational work of the Institute, and also to obtaining a contribution towards the cost of printing by sales to the public, it has been arranged that Messrs. B. T. Batsford, Ltd., of 94, High Holborn, shall act as publishers of the Institute's Transactions, Reports, Papers, etc. It is intended to issue papers in separate pamphlet form as well as in the Transactions.

New Members of Council.—The members of Council chosen to retire under the rules of the Institute were as follows:—Mr. Matt. Garbutt, F.R.I.B.A.; Mr. A. Alban H. Scott, V.P.S.A., who were not eligible for re-election.

The following four gentlemen were elected to serve on the Council:—Mr. Percy J. Black, District Surveyor for Wandsworth (East) and Battersea (Central), member of Reinforced Concrete and Parliamentary Standing Committees; Mr. W. E. A. Brown, A.R.I.B.A., member of Parliamentary Standing Committee; Mr. Bertram L. Hurst, Assoc.M.Inst.C.E., A.M.I.Mech.E.; and Mr. A. R. Sage, Assistant Principal of London County Council School of Building, Member of Science Standing Committee.

New Secretary.—It is much regretted that, owing to pressure of war work, Mr. H. Kempton Dyson, who has been connected with the Institute since its foundation, has been obliged to resign his position as Secretary. He has been asked, and has consented, to act as Honorary Secretary, so as to assist the new Secretary in his duties. Mr. Percy L. Marks has been appointed to succeed him.

THE WORK OF THE SUB-COMMITTEES.

Finance and General Purposes Committee.—The Finance and General Purposes Committee has held regular meetings preliminary to each Council meeting, and the general results of its deliberations are contained in the foregoing particulars of the Council's work for the year.

Science Standing Committee.—The work of this Committee during the past year has chiefly been concerned with the details of the research scheme above referred to. In addition the Committee has considered the suggested amendment of the London Building Acts and Building Bye-laws generally, and it is hoped that something will be done in the matter in conjunction with other societies. The Committee has also advised the Engineering Standards Committee, at the request of the latter, in respect to the use of special steels for reinforced concrete.

Reinforced Concrete Practice Standing Committee.—This Committee has been engaged in drafting a Report, entitled:—"Recommendations to Inspectors, Clerks of Works and Foremen concerning the execution of Reinforced Concrete Work."

THE ANNUAL GENERAL MEETING.

THE eighth Annual General Meeting of the Concrete Institute was held at Denison House, Vauxhall Bridge Road, on the evening of Thursday, November 22nd, Mr. F. E. Wentworth Shields, M.Inst.C.E., the President, in the chair.

DISCUSSION.

The President, in presenting the Annual Report, said that considering the times that they were living in the report was a wonderful record of work done under difficult circumstances. The balance-sheet showed that at all events their finances were fairly satisfactory. War circumstances made it exceedingly difficult for a Society like theirs to be in strong financial position. They had had to make a great many economies and forgo a great many things which in peace-time they should consider necessary. For instance, they had had to defer a great deal of the printing and publication of their minutes of proceedings, but he was glad to say they were now making arangements to print a part of the papers read in 1914-15, and they were now to issue the whole of the papers read during the past session. Owing to the high price of paper and printing, it would unfortunately not be possible to issue the report of the discussions on the papers of last session, but that, he hoped, was only postponed, and later on they should be able to publish the whole of this matter.

Research Work.—As to research work, they had been able to get seven of their University laboratories to work to assist them in carrying out their scheme of research, and the reports from those laboratories were on the whole satisfactory. Some of them had absolutely begun their work, and had made their first tests; others were about to do so. All had got the necessary apparatus and were now ready for a start.

They were keenly interested in a very useful piece of research work which had been carried out by the British Fire Prevention Committee.

The Report gave particulars of what their various Standing Committees had been doing during the past year, and he particularly called attention to a most useful report which had been drafted by their Reinforced Concrete Practice Committee, which gave advice to clerks of works and others engaged in reinforced concrete work. They hoped very soon to publish this in pamphlet form, so that it would be available to anyone who wished to purchase it. He felt sure that it would fulfil a long-felt want and that it would be a most useful document to all who had to do with reinforced concrete and to all who knew how important it was that such work should be carefully supervised and carried out.

He then moved the adoption of the Report and the accounts and balance-sheet.

Mr. H. D. Searles Wood, F.R.I.B.A., seconded, and the motion was unanimously adopted.

PRESENTATION OF THE INSTITUTE'S MEDAL.

The President announced that the medal of the Institute, awarded for the best paper read in the 1915-16 session, was to be given to Dr. Oscar Faber, D.Sc., for his paper, entitled "Shearing Resistance of Reinforced Concrete Beams." Those of them who heard that paper were, he was sure, impressed with the theoretical and practical importance of it. It put forward a theory which bade fare to partly revolutionise the design of reinforced concrete. There was no doubt the medal was well deserved. He was exceedingly sorry that Dr. Faber had sent to say that as he was engaged that night on some very urgent work for the Admiralty he was quite unable to come over and receive it and expressing his very great regret that he could not do so. He was sure that with him they would echo that regret. They were very sorry he was not with them to receive the medal, but he would ask the Secretary to send it to him with the very goodwill and hearty congratulations of the meeting.

On the motion of Mr. Lucien Seraillier, seconded by Mr. Searles Wood, a vote of thanks was passed to the President for his conduct in the chair, and the proceedings terminated.

A REINFORCED CONCRETE BARGE.

By T. J. CLARK.

The rapid movement that is taking place in the shipbuilding world to-day towards the adoption of reinforced concrete as a constructional material, and the wide interest that is being aroused by the hints and rumours that appear in the public press, render doubly interesting any established facts which are allowed to be made known.—ED.

THE photographs shown here and in our frontispiece are, we believe, those of the first reinforced concrete barge that has been constructed in this country to be used entirely for commercial purposes. The barge is being employed in canal traffic in the Midlands and is what is known as a "monkey" barge as distinct from barges of a somewhat similar nature, only having cabin accommodation. These barges are confined to certain over-all dimensions owing to the locks through which they have to pass. The one shown in the photographs is 70 ft. in length over all by 6 ft. 11 in. in width over the fenders by a total moulded depth of 4 ft. The approximate dead load that she will carry is about twenty-seven tons, though, of course, in measurement she will carry a very much greater cargo. In order to conform to the preconceived ideas of the canal "bargee"—who is very similar to his London brethren—the usual design with frames was adopted, though in future barges it is proposed to alter the construction so that it may be very considerably simplified. The barge took about one month to construct owing to the fact that she was the first of her kind, and also owing to the very bad weather that was experienced during the latter end of the summer and early autumn. The actual time occupied in moulding was about six days, and the boat was launched within eight days after completion of the topsides. She was then kept for a further ten days before she took her first cargo of sand. The times between finishing and launching and between launching and loading are merely stated as facts. That they are unusually short will be recognised by everyone who is experienced in concrete construction. That they were possible is due to special circumstances. As a general rule, it would be safer to allow a much greater length of time in each case. The total weight of the concrete and steel in the work amounted to about thirteen tons, and the cost of the barge has come out very much below that of either a steel or a wooden vessel at the present prices. Another barge is now being built to the same design, only with about 4 in. sheer, which is being put in at both the fore and after ends in order slightly to improve her appearance and render her lines more acceptable to the æsthetic tastes of the aforesaid canal "bargee." This second barge will probably be launched before this goes to press.

The draught of water of the unloaded boat amounted to about 14 in. as against 7½ to 9 in. for boats of a similar tonnage in either wood or steel; but to compensate this an extra moulded depth of 6 in. has been put in, so that the

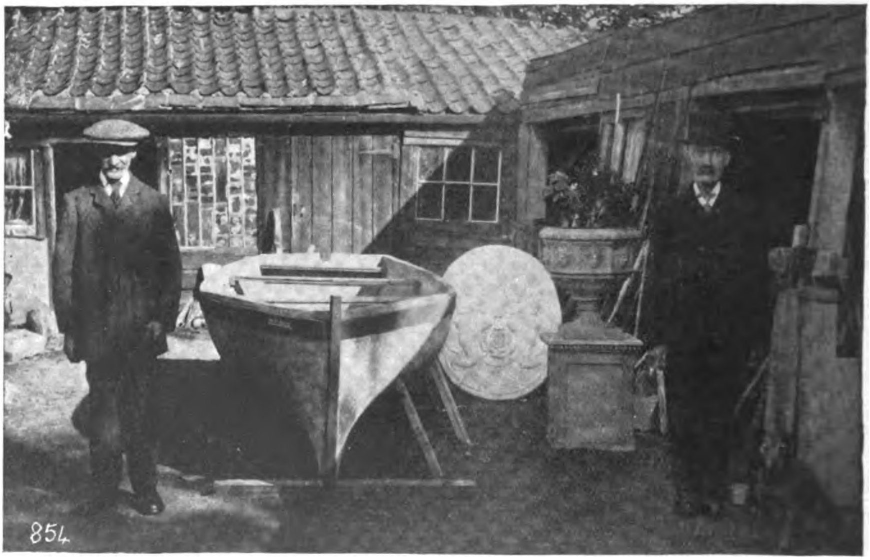
barge will carry the same dead load and be registered exactly the same as would be the case for a vessel of either wood or steel.

The barge is purely of reinforced concrete. No attempt at plastering has been made, as the engineer for this work does not consider that the plastered boat *is* a reinforced concrete one; neither, in his opinion, is it possible for the plastered vessel to stand the severe handling that these barges have to sustain in Midland canal traffic. The concrete is of a rich nature throughout, the cement being of the very highest quality made, and when made into concrete giving crushing results at twenty-eight days of over 400 tons per sq. ft. The cement used throughout was manufactured by Messrs. G. and T. Earle, of Hull. The tensile strength of the concrete at twenty-eight days was in excess of the British Standard requirements for neat cement of the same period.

The work was carried out most satisfactorily by Mr. A. H. Guest, of Coalbournbrook Wharf, Stourbridge, and the whole was designed by Mr. E. P. Wells, of 94, Larkhall Rise, Clapham, London, S.W.4.

SOME FURTHER NOTES ON CONCRETE SHIPBUILDING.

Scotland.—Last month we referred to a concrete boat which had been built in Scotland, called the *Excelsior,* and we are now able to reproduce an illustration of same, which has been sent us by the designer, Mr. James Bowman, of Montrose. Accompanying the photograph are the following notes:—The boat was designed from models. Its length is 12 ft. by 4 ft. 2 in. wide and 2 ft. 9 in. deep. About 140 ft. of steel wire were used in the reinforcement,



A Reinforced Concrete Boat built in Scotland.

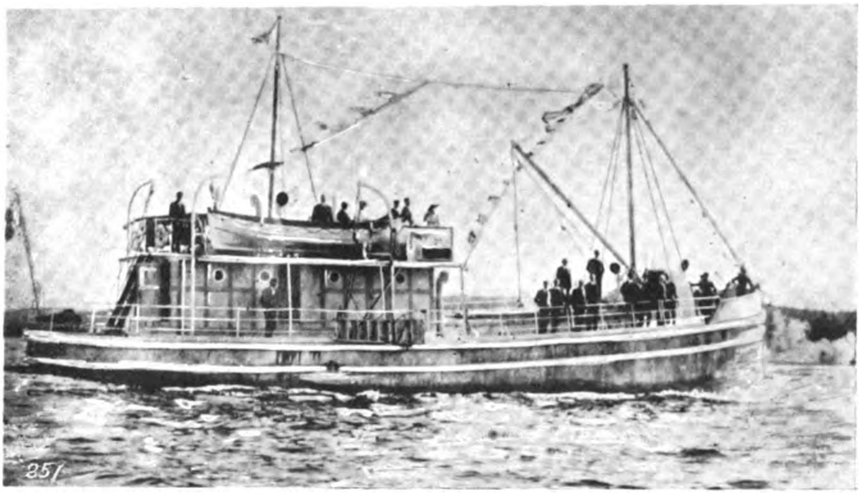
which was placed longitudinally and diagonally. The boat can carry four men easily and has been successfully launched. She was in dock thirteen days and no signs of leakage were apparent. Mr. Bowman further states that with an apprentice or labourer he was able to finish the concrete work of the boat in seven days.

Norway.—By the courtesy of Messrs. Jas. Pollock and Sons we are able to reproduce the following illustration and notes of the *Namsenfjords,* a reinforced concrete vessel which recently ran her trial trip and was launched from the Moss Yard in Norway.

This vessel is of exceptional interest, insomuch as she is the first reinforced concrete full-powered vessel to be completed.

The *Namsenfjords* has a length of 84 ft. by 20 ft. by 11 ft. 6 in. draught on which she carries 200 tons of cargo, and with her 80 b.h.p. Bolinder engine develops a speed of about 7½ knots.

It was found on trial that vibration was practically non-existent, which speaks well for the method of construction, as even with a steel vessel of comparatively heavy scantlings there is always, more or less, a certain amount of vibration from the propelling machinery.



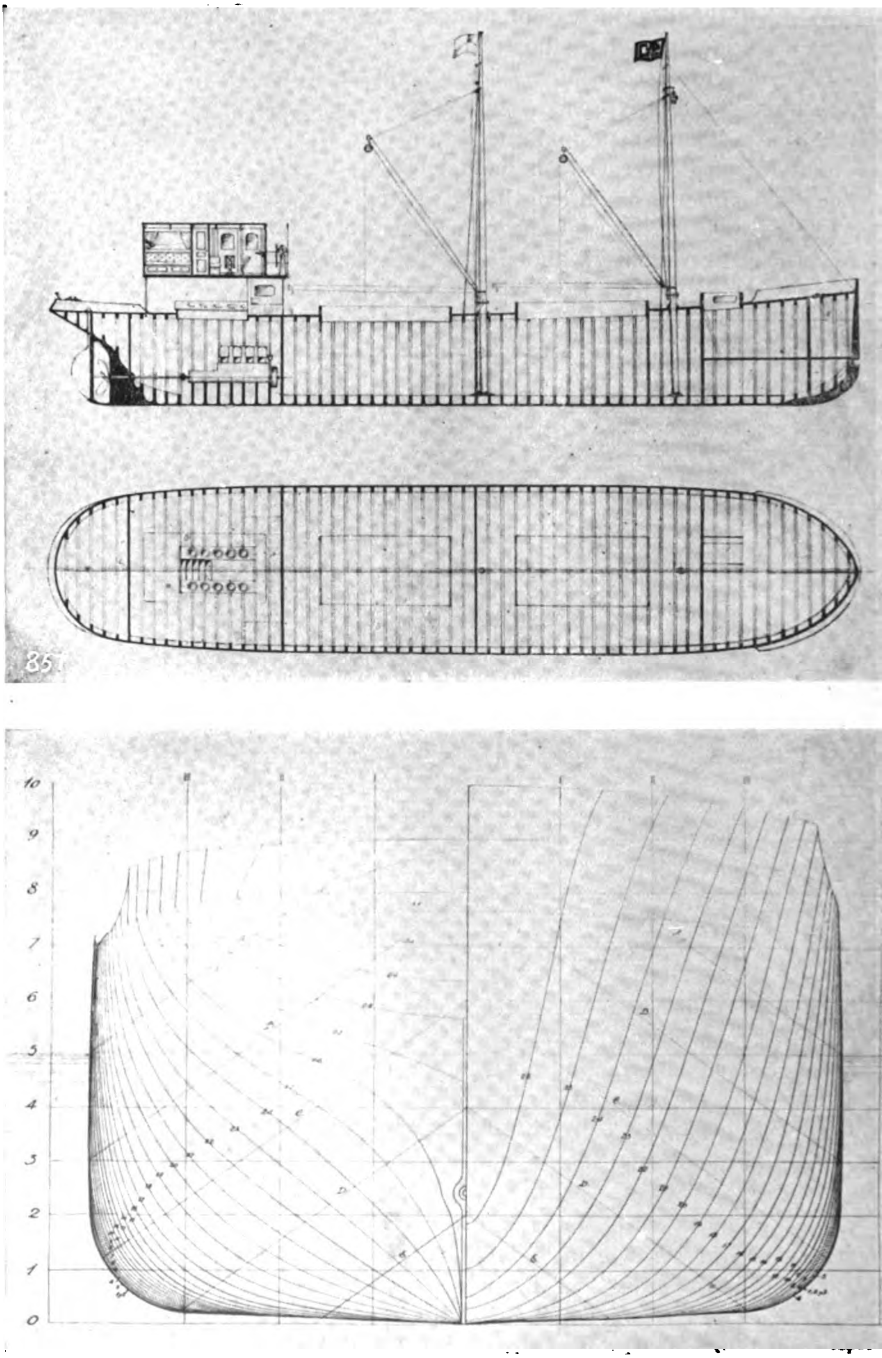
THE "NAMSENFJORDS" BUILT OF REINFORCED CONCRETE.

Whilst on trial the vessel's sea-going qualities were thoroughly tested, and she behaved excellently.

A large hold is arranged for, and a maximum-sized hatch will largely facilitate the loading and discharging of bulky packages.

The cargo will be dealt with by a powerful motor winch. The crew's quarters are forward, and the captain, mate, and engineers will be berthed aft on deck.

Spain.—The first Spanish reinforced concrete cargo boat is shortly to be launched. The vessel is being constructed in the yards of "La Société Construcciones y Pavimentos," of Barcelona, to whom we are indebted for these particulars and the accompanying illustrations. The vessel was designed by the company's engineer, Mr. Capmany. The illustrations give some idea of

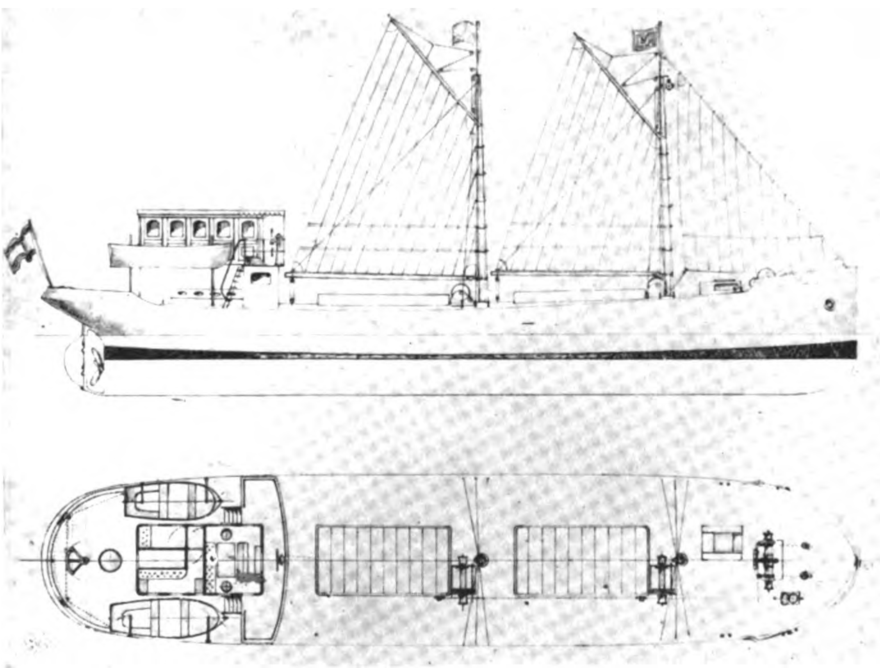


DETAILS OF DESIGN OF REINFORCED CONCRETE BOAT IN COURSE OF CONSTRUCTION IN SPAIN.

the construction of the boat, which is to serve for the transport of merchandise between Spain and France.

The boat has a length of 34 metres by 7 metres 30 wide by 3 metres 50 deep. She has a displacement of 450 tons and will be equipped with a 120 h.p. Diesel oil engine, and in addition sails will be fitted to the vessel.

This being a trial boat, the designers decided to limit her size, and they also wished to give their staff an opportunity of acquiring practice in this form of construction. Much larger vessels up to 1,500 tons load are, however, in course of construction, and the above company have decided to construct



DETAILS OF DESIGN OF REINFORCED CONCRETE BOAT IN COURSE OF CONSTRUCTION IN SPAIN.

reinforced concrete boats on a large scale, being of opinion that there is a great future for this branch of the reinforced concrete industry.

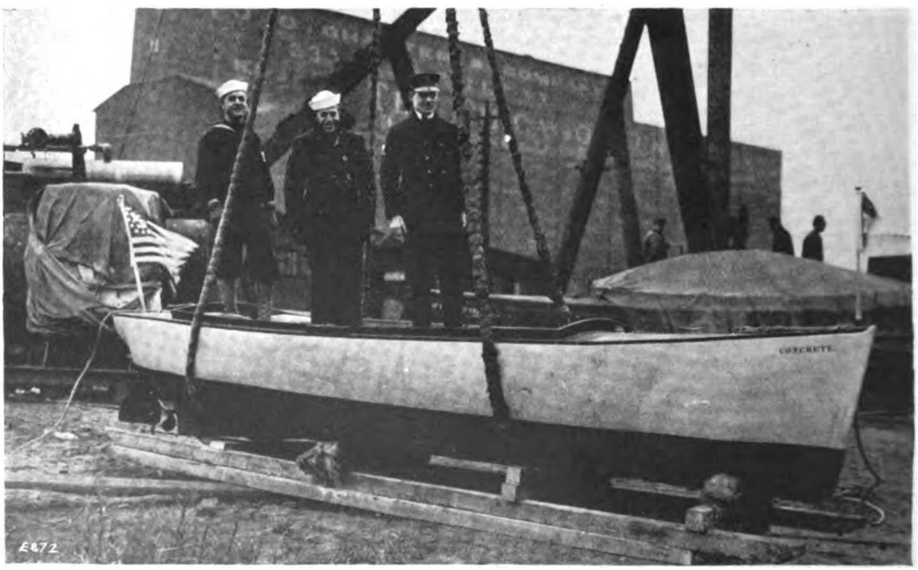
U.S.A.—We are informed by a correspondent that:—In the latter part of October an 18-ft. reinforced concrete motor boat was presented to the U.S. Naval Reserves for use on the Great Lakes. The boat was built in 1911 by Mr. W. M. Dowsey, of Iron River, Mich. Living in the northern lumber and mining country, he needed a motor boat to ply an inland lake near Iron River. Materials were not at hand to build a boat of the usual type, but steel and cement were easily obtained. These he used with fair success, but, being an experiment, the boat did not have proper draught. In 1914, with previous experience to guide him, Mr. Dowsey built a very satisfactory hull, that he has used continuously for three years.

He was of opinion that a thin shell of concrete could be made watertight, and that its weight need be no more than that of a steel hull. During odd moments he built up the frame, covered it with wire mesh, and applied concrete with a trowel in a single operation, to do away with joints. The ribs, riveted to the T-bar keel on 12-in. centres, were made of flat 12 gauge steel 1 in. wide. To hold the ribs in place, steel strips were then riveted to the ribs from prow to stern. Upon this light framework ¼-in. square wire mesh was wired to cover the entire hull, two thicknesses being applied below the water-line.

It required nearly fifteen hours to apply the concrete, and while hair cracks appeared, due to too rapid drying, yet these received no attention and caused no trouble. There was no effort to trowel the surface smooth, which made skin friction greater than with a smoothly finished surface, but in spite of this the boat makes ten miles per hour easily.

The dimensions of the boat are: Length, 18 ft. 6 in.; beam, 4 ft. 6 in.; depth of hull, 38 in.; thickness of hull, ¾ in. Portland cement and sand were used in proportion of one part cement to one and a half parts sand. The hull is painted black below water, white above, and was named *Concrete*.

We understand that this is the first boat of reinforced concrete to be used by the United States Government. The vessel makes a speed of ten miles an hour with its 6 h.p. motor.



View of the Concrete Boat taken over by the U.S. Naval Reserves.

GOVERNMENT SCHEME FOR THE HOUSING OF THE WORKING CLASSES IN ENGLAND AND WALES.

COTTAGE COMPETITIONS.

THE Local Government Board, being desirous of obtaining designs for cottages suitable for the housing of the working classes, have placed at the disposal of the Royal Institute of British Architects a sum of money for this purpose, and the Institute has therefore decided to invite its Allied Societies to assist in obtaining designs under the following conditions :—

For the purpose of the competition the country is divided into six areas, comprising the districts of the Allied Societies and the R.I.B.A., as follows :—

I. *Northern Area*—
- Northern Architectural Association.
- Leeds and West Yorkshire Architectural Society.
- York and East Yorkshire Architectural Society.
- Sheffield, South Yorkshire and District Society of Architects and Surveyors.

II. *Manchester and Liverpool Area*—
- Manchester Society of Architects.
- Liverpool Architectural Society.

III. *Midland Area*—
- Birmingham Architectural Association.
- Nottingham and Derby Architectural Society.
- Leicester and Leicestershire Society of Architects.
- Northamptonshire Association of Architects.

IV. *South Wales Area*—
- South Wales Institute of Architects.

V. *South-West Area*—
- Devon and Exeter Architectural Society.
- Bristol Society of Architects.
- Hampshire and Isle of Wight Association of Architects.

VI. *Home Counties Area*—
- Royal Institute of British Architects.

CONDITIONS.

VI.—Home Counties Area.

1. Pursuant to the scheme above described, the Royal Institute of British Architects invite designs for cottages in accordance with the instructions and particulars stated below. The competition is open to any British subject.

2. The designs are to be suitable for erection in urban and rural districts in the counties of Norfolk, Suffolk, Cambridge, Huntingdon, Middlesex, Essex, Hertfordshire, Bedfordshire, Oxfordshire, Buckinghamshire, Berkshire, Surrey, Sussex, and Kent.

3. The designs are to include four classes or types of cottages as described below, and premiums are offered as follows:—

	1st—£	2nd—£
Class A	100	50
,, B	100	50
,, C	100	50
,, D	50	30

4. The adjudication will be made by a Committee of not less than three architects appointed by the Royal Institute of British Architects, and their judgment is to be accepted as final.

5. It is to be understood by competitors that the payment of the premiums conveys the absolute possession of the designs, including all copyright or other rights, and that the promoters will be at liberty to make any use whatever of the designs, and to publish them with the names and addresses of the authors. The promoters reserve the right to exhibit publicly, after the award, all or any of the designs as they may think best with the names of the authors attached. No architect shall compete in more than one area.

6. Designs are to be prepared strictly in accordance with the instructions below, and any design which does not so conform will be excluded. On this point the Committee of Selection are to be the sole judges.

7. Designs are to be delivered carriage paid to the Secretary R.I.B.A., 9, Conduit Street, Regent Street, London, W.1, on or before January 13th, 1918.

8. The unsuccessful designs will be returned to the authors carriage paid as soon as practicable

9. Any questions must be addressed to the Secretary of the Royal Institute of British Architects, 9, Conduit Street, W.1, on or before November 27th. Replies will be issued to all competitors as early as possible.

10. Each set of designs is to be accompanied by a sealed envelope containing the name and address of the author.

11. No motto or distinguishing mark is to be put on the drawings.

12. Every care will be taken of the drawings, but the promoters will not be responsible for any damage they may sustain, or for their loss.

13. Designs may be submitted in any or all of the classes as follows:—

Class A.—Living room, scullery, etc., and three bedrooms.
,, B.—Living room, parlour, scullery, etc., and three bedrooms.
,, C.—Living room, parlour, scullery, etc., and two bedrooms.

All the above to be treated as two stories.

Class D.—Variations of either A, B, and C planned entirely or mainly on one floor.

Larder, fuel store, w.c. or e.c., cupboards, etc., to be included.

14. In all cases back additions are to be avoided or minimised as much as possible.

15. All houses are to be provided with a fixed bath and a cold-water supply. Arrangements for the supply of hot water are to be indicated on the plan.

16. Positions of all principal pieces of furniture, such as dressers, tables, beds, etc., together with opening of doors, the points of the compass, and dimensions of rooms, are to be indicated on the plan.

17. In Classes A, B, and C several houses must be shown as a block, of which

three are to be planned in detail, the others in outline only. Of these three, one is to be an end or semi-detached house; another a terrace house or one between party walls with narrow frontage (not exceeding 18 ft.), and a third with wide frontage. The depth of the site is left to the discretion of the competitors, and the site may be regarded as level.

18. The general height of rooms is to be not less than 8 ft., the floor area of the principal bedroom to be not less than 160 ft., and no bedroom to be less than 70 ft.

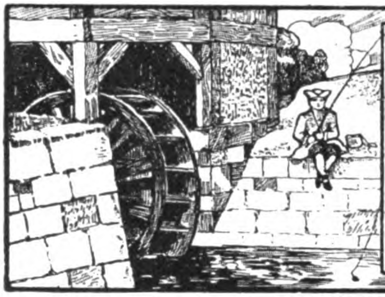
19. The plans may be prepared without regard to any existing by-laws or local Act provisions, the object being to show the best types possible if existing restrictions are removed.

20. Each design is to show plans of each floor, one section indicating the staircase, and two elevations, and to be drawn to a scale of $\frac{1}{8}$th of an inch to the foot on half double elephant sheets. No other drawings to be submitted.

21. All drawings are to be in line only without washes, with the walls blacked in, and are to be sent flat.

22. The designs in each of the Classes A, B, C, and D are to be on separate sheets. Notes of materials, etc., are to be printed on the drawings, together with the cubic contents of each house measured from one foot below the floor to half way up the roof. No separate report is necessary.

23. Wherever possible, materials of the locality, if reasonably obtainable, should be specified; but as there exists at the present time a serious shortage of certain materials, competitors are invited to consider and suggest the substitution of others, with a view to facilitating and cheapening construction. It is essential that strict economy be exercised throughout the design, and this will be an important consideration in making the awards.



REINFORCED CONCRETE CONSTRUCTION IN CONNECTION WITH THE CABBAGE TREE CREEK RESERVOIR, BRISBANE.

The following interesting particulars of a large reinforced concrete dam in Australia have been sent us by Mr. J. Peart, the engineer to the Water Supply Department of the Metropolitan Water Supply and Sewerage Board at Brisbane.—ED.

THE water supply to the city of Brisbane and suburbs is chiefly derived from the Brisbane River.

The pumping station is situate on the left bank of the river at Mount Crosby, about twenty miles from the city and above the reach of the tide. The pumping station consists of three recently installed triple-expansion condensing engines, each of six million gallons capacity in twenty-four hours. The station is complete with tubular boilers, economisers, electric power and lighting.

The population supplied with water at December 31st last may be taken at 158,000, at an average daily consumption of forty-six gallons per head.

Other works in connection with the water supply are: greater service reservoir, storage, and purification works.

A comprehensive scheme of sewerage works is now in hand, comprising main sewers and connections, also purification works and outfall works.

The Cabbage Tree Reservoir Dam and other works included therewith is situated on Cabbage Tree Creek, a tributary of the Brisbane River, and lies to the north-west of the city of Ipswich, a distance of about 11½ miles, and 30 miles from Brisbane as the crow flies, and 5½ miles from the pumping station. It is proposed to bring this water to the pumping station by a concrete conduit.

The site of the dam is ideal for the purpose, situated as it is at the mouth of a gorge between two hills, beyond which the area opens out into a most suitable site for a large and commodious reservoir.

The geology of the site is what may be termed quartzite. The exposed strata shows decomposed quartzite, in some places to a considerable depth, overlying the blue quartzite, which is tough, tenacious, and impermeable, and suitable for the foundation of such a dam.

The foundation of the dam is founded for the full width on the blue quartzite. This was found at 15 ft. below the creek bed and irregularly on each side of the creek. Although some 5,860 cubic yards of extra excavations were removed to secure this foundation, no unforeseen difficulties were met with in so doing, neither were any streams of water cut.

The dam is of Cyclopean concrete, face work 1 : 2 : 4 concrete and the interior 1 : 2 : 6½ concrete, and includes 25 per cent. of rock plums. It is of gravity section and 125 ft. high from foundation to top. The thickness is

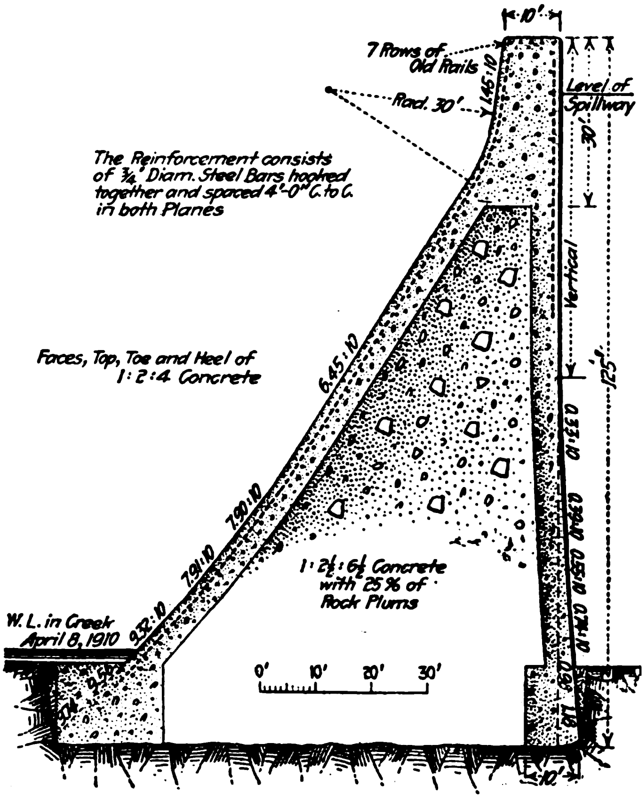
95 ft. at the base at the thickest part and 10 ft. wide at the top. The length is 580 ft. and the length of the byewash 160 ft., a total of 740 ft.

The quantity of water that can be impounded by this dam is 5,800,000,000 gallons.

The surface area of the lake is 700 acres.

The catchment area comprises 28 sq. miles of very suitable country for the purpose, hilly, well wooded, and free from soft parts, hence the water comes off in a pure condition.

The whole area of the reservoir was carefully cleared from timber and detritus.



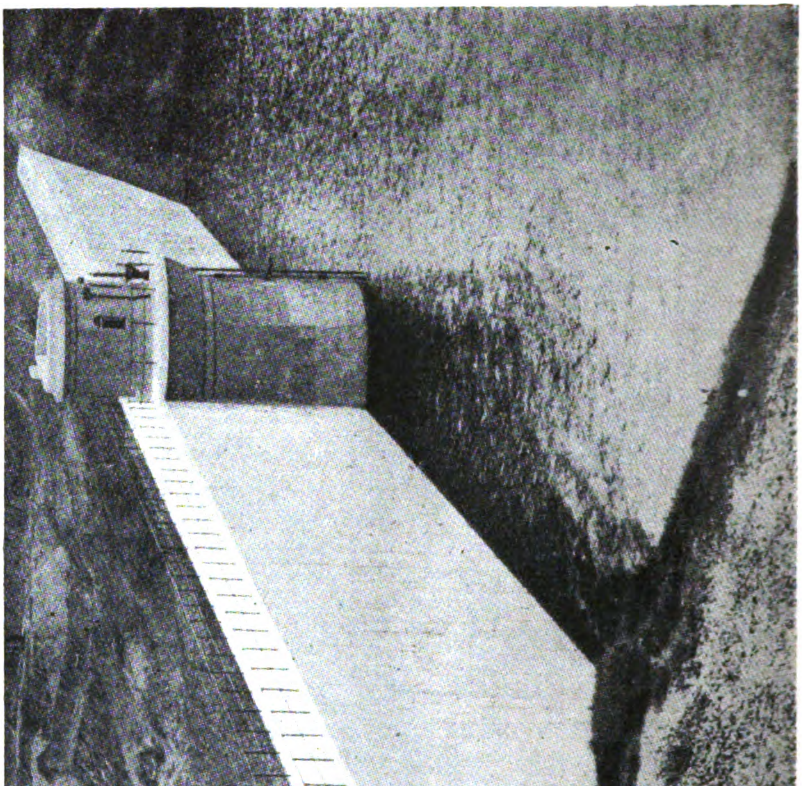
Section.

Reinforced Concrete Dam, Cabbage Tree Reservoir, Brisbane.

The principal figures are :—

		Cu. Yd.
Excavation for dam		33,222
Do	extra, below assumed bottom	5,859
Do	byewash	64,500
Cyclopean concrete		58,400

The rainfall is intermittent, and for long periods there is no rainfall, but the area is subject to periodical heavy downfalls, when large floods have been recorded.



Reinforced Concrete Dam, Cabbage Tree Reservoir, Brisbane.

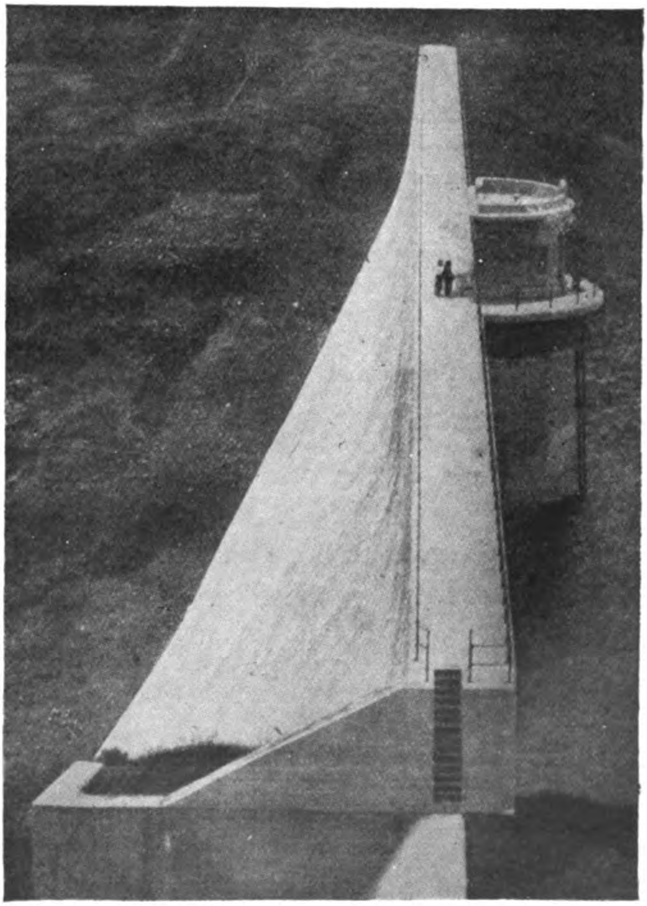
The reservoir is at present within 20 ft. of top water. It is, however, anticipated the next season's rains will fill it. The available quantity of water when full, after allowing for evaporation, may be taken at twelve million gallons daily for 300 days, and with economy over a longer period.

The longest period of drought known occurred in 1915, when the principal source of supply—viz., the Brisbane River—was dry for eight weeks; the period of greatest scarcity of water may therefore be put at 100 days.

The dam was opened for public use in December of last year.

The dam and other works in connection with this reservoir were carried out under contract by Mr Arthur Midson. The actual cost of the reservoir and works under this contract was about £172,000. The works were supervised by the board's engineer for water supply and a staff of capable assistants.

The water supply, as well as the sewerage works, are under the control of the Metropolitan Water Supply and Sewerage Board, of whom Mr. E. J. T. Manchester, M.C.E., is the president.



REINFORCED CONCRETE DAM, CABBAGE TREE RESERVOIR, BRISBANE.

RECENT BRITISH PATENTS RELATING TO CONCRETE.

We propose to present at intervals particulars of British Patents issued in connection with concrete and reinforced concrete. The last article appeared in our issue of August, 1917.—ED.

Tunnelling.—*No.* 104278. *T. M. McAlpine, 2, Central Buildings, Westminster. Dated May* 29/16.—Tunnels of concrete or other suitable material are constructed in accordance with this invention by excavating separated sections of the tunnel at intervals round the tunnel arch and filling such sections with the concrete; the sections between the spaces thus filled in are then excavated and filled. The tunnel arch is thus completed, whereupon the core or dumpling enclosed by the arch is removed.

In one method, *Fig.* 1, headings *c* are first driven along alternate sections as shown, and the arch voussoirs thus excavated are filled in with concrete; the other sections *d* are then excavated and filled with concrete, with or without suitable

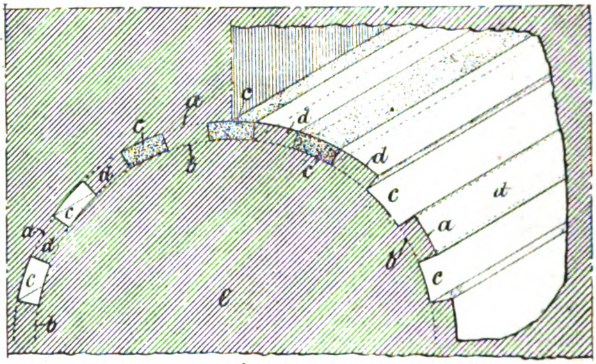


Fig. 1.

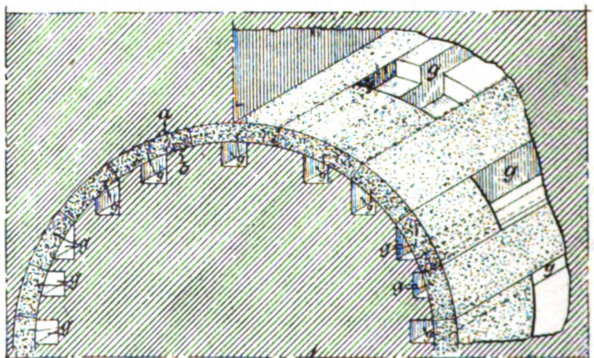


Fig. 3.

reinforcement. Lateral headings may be run from one heading *c* to another to facilitate filling of these headings at the rear.

In another method, *Fig.* 3, for completing the tunnel arch in sections along the arch, small headings *g* are driven at intervals along the arch space; these headings extend into the core to provide passages to facilitate both excavation and filling of the arch sections. Widening of the headings within the arch space is then effected and the excavated space forming part of the ring is then filled in, the work proceeding in sections as in the previous case.

The core or dumpling *e* is removed after the tunnel arch has been completed.

Concrete Reinforcement.—*No.* 104795. *J. W. Haran, " Rosslyn," Station Road, Yardley, Birmingham. Dated May* 25/16.—This invention comprises a reinforcement framework for floors, roofs, road-beds, etc., consisting in longitudinal wires or rods combined with transverse trough-shaped bars which are notched for the reception of the rods, which are secured in position by cotters.

The trough-shaped bars are provided with notches *c* in the angle to receive the longitudinal bars *a*; ear pieces *e* are formed by stamping, and these ears rest upon the formwork during the construction of the floor and thus act as spacers to keep

Fig. 1

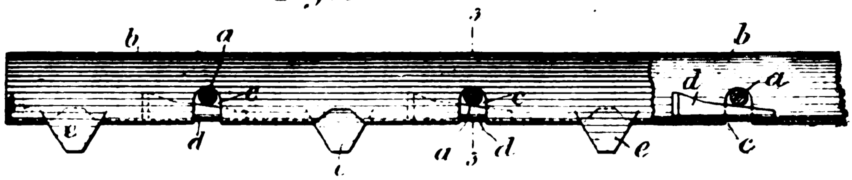
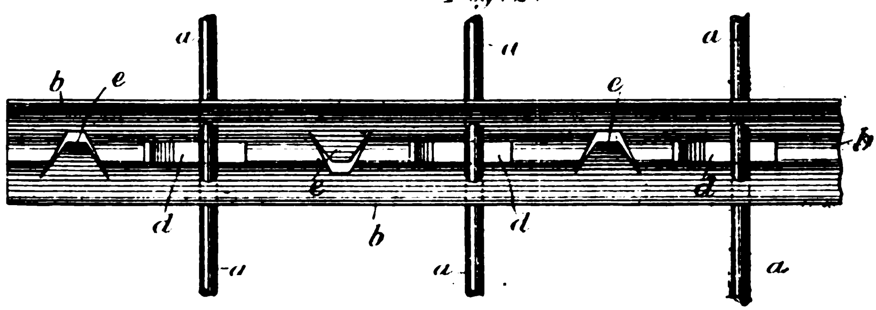


Fig. 2.



the reinforcement at the requisite distance above the bottom of the slab.

When it is desired to avoid markings upon the ceiling of the room below, the projecting ears *e* may be dispensed with, and slots may be formed in the troughs to receive studs of unglazed earthenware or porcelain.

The ears *e* serve to connect successive lengths of trough-shaped bars *b* together, the ear at the end of one bar being engaged in the corresponding hole in the other. Wedge-shaped cotters *d* secure the bars *a* in the slots *c*.

Shear Stirrups for Reinforced Concrete.—*No.* 105108. *British Reinforced Concrete Engineering Co., Ltd., and E. B. Hall,* 1, *Dickinson Street Manchester. Dated March* 30/16.—Shear stirrups are formed in accordance with this invention in groups comprising a series of substantially U-shaped members connected by cross-members, so that they can be handled at one stirrup and attached to any part of a main reinforcing bar.

These compound stirrups are preferably made from electrically-welded or similar fabric, the longitudinal wires when bent forming the stirrup members and the transverse wires forming the connecting wires of the compound stirrups.

Starting with a piece of mesh fabric, *Figs.* 1, 2, the wires *b* are bent up to form the series of stirrups or shear members, while the bars *b* form the connecting wires, the bend being preferably so effected, as shown in *Fig.* 3, that a wire *b* occurs at the bend.

The wires *a* may be, as shown in *Fig.* 6, arranged other than at right angles to the wires *b*, which then become kinked, and the stirrups are lashed by wire *d* to the main reinforcement *c*, either between the wires *a* as shown in the left-hand side of the figure, or on each side of the wires as shown on the right-hand side.

Fig. 8 shows the application of the invention to the transverse reinforcement

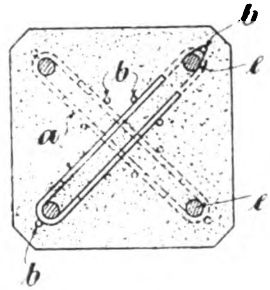


Fig. 8.

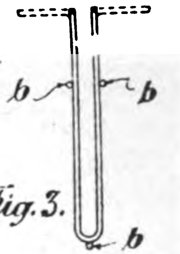


Fig. 3.

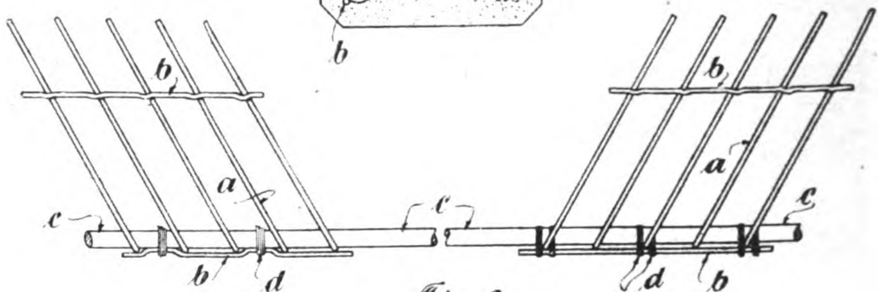


Fig. 6.

Fig. 1.

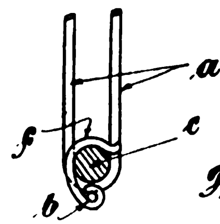


Fig. 12.

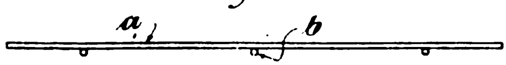


Fig. 2.

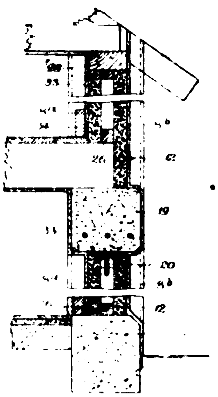
of a pillar, the stirrups converging towards the axis and lying at different elevations along the vertical bars *e*.

The stirrups forming a group may be arranged at different distances apart, and one group may be arranged within another.

Fig. 12 shows an alternative method of fixing the stirrups to the main reinforcement *c*; two or more hooks are provided, each linked to one of the cross-wires *b* at one end and adapted to lie over the bar *e*.

Concrete Slab Buildings.—*No.* 107390. *E. O. C. Howells, Haynstone, Stoke Park, Coventry. Dated March* 23/16.—This invention deals with concrete buildings with double walls of concrete slabs formed between pillars. According to the first part of the invention, horizontal spacing battens or cleats (preferably of wood) are provided along the top and bottom of the wall, and vertical battens are employed in conjunction with flanged pillars for spacing the inner and outer walls; according to the second part concrete pillars are formed with double grooves to receive the slabs, and horizontal battens are used along the top and bottom of the wall.

When reinforced concrete beams are employed, *Figs.* 2, 5, they are carried by bearer plates 20 bearing upon the top of the double slab wall 8*a*, 8*b*. The vertical



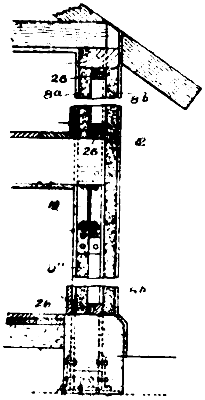
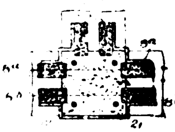


Fig 7



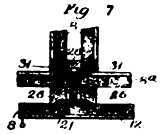


Fig 10

faces of the reinforced concrete pillars 21 are each formed with double parallel grooves 24 to receive the slabs. The slabs break joint and are spaced at the required distance apart by wooden battens 26, about 3 ft. 6 in. long, at top and bottom.

When rolled steel sections are employed for pillars and beams, *Figs.* 7, 10, the outer slabs 8*b* may be formed on the outside so as completely to enclose the steelwork, the inner slabs 8*a* interlocking with and abutting against the flanges of the pillars and being supported by vertical battens 26. At the junction of outer and interior wall the pillar 21 may be of double channel or I section, to the inside face of which angles 31 are riveted to receive the free ends of the interior wall slabs. Window sills are preferably grooved to receive the cleats 26.

Concrete Walls.—*No.* 108195. *J. B. Dawson, Cwm Garw, Mayhill, Swansea, S. Wales, and J. J. Jubb, Albert Buildings,* 151-7, *Fitzwilliam Street, Sheffield. Dated*

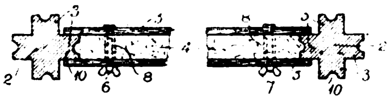


Fig. 1.

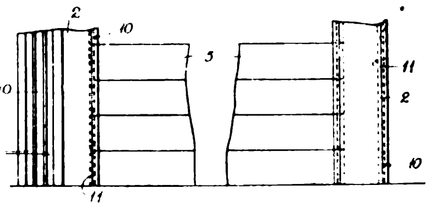


Fig 6

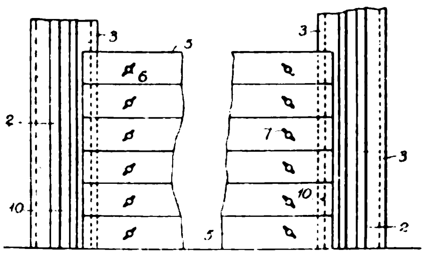


Fig 2

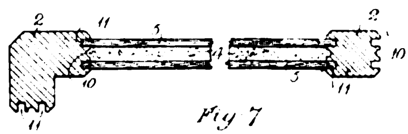


Fig 7

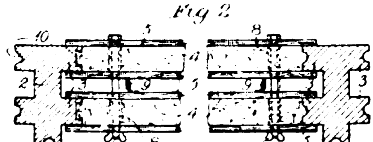


Fig 3

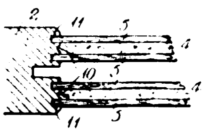


Fig 8

July 27/16.—This invention relates to the erection of concrete or cement walls cast ***in situ*** between concrete principals, and consists in either clamping the shuttering boards against vertical ribs formed integrally with the principals or inserting the ends of the boards in vertical grooves in the principals.

In the first-mentioned arrangement, *Figs.* 1-3, the concrete principals 2 are formed with ribs 3, against which the shuttering boards 5 are clamped by means of bolts 6, provided with fly nuts 7; loose tubular distance pieces 8 may be provided to facilitate removal of the bolts after the concrete has set. In the case of double walls, *Fig.* 3, the bolts 6 pass right through the four shuttering boards; the inside boards are supported by distance-pieces 9 hinged to one set of the boards.

MEMORANDUM.

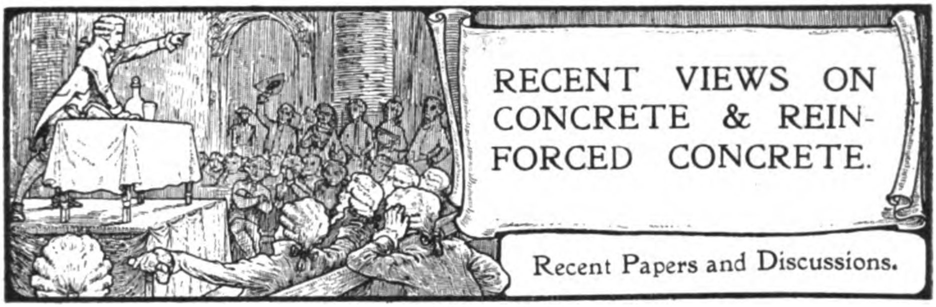
A Reinforced Concrete Power House for Sugar Refinery at Greenock.—We recently referred to this building, which was then in course of construction. It possesses some novel features, and we give below a few structural particulars taken from the *Engineer*:—

"The power-house, coal storage, and cantilever roof constitute a single structure, monolithic throughout. The floor of the power-house is 24 ft. above ground level, and supports two reciprocating engines, seated upon a plain concrete foundation 9 in. thick, laid directly upon the reinforced concrete floor slab of 6 in. thickness. On each engine seat the load is 25 tons, and the floor is so designed that no vibration may be perceptible when the engines are in full working order. This engine-house floor is a continuous slab, carried by longitudinal beams over two rows of columns, bringing the surface of the engine-house floor 24 ft. above ground level. There are two intermediate longitudinal beams, 5 in. wide by 18 in. deep, and four transverse beams, each 14 in. wide by 28 in. deep. The cantilever roof is over the boilers, and projects 17 ft. beyond the supports.

"The whole structure—engine-house, coal storage, and cantilever roof—is supported by nine reinforced concrete columns in three rows. The columns in one row support the power-house; another row supports one side of the power-house and one side of the coal bunkers; and those in the third row support the other side of the coal-bunkers and the cantilever roof over the boiler-house. Six of these columns are 1 ft. 9 in. square, and the other three measure 2½ ft. by 1 ft. 9 in.

"The power-house measures 40 ft. by 22 ft. 5 in., and is 21 ft. 4 in high inside—the roof lantern rising 6 ft. above ceiling level. Three of the outer walls are 4 in. thick, and the party wall next the bunkers is 6 in. thick at the foot, tapering to 4 in. at the top. Counterforts in the form of pilasters are built, with the two side walls of the power-house having bracketed extensions to carry a 10-ton travelling crane, installed for the purpose of lifting parts of the engines for examination and repair. The wall between the bunkers and power-house is designed to act as a partition between these two portions of the general structure, and the necessity of placing the central row of columns about midway between the bunker wall and the exterior of the discharge outlet for coal has led to details in providing for the transference of the load from the power-house beams to the supporting columns. The longitudinal main beam connecting these columns acts as a stiffener for the hopper bottoms of the bunkers, in addition to supporting the power-house floor, and the four transverse beams of the latter pass through the longitudinal beam at the right hand, so as to form cantilevers for the support of the corresponding wall of the power-house

"The roof over the boilers is cantilever planned, and projects 17 ft. beyond the supports. It consists of four cantilevers, 12 in. wide, and of varying depth, increasing as the supports are approached, two series of longitudinal beams, measuring 4 in. by 9 in. respectively, and a continuous roof slab 3 in. thick. A gangway over the front end of the boilers is suspended from the roof. The receiving hopper for coal is constructed in the ground; the coal passes into it from trucks on the railway siding, and is elevated thence to the top of the storage bunkers."



It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.—ED.

THE AMERICAN CONCRETE INSTITUTE.

TEST OF A FLAT CONCRETE TILE DOME REINFORCED CIRCUMFERENTIALLY.

By W. A. SLATER and C. R. CLARK, University of Illinois, Urbana, Ill.

The following is an abstract from a paper read at the last meeting of the American Concrete Institute.

THE test described in this paper was made on a dome-shaped structure (*Fig.* 1), which in plan formed a panel 10 ft. wide and 12 ft. long between the interior surfaces of the supporting walls. *Fig.* 2 gives a view of the completed panel. The structure consisted of a thin shell made of concrete tiles (*Fig.* 5) $2\frac{1}{4}$ in. thick, supported on concrete walls 8 in. thick, the entire structure being levelled up by means of a 1 : 3 : 8 mix of cinder concrete 2 in. thick at the centre and increasing to 6 in. at the ends. The average thickness of the cinder concrete fill was about $4\frac{1}{2}$ in. The concrete shell was reinforced by means of circumferential rods $\frac{3}{8}$ in. in diameter spaced 9 in. on centres.

The concrete shell formed a portion of a hollow sphere 100 ft. in diameter. Thus any vertical section passing through the centre of the dome formed the arc of a circle of 100 ft diameter. This gave a rise of 3 in. between the inner surface of the wall and the centre of the dome on the 10-ft. span and of 4·1 in. on the 12-ft. span. The shell was built of tiles of the form shown in *Fig.* 3. The tiles were made from a mortar of 1 part of cement to 2 parts of sand. They were laid in a mortar made up of 1 part cement, 1 part of lime, and 6 parts of sand. They were laid in concentric circular course beginning at the corners and working towards the centre without the aid of forms. The corners were filled in with partial courses until a complete circular course could be laid. Each tile dovetailed into a tile of the previous course in such a way as to support the individual tiles by cantilever action until the course was completed.

The true spherical form of the dome was maintained by the use of a template, which consisted of an arm cut to conform to the arc of a true circle whose diameter coincided with the vertical axis of the dome and whose radius was 50 ft. As this arc rotated about the vertical axis an arc of a true spherical dome was generated. By laying the tiles to conform to the position indicated by this template a spherical dome was secured. Each course formed a zone which after completion was reinforced with a circular rod of $\frac{3}{8}$-in. round steel placed in the circumferential groove formed by the notches cast in the tiles. Mortar similar to that above described was slushed into the groove around the reinforcement to give a bearing to the reinforcement.

After a course was completed it depended no longer upon cantilever action in the tile for support. Although cantilever action was still present to some extent, any yielding of the course would bring compression into the upper edges of the tile in a

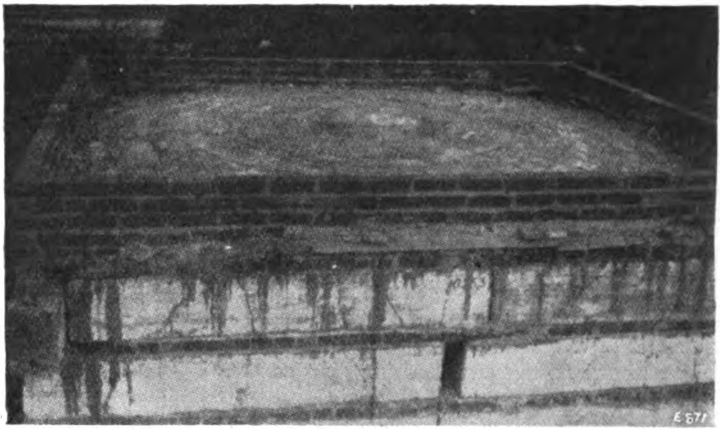


FIG. 1. VIEW OF DOME BEFORE CINDER CONCRETE FILL HAD BEEN PLACED.

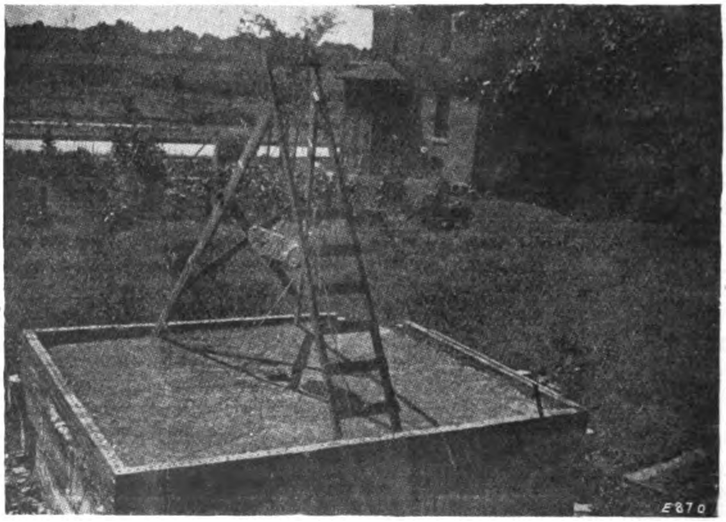


FIG. 2. VIEW OF COMPLETED STRUCTURE DURING IMPACT TESTS.

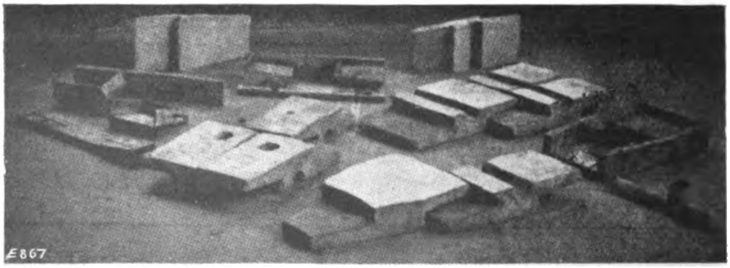


FIG. 3. FORM OF TILES USED.

circumferential direction, and this compression would be resisted by the tension in the circumferential reinforcement and by friction against the adjacent outer course. The reinforcing rods for the incomplete courses in the corners were carried along the exterior edge of the dome on the supporting wall, as indicated by dotted lines in *Fig.* 4, and were thoroughly encased in mortar for anchorage.

Lack of promptness in taking these precautions to anchor the bars caused the premature destruction of the dome the first time its construction was attempted. The

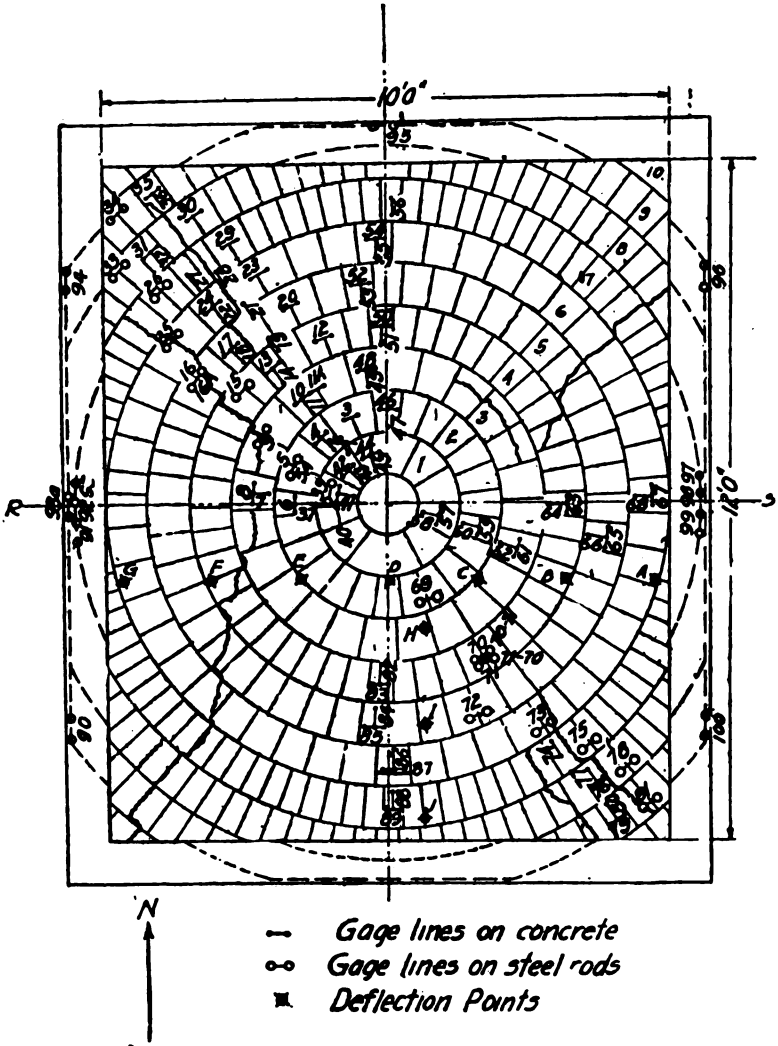


Fig. 4. Plan showing Location of Gauge Lines, Deflections, Points and Cracks.

outer courses of the structure had been completed without first grouting the reinforcing bars of the outer incomplete courses. When all but two or three courses of tiles had been laid the reinforcing bars for courses eight and nine were seen to loosen throughout most of their position on the side wall, *Fig.* 4, and let down the entire construction rapidly but not instantaneously. With the second attempt greater attention was paid to the reinforcing and anchoring of each course as soon as it was completed, and no difficulty of the kind above named was experienced. Where it was necessary to splice bars a lap of about 50 diameters was provided, and the bars were hooked at the ends. Measurements of deformation were taken at one of these splices to see how effective the splices were. (See gauge lines 70-71, *Fig.* 4).

The dome was tested with static load at somewhat less than 30 days after erection. The load consisted of pig-iron, which was placed in increments of 2,000 lb. (16⅔ lb. per sq. ft.) until a load of 8,000 lb. had been reached, and in increments of 4,000 lb. from then until the maximum load of 16,000 lb. had been reached. Observations taken during this vertical load test were (*a*) strain-gauge readings at gauge lines shown in *Fig.* 4; (*b*) deflection readings taken at the centre and at the deflection points shown in *Fig.* 4; and (*c*) outward deflection of the walls at the centres of the four sides. The latter measurement was to determine whether the walls were called upon to resist thrust. Fearing the possibility of sudden failure of the thin shell of the dome thus letting the entire load fall through, with serious consequences to the observers, use was made of the brick pier shown in *Fig.* 5 and the walls, to

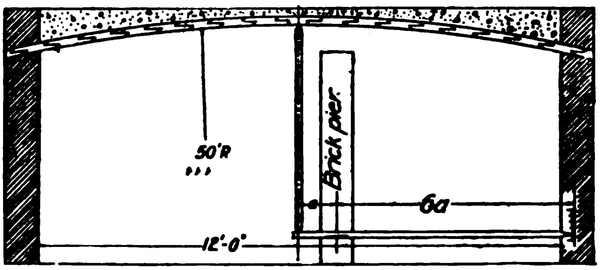


FIG. 5. CROSS-SECTION OF STRUCTURE SHOWING ARRANGEMENT OF DEFLECTION APPARATUS.

FIG. 6. VIEW SHOWING FRACTURE DUE TO IMPACT AT CENTRE OF DOME.

support a framework in the north-east corner of the panel. This was intended to serve as a shelter in case of unexpected failure of the dome.

After the static load tests had been completed an impact test was made by dropping a stone various distances and observing the effect on the structure.

After the dome had been removed a determination was made of the ability of the walls to resist thrust by applying to them known horizontal loads and measuring the amount of horizontal deflection of the wall under these loads.

Immediately after the removal of the load deflection readings were taken, and these showed a recovery of 27 per cent. of the maximum deflection under full load. After standing eleven days without load another 6 per cent. recovery had taken place, giving in all 33 per cent. recovery. In order to see what effect an eccentric static load would have on the structure a load of 6,000 lb. was uniformly distributed over the north half of the dome and readings of deflection and deformation were taken. The effect was only slight.

Deflection readings on a north-south section, 8 in. from the north-south centre line, indicate that the eccentric load did not change the shape of the north-south section more than that of the east-west section. The effect of the eccentric load seems to have been well distributed and not more marked than that of the same amount of load distributed uniformly over the entire area in the first application of load.

With the thin shell as the only structural support and with no radial reinforcement, danger of sudden failure and of peculiar susceptibility to impact was considered. As a preliminary test a 50-lb. weight was dropped from a height of about 6½ ft. about a dozen times at the centre of the dome, where the thickness of the cinder concrete fill was only 2 in. This caused a slight vibration of the structure, but had no permanent effect. Accordingly a more severe impact test was devised. A stone weighing 195 lb. (about 10 in. wide and 27 in. long) was raised varying distances and dropped on the dome.

The derrick improvised for raising the stone to the desired height is shown in *Fig.* 2. The hook with which the stone was attached to the block and tackle used

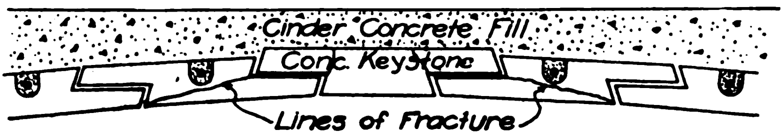


FIG. 7. SKETCH SHOWING MANNER OF FAILURE AT CENTRE UNDER IMPACT.

FIG. 8. VIEW SHOWING FRACTURE DUE TO IMPACT ON UNPROTECTED SURFACE.

in this apparatus was provided with a trip so that the stone could be suddenly released and allowed to fall entirely free from all restraint. The first seven blows were applied at the centre of the dome, where the thickness of the cinder concrete fill was 2 in. In order to approximate the conditions under which such a structure would have to meet service tests 1-in. boards were at first laid on the top of the dome to receive the force of the blow. It was soon ascertained that the effect was slight enough that in order to produce appreciable permanent effects the boards would need to be removed, and they were not used after the application of the first two blows. To determine the effect of each blow the multiplying lever apparatus sketched in *Fig.* 5 was used to determine the deflection at the centre at the instant of impact.

The data of the test are given in Table I. Also a view from the interior looking upward toward the centre of the dome is given in *Fig.* 6.

The above described test showed an unexpected resistance to impact. To determine whether the resistance to impact would be less if the blows were applied eccentrically the derrick shown in *Fig.* 2 was moved to a point 3 ft. south of the centre and a similar test was made. In this instance the height of the drop was uniformly 6 ft. 8 in., and no board was placed on the cinder concrete.

The stability of the structure as a whole did not seem to be impaired by the tests previously described, and the derrick was then moved to a point near the north end of the slab and an excavation made through the cinder concrete deep enough to expose the upper surface of the tiles. This area was approximately a rectangle 14 in. by 34 in. The 195-lb. stone was dropped a distance of 7 ft. 1 in. upon the unprotected dome. The first blow cracked the dome but made no hole. *Fig.* 8 shows the effect of this blow as photographed from beneath the structure. One more blow from a height of 7 ft. 1 in. was applied at this point. This made a small hole but the stone did not fall through. The derrick was then moved to a point about 1½ ft. south of the centre—that is, to a point about half-way between the first two points of application. Here the stone was raised to a height of 6 ft. 8 in. and dropped upon the cinder fill, which was 2¼ in. thick at this point. At the seventh blow a hole was made and the stone fell through.

In wrecking the structure the central portion of the shell was broken out from end to end. At that time there was still sufficient strength to support the weight of two men jumping upon the shell on one side of the centre. This fact is mentioned merely as indicating the considerable degree of toughness in the structure.

In all the tests previously described the failures were entirely local in nature, and the thing that had been feared—that due to the absence of radial reinforcement a fracture at one point might drag down the entire ring and all that portion of the structure within the ring—was not realised.

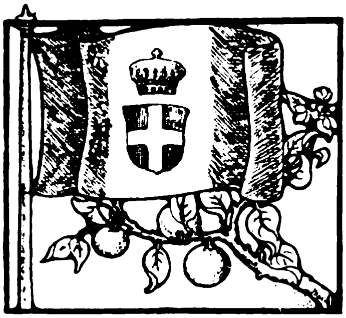
TABLE 1.—DATA OF IMPACT TEST NO. 1.

Drop No.	Height Dropped.	Deflection, in.	Remarks.
	ft. in.		
1	4 0	0·16±	
2	6 6	0·33±	
3	6 8	0·41±	
4	6 8	0·55±	A few radial cracks at centre and edges of keystone chipped.
5	6 8	0·67±	Edges of keystone broken off.
6	6 8	1·0	Appearance of diagonal tension starting about 15 in. from centre.
7	6 8	—	Punched small hole in centre.

In order to find out how much lateral thrust was required to produce this lateral deflection of the walls a test was made after the dome had been wrecked and removed from the supporting walls. In this test a horizontal load was applied at the middle of the side walls close to the top of the wall.

The test of the walls by application of horizontal load indicates that even if the action of the dome required considerable elongation of the span, there was not sufficient stability to the walls to resist this increase in the span length. On the other hand, the small deflection of the non-resistant supporting wall under the action of the vertical load upon the dome indicates that even if supporting walls of such a structure are capable of resisting considerable horizontal thrust, only a very small amount of horizontal deflection (or lateral movement of the support) is necessary to relieve the thrust to be resisted, and to relieve the walls of the necessity of carrying the thrust.

On the basis of the data recorded in this paper an attempt was made to analyse the action of a flat dome of this type. It seems that there are certain laws of action disclosed, and yet there are inconsistencies which prevent a great deal of dependence on conclusions, and no analysis is presented. In a general way, however, the test has afforded data from which it is believed the action of such a structure may be predicted to a certain extent. The test has indicated that a structure built after the manner of the dome tested is feasible and exhibits considerable toughness. For cases in which a large unobstructed space with a domical ceiling capable of carrying a load on the floor above is desired it seems that there are possibilities in such construction as that described. In any contemplated use of such a structure it is obvious that a circular plan would be more advantageous than a square plan, and that a square plan would be more advantageous than a rectangular plan.



SOME NOTES ON RECONSTRUCTION FROM ITALY.

For the following particulars and illustrations we are indebted to the Italian Journal "Il Cemento."—ED.

AMONG the numerous suggestions for the reconstruction of localities devastated by the war it is only natural that the use of concrete—both plain and reinforced —should play an important part. It is particularly adapted to this because it avoids the permanent use of timber, which is becoming increasingly difficult to obtain, and it requires a far smaller proportion of metal than any other form of constructional iron or steel work. In addition, concrete structures can be

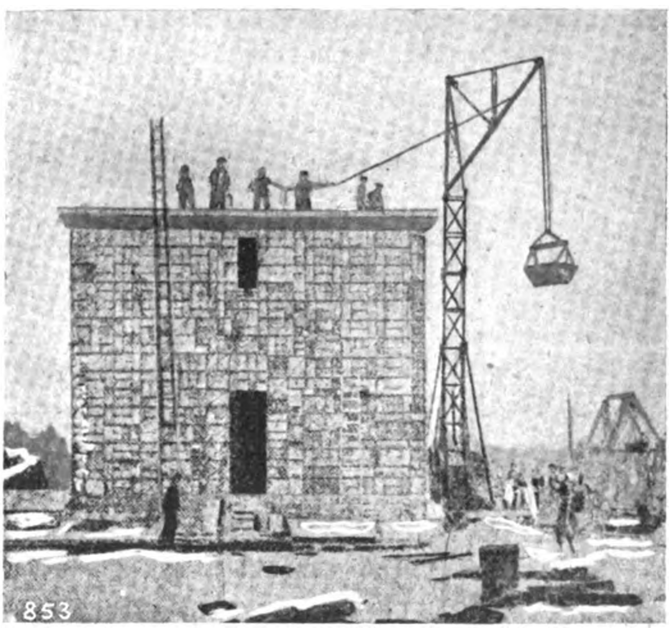


FIG. 1. MONOLITHIC HOUSE DURING CONSTRUCTION.

built rapidly with much less skilled labour than is required for the production and erection of brickwork or the quarrying, dressing, and laying of masonry, so that there is every likelihood of the use of concrete being extended in a remarkable manner.

The use of plaster has been contemplated in Italy, the material being

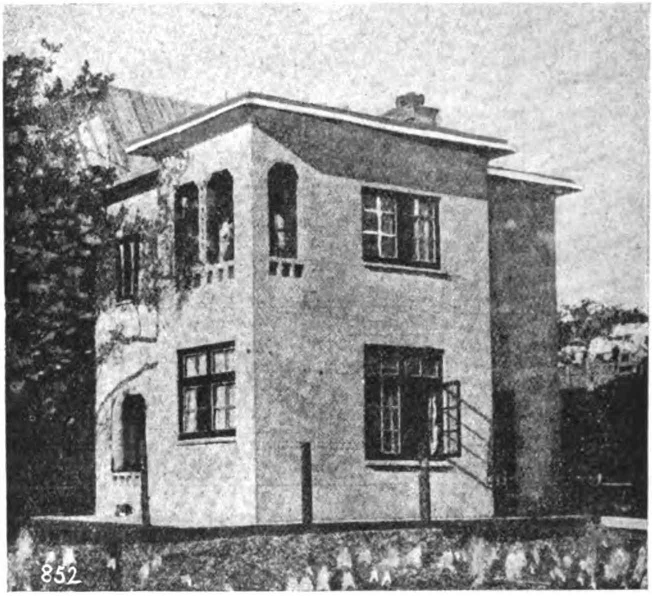


FIG. 2. MONOLITHIC HOUSE WHEN FINISHED.

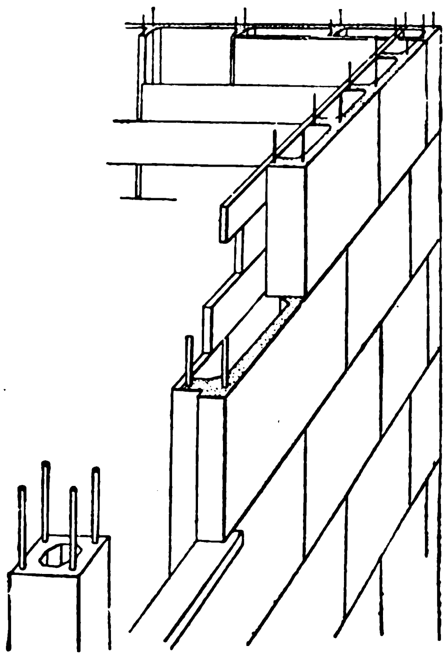


FIG. 3. SOULAR'S METHOD OF CONSTRUCTION.

employed in connection with a fine lattice or network reinforcement in order to give the requisite strength. The objection to this material in more severe climates is its lack of durability, and in any case it requires more metal and is inferior in strength to reinforced concrete. A similar criticism applies to the use of hydraulic limes and slag cements.

In order to reduce the cost, increase the rapidity and ease of construction, and to avoid the use of an unnecessary quantity of materials, it is necessary to calculate accurately the loads on each part of the structure and to see that they are properly distributed. The correct proportions of gravel, sand, and water must also be used. The structure must be monolithic in character, and simple yet robust in design.

A difficulty arises in connection with the wood required for the forms. This may, according to a writer in *Il Cemento*, be reduced by using a concrete which is fairly fluid but sufficiently viscous not to permit the ingredients to separate, and somewhat quick setting.

If sufficient skill and care are used a building with a ruberoid roof such as that shown in *Figs.* 1 and 2 can be finished in a couple of weeks.

Another type of construction in reinforced concrete recommended by a writer in *Il Cemento,* which can be erected rapidly and with a minimum of timber, is shown in Fig. 3, and needs no description.

MEMORANDA.

Association of Municipal Electrical Engineers (Union of South Africa).— In the course of his presidential address to the Association at their second annual convention, Mr. John Roberts made the following references to reinforced concrete. Referring to the construction of poles he said :—" Owing to local supplies of cement the cost of concrete has not advanced much, and we have adopted in certain instances concrete poles in place of steel or cast-iron poles we used to employ. These, we find, have advantages as regards durability. Steel poles being practically unprocurable, we have also adopted wooden poles (Jarrah), but the price of these is also advancing at a very formidable rate."

Dealing with reinforced concrete generally, he went on to say :—" We have been carefully studying the possibilities of the substitution of this material for steel and iron wherever possible, and I have already referred to it under the heading of poles. We are now considering it for the making of tanks, etc., and have planned to build a new condensing water pipe line of reinforced concrete pipes 21 in. in diameter. The local cement, though slow in setting qualities, gives quite satisfactory reinforced concrete results."

NEW BOOKS
AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

Houses for Workers.

Technical Journals, Ltd.

It is very rare, even in these times of war, for six months to pass without one or more books appearing that deal with the designing of small cottages and houses.

Notwithstanding this fact, the volume before us supplies a distinct want and, coming at a most opportune time, should find a place on the desk of everyone interested in the housing of the worker.

Briefly, the book is divided into three sections, which deal respectively with :—

(*a*) Cottages for rural and urban workers.

(*b*) The housing scheme for munition workers at Well Hall, Kent.

(*c*) The new Duchy of Cornwall housing scheme at Kennington.

The first section contains plans, sections, elevations and illustrations of houses suited to all neighbourhoods and all classes of workers, and a description of materials used, and the cost price is printed on each sheet. These costs are, of course, far below what they would be to-day or will be after the war, and we would suggest that any further addition or amplification of the work should have the date of erection printed after the cost of the work.

We would also have liked to have seen a greater number of cottages built of concrete or concrete blocks, for when, after the war, reconstruction commences, concrete will be called upon to play its part. Where sand and gravel suitable for the aggregate are on or near the site the use of concrete will, besides tending towards cheapness, help to lighten the difficulties of transit which will be felt for long after hostilities have ceased; and therefore if, as we hope, a further edition is called for, a fourth section dealing with these constructions should be added.

The second section is an interesting example of a housing and suburban planning scheme carried through in a few months, and will, we believe, have great influence on schemes for model villages that may be mooted in the near future.

All types of houses are illustrated, and the drawings give a great deal of information; but, whilst admiring the picturesqueness of the individual blocks, we would have preferred to have seen a scheme so near to Woolwich carried out more on the lines of that in the third section of the volume.

Here an architectural character based on late Georgian "motifs" has been given to the whole, which comprises flats, shops, old tenants' hostel, a crêche, and a vicarage.

The buildings are modern in planning and construction, flats roofs being used in many cases; but by careful choice of facings and care for proportion the architects have produced buildings that, whilst being suited to the urban worker, yet have that indefinable old-world atmosphere that clings to so many of the older districts of London, and possesses a charm which so far we have not met with in the garden cities that we have visited.

Beyond these three sections, valuable information is contained relative to the small holder's house, arrangement of rooms to avoid draughts, and other constructional details which will be useful to the designer who is called upon to help in the building of the thousands of dwellings that will have to be erected in the near future.

Modern Underpinning. By Lazarus White and C. E., and Edmund Astley Prentis, Jr.

Wiley & Sons, New York. Chapman & Hall, London. 7/- net.

It is rather a surprising thing that in these days, when there are generally at least a dozen standard works on every subject (which overlap each other and cover the same ground), so few books dealing with shoring and underpinning have been published.

We therefore welcome this volume, which gives a description of the most modern methods of dealing with this difficult subject, and is, as the publishers explain, a manual of practice, the theoretical questions being assumed to be common knowledge to the reader.

The work is an able exposition of the difficulties met with in the building of the New York subways and the means taken to overcome them, and is illustrated with numerous constructional details and photographs of the actual work.

Although the heavy skyscraper type of structure is not built in this country, many of our modern buildings transmit enormous weights to their foundations; and the ever-increasing tendency to go deeper in our new structures, and the provision of shallow tubes and subways, will tend in the near future to raise problems in the solution of which this book should be a great help.

Terms of Industrial Peace. By Alex. Ramsay.

Constable & Company, Ltd., London. 3/- net.

Of the books that have been written relative to industrial reconstruction after the war the name is legion, but notwithstanding the fact we cordially welcome this volume, for unlike so many of the works on this subject, one feels in laying down the book that the author has no ulterior personal axe to grind.

That some common meeting ground must be found for capital and labour is evident to everyone taking an interest in the industrial work of the Empire, and unless an agreement can be made between them and a code of rules absolutely binding on both parties formulated, the future may well see our foreign trade sapped at its foundations by petty jealousies and civil strife.

In the work before us the author discusses the so-called exploitation of the employee by the employer, also the limitation of output practised by the former, and outlines a basis on which all troubles might be settled.

His premises have undoubtedly a basis in fact, his conclusions are worthy of study, and although agreeing in the main with him, we cannot foresee their application without a wider and broader education of all classes of the community.

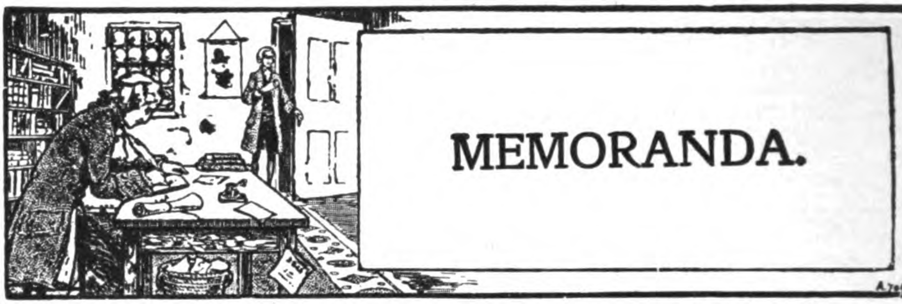
Meanwhile we recommend the book and trust that it will be widely read; and we would suggest that every employer, after reading it, should see that other copies are distributed among his workmen, for only by a mutual understanding and a willingness on both sides to surrender some of their assumed privileges can a settlement be reached that will lead to industrial peace.

MEMORANDA.

Fire Tests of Reinforced Concrete. —Having conducted fire tests of reinforced concrete in 1910, the Materialprüfungsamt, of Gross Lichterfelde, near Berlin, undertook new tests in 1914-15, on which Professor M. Gary has recently reported in the publication of the *Deutsche Ausschuss für Eisenbeton.* Two houses were erected 4 m. by 4 m., 8 m. high, the chief materials being reinforced concrete prepared either with crushed granite or with crushed basalt. The particular points investigated were: Resistance of the concrete to internal fires, heat transference through the concrete, strength of the reinforced concrete structure before and after the fire, and behaviour of the structure during demolition.

The report is not available, but from the *Schweizerische Bauzeitung* it is seen that the houses stood the repeated, severe tests surprisingly well, better even than experts expected. The stairways of reinforced concrete and also of artificial stones proved excellent, and the mechanical properties of the iron were hardly impaired, although the temperature of the iron rose to 350 deg. C.

The one unsatisfactory and, so far, unexplained feature was that fairly big pieces of hot granite concrete sometimes flew off with almost explosive energy. This point is to be further investigated in the experiments, which have already been resumed.



Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

The Use of Concrete and Timber for Artificial Mine Roof Supports.—The Transactions of the American Institute of Mining Engineers contains a paper dealing with the Resistance of Artificial Mine Roof Supports, by Mr. Wm. Griffith, C.E., Scranton, Pa. The paper is printed fully in the *Colliery Guardian,* from which we abstract the following notes :—

The purpose of this paper is to make public record of new information in regard to the sustaining power of artificial mine roof supports (not timber props), the result of investigations recently made in the anthracite coal fields of Pennsylvania: (1) By the "Scranton Mine Cave Commission," appointed to investigate the mining conditions under the City of Scranton; (2) by the "Pennsylvania Mine Cave Commission," appointed by the Governor to investigate the general subject of mine caves in the anthracite region of Pennsylvania; (3) by the personal researches and tests made by the author in an effort to secure a better artificial mine roof or surface support.

The author, during his connection with the Scranton Mine Cave Commission, observed that of all the various devices employed for sustaining the roof of coal mines, the one universally used and the best known—the "timber cog," consisting of a cribwork of logs filled with mine rock and rubbish—was possessed of comparatively small resistance under the initial pressure, but withal was exceedingly elastic, its sustaining power increasing rapidly under compression. Such cogs or cribs would not fail completely until the compression amounted to one-third or one-half the original height of the structure.

The kind of roof support that seemed to have the greatest initial resistance was found to be concrete piers, which, although somewhat costly, are nevertheless used to a small extent in some portions of the anthracite region; but the tests showed that such rigid piers would fail completely when the load upon them was sufficient to cause a compression of about 3 per cent. of the total height, and this failure of concrete piers under pressure was sudden and without warning, thus being a menace to the safety of the miners.

It was desirable, therefore, if possible, to devise some sort of artificial roof support which would partake of both the elasticity of the timber cog and the rigidity of the concrete pier, and the author tested a number of devices in order to accomplish this end. The result of this series of tests was the production of what is referred to in this paper as "Griffith's mine pier," which consists essentially of a timber crib, each element or member of which is provided with a series of notches, and which may be framed in quantity, by machinery, and creosoted outside of the mine, so that the crib may be easily erected inside, the members fitting together one upon the other and forming a rigid cribwork. Concrete is poured into this crib, thus forming an artificial mine pier of simple construction, yet having an initial resistance equal to a concrete pier of the same dimensions, but which is so elastic that it will not fail under pressure until the total compression amounts to nearly 15 per cent. of the original height, and the ultimate load sustained is equal to about three times the ultimate strength of concrete piers of the same dimensions, and about 20 times the resistance of the well-built timber cog. We have thus produced a concrete pier reinforced with notched timbers, in the manner described.

The variety of concrete proved by the tests to be most efficient seems to be the cheapest mixture that can be made—viz., cyclopean concrete composed of pieces of mine rock as large as can be conveniently handied by one or two men; the interstices between these pieces of rock being filled with ordinary concrete grouting, composed of cement, sand, and small broken stone, the object being to secure the greatest density possible. In preparing the crib mentioned, the notches in the timber should be of sufficient depth—that is, nearly one-fourth the thickness of the timber—so that when the crib is finished the timbers will be separated by a space of about 1 in. or less. This permits the grout to flow in and partly fill the space between the timbers during the course of construction. After the structure is completed the unfilled spaces may be pointed with a trowel. from the outside, after which the outside of the pier may be coated with cement by the use of a cement gun or any other device.

It will be impracticable to build such a crib tight against the mine roof. There will be a small space which should be filled by ramming with dry concrete—that is, concrete with a small proportion of water. Thus will be formed a very lasting mine pier, because each timber will be surrounded or embedded in concrete, and if the timbers are first creosoted the construction should be very durable.

In nearly all cases it was found that there was an elasticity of about 3 per cent. in the pier when the load was removed. In other words, the height of a tested piece, after the load was removed, was about 3 per cent. more than the height under greatest pressure. Some of the piers were tested the second time, and sustained the same weight, under the same compression, as in the first test.

There are many localities and circumstances in coal and metal mines where strong, elastic roof supports of this sort would be exceedingly useful, and the cost of placing the same for such emergencies would not be excessive.

Since it is a practical impossibility to introduce artificial roof support in a mine in such a manner as to prevent minute subsidence, it is necessary to assume a certain amount of surface settlement as permissible.

The Institution of Civil Engineers.—The following is a short abstract of a paper read at the ordinary meeting of the Institution on Tuesday, November 20th, 1917, by Sir Robert Richard Gales, F.C.H., M.Inst.C.E., regarding the construction of the Hardinge Bridge over the Lower Ganges at Sara. The Hardinge Bridge connects the standard 5 ft. 6 in. gauge system of the Eastern Bengal Railway south of the Ganges with the metre-gauge system north of the river. It comprises fifteen girder spans of 345 ft. 1½ in., with three land spans of 75 ft. at each end.

The paper deals first with the conditions of the site, in the recent delta of a great river. A short description of the delta is given, and attention is drawn to the desirability of the construction of certain railway connections for traffic reasons, and for the purpose of creating a tendency to further stabilisation of the course of the river.

The local choice of site and the design and construction of the training-works considered necessary to render permanent the channel of the river in the immediate vicinity of the bridge are then described, and the particulars given show that the training-works alone constitute a work of great size.

The considerations on which the main dimensions of the bridge have been based are detailed, and attention is drawn to the very large flood-discharge, which appears to challenge comparison with that of any river yet bridged.

The magnitude of the work, the high and increasing cost of Indian labour, and the importance of rapid completion, indicated the desirability of making greater use of modern plant and special methods of construction than had hitherto been considered economical in India; and the paper describes the methods of construction adopted, which, briefly, were the laying down of electric power-plant and the use of electric power throughout the bridge, the use of cement concrete blocks in the steening of the well foundations, thereby ensuring great weight in the wells and rapidity in building and sinking, and the employment of a temporary service girder of large span for girder-erection in the water spans, thereby ensuring greater certainty and rapidity of construction and a longer working season than was possible with timber staging under the conditions obtaining.

The rate of construction and details of cost are stated, and, it is believed, show that the bridge was constructed both rapidly and economically.

The paper also gives a description of the temporary service works and of the medical and sanitary arrangements, which may be of use to engineers who have large works to carry out in similar conditions of isolation and climate.

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Concrete and the Rebuilding of Poland. — In a recent issue of the *Architect and Contract Reporter* an article appeared on the above subject, by Mr. A. E. Gurney, who has been in practice as an architect in Warsaw for some years. Mr. Gurney opens his article by pointing out "what a gigantic task the rebuilding of Poland represents and what possibilities it opens up for enterprising manufacturers in this country." He continues to say that "The destruction of property in Poland has been incomparably greater than in any of the other territories invaded," and this he attributes to be due "to a great extent to the manner in which the Polish towns and villages were laid out and the materials of which the buildings were constructed." The houses in the villages, domestic and otherwise, were built almost entirely of timber, the roofs being sometimes covered with shingles, although thatch was more commonly used. Some of the churches, and even the larger residences, were built of wood (mostly larch) and covered with plaster. In view of the above remarks it is somewhat interesting to note that in making their recommendations for the rebuilding of Poland the "Architects' Circle" of that country should urge again that timber be used in large quantities even for walls, and that "no new materials be made use of," and they have strongly opposed the use of concrete blocks and cement brick. It is not surprising that the 'Circle of Ferro-Concrete Engineers" shortly after issued a declaration protesting against these recommendations, as they are strongly of opinion that concrete blocks for the construction of walls had been too hastily condemned, as they had been greatly improved of late and all their alleged shortcomings had already been removed. The "Circle" laid stress on the generally admitted fact that these blocks greatly facilitate rapid building, and that their adoption would represent a great saving of time and money—two factors which would be of the utmost importance in the work of reconstruction.

There can be no doubt that if an improved kind of blocks—free from the defects which those hitherto known undoubtedly possessed—could be devised, they would be very welcome, and very extensively made use of. The chief objection to all concrete blocks which have so far been put on the market is the circumstance that frost penetrates through the walls built of them, and that these are cold and damp. This was found to be the case even with walls constructed of blocks having two or even three rows of channels.

The ferro-concrete engineers strongly recommended the general adoption of concrete and reinforced concrete mangers, drinking-troughs, sections for constructing wells, paving slabs, reservoirs, fencing posts, etc. They added the very apposite remark that "only the intelligent application of technical improvements, on the land no less than in every other field of productive labour, can assure success in the struggle for existence, not only to individuals, but whole nations."

Mr. Gurney closes his article with the following remarks:—

"Any firms desiring in the future to do business with Poland should, if they do not wish to be forestalled, take the requisite preparatory steps at once, as it must be borne in mind that the task of rebuilding will be an extremely urgent one as soon as peace is restored. The indestructible vitality of the Poles, which has so wonderfully outlived innumerable trials in the past, will be augmented by these new conditions—the reunification of their dismembered territories and restoration of their independence will intensify their natural energy, and their remarkable resourcefulness will assist them in devising means for pushing forward the work of reconstruction with the utmost celerity.

"It is sincerely to be hoped that Great Britain will play an eminent part, not only in the political, but also the material reconstruction of Poland, and that that sorely tried country will in future enjoy greater power, prosperity, and happiness than at any time in the past."

Reinforced Concrete Dry Docks. —Of the two big dry docks to be built at either end of the Panama Canal, the one at Balboa is to be the larger. This dock will be 1,000 ft. long, the entrance width will be 110 ft., and at mean low water the depth over the keel blocks will be 29·3 ft. The structure will be of concrete, and the entrance will be closed by mitre gates. Here it will be possible to repair the largest vessels afloat, as the main repair shops in the canal are also situated at Balboa. This dock is to be completed this year. The dock that will be built at Christobal, on the Atlantic side of the canal, is to be begun very shortly, and will be 300 ft. long.

Decimal System.—We are asked to call attention to a book by Mr. F. J. Shaw containing decimal, discount, and commission tables. The book costs 2s. 1d. (post free), and is obtainable from Mr. Shaw, at St. Hugh's Chambers, Corporation Street, Lincoln, or at any bookseller's.

TRADE NOTES.

Waterproofed Cement.—Owing to the scarcity of metals, the necessity frequently arises of finding substitutes for use on work which cannot be delayed. The dome of the National Museum of Wales, at Cardiff, has been made watertight with a rendering of waterproofed cement as a temporary measure. When the war is over it will be covered with lead as originally intended. The architects (Messrs. Smith and Brewer) state that the Pudloed cement rendering has proved quite satisfactory, which again shows that the uses of waterproofed cement are many and varied.

Barimar Welding Process.—The Board of Trade have now given formal sanction to a new company, with works in London and Liverpool, and known as the British Barimar-Thermit Welding Co., Ltd., to take up and exploit the Thermit welding process, which, prior to the war, was exclusively in German hands. Thermit is specially applicable for tramway welding and for the repair of heavy castings and machine parts, and it is the intention of Mr. C. W. Brett, the managing director and general manager of Barimar, Ltd., scientific welding engineers (who is largely responsible for the formation and management of the new company), to train disabled British soldiers and sailors to carry on the work. The registered offices of the new company are at 10, Poland Street, London, W.1.

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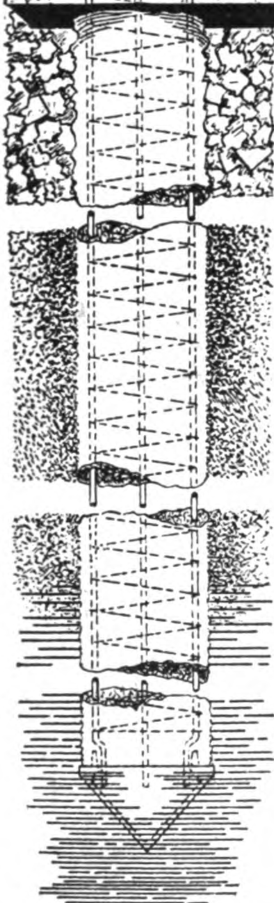

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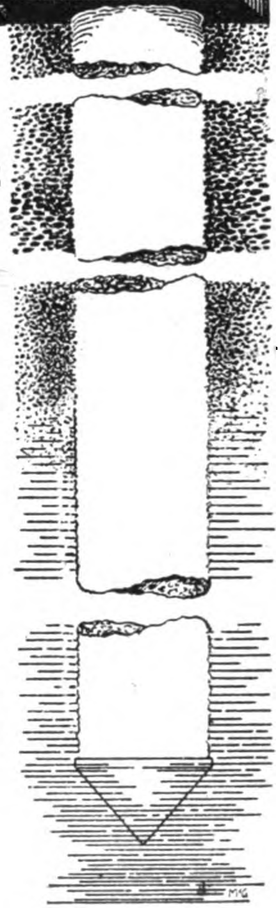

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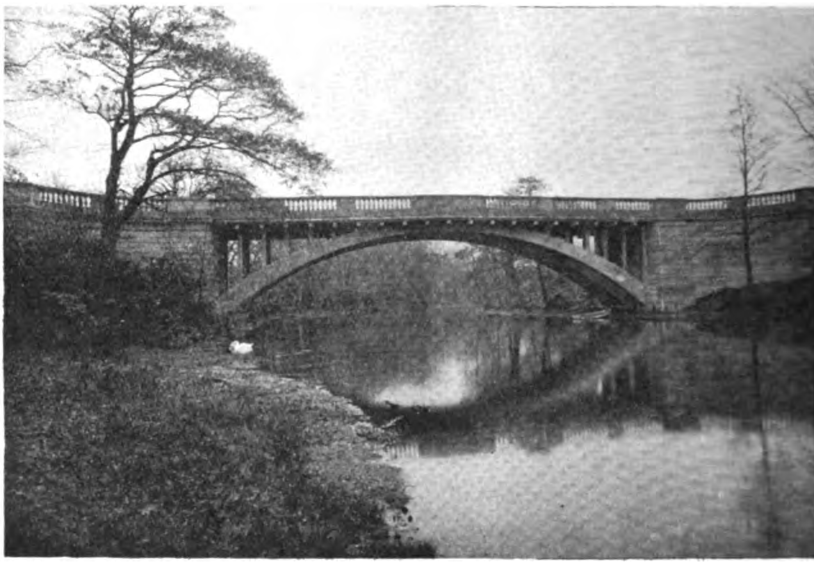

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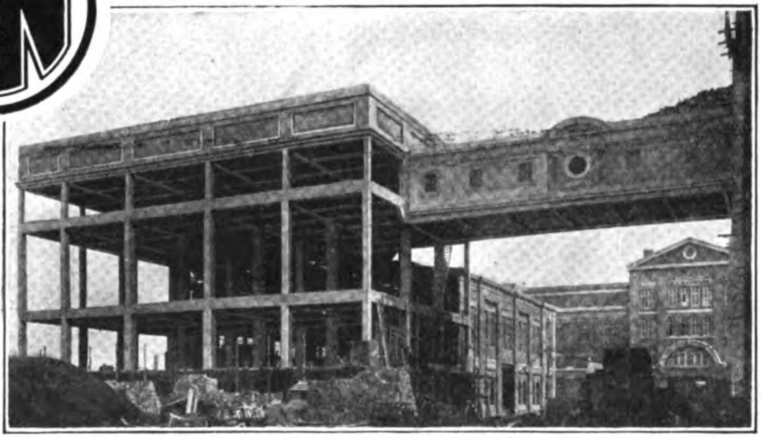

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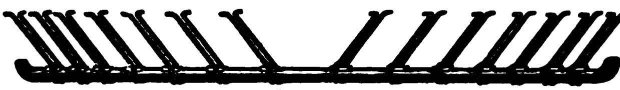

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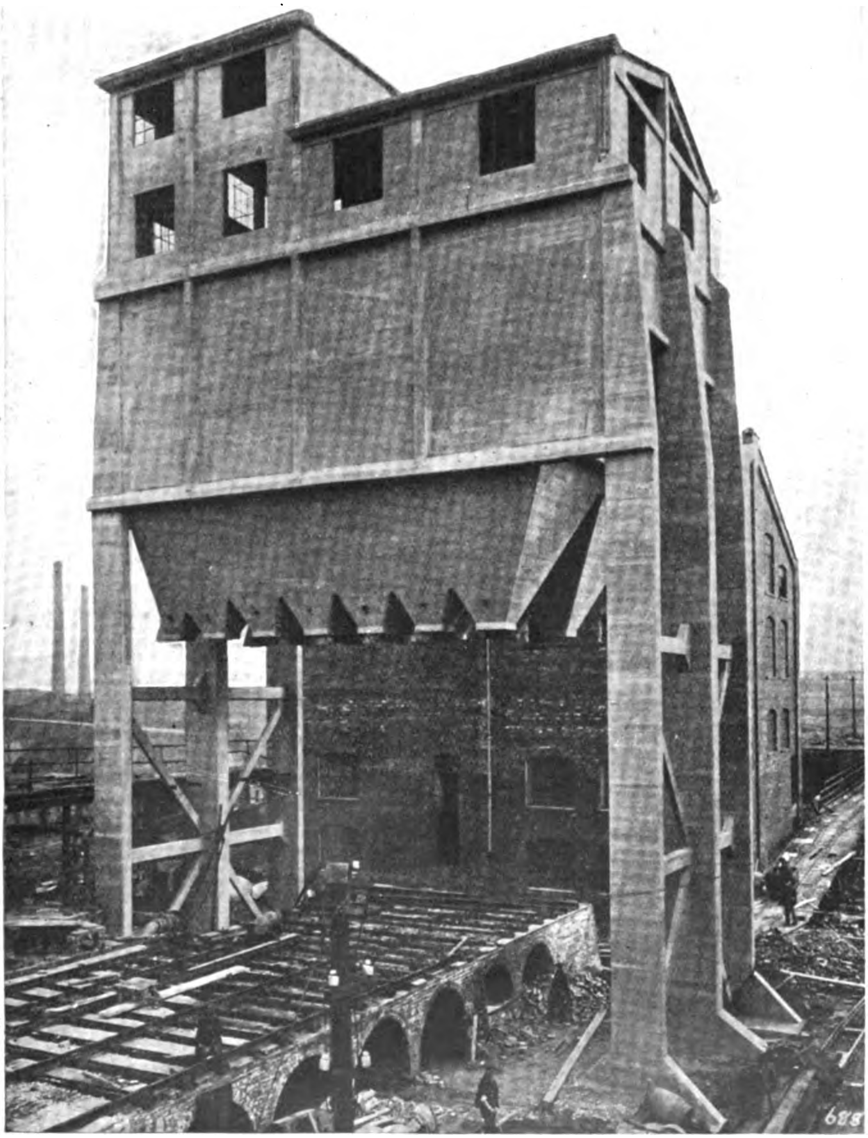

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