Reinforced Concrete in Europe

BY

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Reinforced Concrete in Europe

INCLUDING

ITS APPLICATIONS, ECONOMIES, AND ENDURANCE; THE SYSTEMS, THE FORMS OF BARS AND THE METAL USED IN ENGLAND AND ON THE CONTINENT,

TOGETHER WITH THE PRINCIPAL

SPECIFICATIONS FOR THE CEMENT, AND THE CONCRETE USED, AND THE RULES GOVERNING FOREIGN REINFORCED CONCRETE CONSTRUCTION,

TO WHICH IS ADDED

A LIST AND DESCRIPTION OF THE FOREIGN OFFICIAL AND TECHNICAL INSTITUTIONS WHICH HAVE STUDIED REINFORCED CONCRETE CONSTRUCTION AND ABSTRACTS OF THEIR RECOMMENDATIONS

AND FINALLY A COMPLETE

BIBLIOGRAPHY OF BOOKS AND PERIODICALS ON REINFORCED CONCRETE, CONCRETE AND CEMENT

BY

ALBERT LADD COLBY

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South Bethlehem, Penna.
July, 1909.

PREFACE.

A private edition of fifty copies of this Report was printed last May for distribution to the Subscribers.

In response to numerous requests, permission has been given to the Printer to reprint the Report for sale by him as a Book.

The Report is a compilation of information, on current practice in Reinforced Concrete Construction in Great Britain and on the Continent, collected during 1908, chiefly by personal interviews, with the leading authorities in each Country.

The theoretical branches of the subject, including the rules for calculation, are but briefly referred to, because elaborate Treatises in English, French and German, recently published, deal with the latest practice of each country in these matters.

The practical branches of the subject, on which the Subscribers desired information, are fully treated, including the economy and proof of the endurance of foreign Reinforced Concrete Construction, the Systems used Abroad, the specifications for the cement used, the ingredients and the mixing of the concrete, and the rules governing construction; much space is devoted to the kind of steel and the forms of bars at present in vogue Abroad, as the writer was requested to give particular attention to these two subjects.

The addresses of prominent consulting and contracting engineers of each country, are given, to enable the reader to obtain further information, if desired.

In Appendix No. 3, the addresses are given of the official and technical testing Stations, Congresses, Institutions, Associations and Committees of each Country, which are giving particular attention to this subject and from whom additional information can be obtained.

Besides the discussion in the body of the Report, of the forms of bars used in the Systems of each Country, an alphabetical list of 144 Foreign Systems, is given in Appendix No. 1, with a concise description of the special feature and the address of the inventor or owner of each System.

In Appendix No. 2, a comparison of the requirements of 14 foreign Cement Specifications is given.

A complete Bibliography of the Books, Journals, and Periodicals of each Country will be found in Appendix No. 4, with the price and the date of publication.

As the information contained in this Report was obtained from many sources, any, in fact, which were proved by inquiry or known to be reliable, only a general acknowledgment can here be made of the writer's indebtedness; in the text of the Report and Appendixes, reference is given to the source of information in most cases.

The writer visited England, France, Germany, Austria, Hungary, Switzerland and Italy, and desires to here record his appreciation of the courteous attention to his inquiries, accorded to him in each Country.

ALBERT LADD COLBY.

South Bethlehem, Pa., July, 1909.

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ECONOMIES OF REINFORCED CONCRETE CONSTRUCTION.

FOREIGN OPINIONS AS TO THE ACTUAL SAVING IN COST OF ERECTION.

In compliance with the request to include in this Report information as to the *cost of erection* in reinforced concrete in comparison with other materials including steel, the writer submits the following as the result of his many interviews with leading authorities in England, France, Belgium, Holland, Germany, Austria, Hungary, Switzerland and Italy.

No exception was found to the opinion that in most cases the cost of erection in reinforced concrete was less than in any other material including steel, and in some classes of civil engineering work, and in the erection of factories, the saving was admitted to be phenominal.

As to actual percentage savings, statements varied from 10 to 30 per cent. and in one case 50 per cent.

One instance was cited of a warehouse which had been entirely constructed of reinforced concrete at a cost of not more than that of the *steel alone* which would have been required, if erected as a steel structure.

The best impartial opinion obtained, was from the Chief Commissioner of Works, who stated that he had reported to the British Parliament that, by employing reinforced concrete in lieu of ordinary materials, a saving of 20 per cent. had been effected in his Departments.

FOREIGN OPINIONS AS TO THE ECONOMIC FACTORS, BESIDES THE FIRST COST.

There are *other factors,* however, which should enter into any calculation of the Economy in this form of Construction, which, even when the original capital outlay for erection is not less, which is seldom the case, proves that reinforced concrete is ultimately by far the most economical.

From the information collected, the writer summarizes these factors as follows:

1. Its superior Fire-resisting qualities. This should be

looked upon as a large factor in the erection of Mills, Factories, Power Stations, etc., because the loss of the original investment by the burning of such a Building. is not nearly as great as the loss due to the cessation of manufacturing operations during the interval before the Building can be replaced.

2. Greater Rapidity of Construction.
3. Increase in some cases of the Interior Floor Space due to thinner walls and partitions.
4. Decrease in cost of Maintenance due to its being practically indestructible, especially when compared with structures of wood or steel.
5. The monolithic nature of Reinforced Concrete Structures makes them less liable to shock and vibration.
6. Decreased rate of insurance, due to its superior fire resisting qualities.

The recent Improvements in the Finish and Exterior Decoration, including Coloring, which have been made in reinforced concrete construction are leading to its increased adoption abroad by Architects who have heretofore hesitated to use it, although fully convinced of its economy.

ENDURANCE OF FOREIGN REINFORCED CONCRETE CONSTRUCTION.

The Writer was requested to report upon the *Endurance* of Foreign Reinforced Concrete Construction and after a study of the data collected, has subdivided this question under the following headings:

1. **RESISTANCE TO ATMOSPHERIC CHANGES.**

   Explanation of the cases where deterioration has occurred.
   Proof of durability.

2. **RESISTANCE TO FIRE.**

   The terms "Fire-proof" and "Fire-resisting" defined.
   Standards of fire resistance.
   Foreign Fire-test Committees.
   Degree of fire-resistance dependent upon the aggregates of the Concrete.
   Reinforcing metal must be covered with two inches of Concrete.
   Coefficient of expansion of concrete and steel.
   Good reinforced concrete is the most practical form of fire-resisting construction.
   Recommendations of the International Fire Service Congress, Milan, 1906.
   Rules on fire-resistance of the Joint Committee on Reinforced Concrete, adopted by the Royal Inst. of British Architects, May, 1907.

3. **RESISTANCE TO SEA WATER.**

   Proved by the recent adoption of Reinforced Concrete for "Sea Defences" in Holland.
   Early failures due to "Voids" in the Aggregate.

4. **RESISTANCE TO ABRASION.**

   Proved by the increasing use Abroad, of Reinforced Concrete for piers and bridge abutments exposed to the abrasion of running water and to tidal waters.

5. **RESISTANCE TO VIBRATION.**

   Proved by the general adoption of Reinforced Concrete

Abroad, for machine shops, power-houses, etc., including even the beams carrying the shafting.

6. **RESISTANCE TO SHOCK.**

Proved by a test made by the Paris and Orleans Railway Co.; by the resistance of foreign reinforced concrete Piles to deep driving and of Dykes to the beating of heavy waves.

7. **RESISTANCE TO EARTHQUAKES.**

Proved by the resistance to the Earthquakes of Jamaica and San Francisco, of reinforced concrete structures.

8. **RESISTANCE OF EMBEDDED STEEL TO CORROSION.**

Proved by quoting important authentic instances Abroad, where iron or steel, embedded in concrete for hundreds of years, has shown no evidences of rust, and more recent foreign experiments and experiences also proving that properly made concrete is the best known protector of unpainted steel against corrosion.

9. **CAUSES OF THE ACCIDENTS AND FAILURES IN REINFORCED CONCRETE CONSTRUCTION.**

The collapses occurring in the United States during 1905-1907.

The most important European failures.

Conclusions drawn from a study of foreign failures.

(1) Number of failures Abroad are comparatively very few.

(2) Failures Abroad have almost always occurred during construction.

(3) No failures Abroad could be traced to lack of durability or inherent weakness in reinforced concrete construction.

(4) Defective designs have caused a number of early foreign failures, but defective designs in all-steel structures have caused failures—(Quebec Bridge).

(5) The use of unsuitable materials (which are itemized) has caused some foreign failures.

(6) Some early foreign failures have been due to careless

or inexperienced workmanship, even where the design was good. (The usual mistakes are itemized).

(7) Applying "Test Loads" or using floors up to "Maximum Allowable Load," before the concrete has had time to harden, has caused some failures Abroad. Foreign Practice now requires a lapse of 2½ to 3 months.

(8) That reinforced concrete gives long prior notice of the approach of failure, is proved by citing certain foreign tests.

(9) Conclusions showing that Abroad, the present enforcement of good Building Laws, the wide publicity of the theories and principals involved, and the rules governing the materials used, will reduce to a minimum, future failures Abroad in reinforced concrete construction.

I. Resistance to Atmospheric Changes.

Its rapidly increasing adoption, in all parts of the world, is proof that Reinforced Concrete construction resists a wide variation in temperature and *climatic conditions,* if expansion joints are provided for in the design and if the Concrete is made of proper materials.

One instance of deterioration, due to poor materials, is that of the failure of some open cattle sheds in Egypt located at Mex about 65 feet from the Sea, and where they were exposed to climatic extremes. Through the use of a local non-silicious limestone in the mixture, the reinforced Concrete roofs soon became neither air-tight nor water-tight.

Proof is given, when discussing the resistance to corrosion afforded to the reinforcement by a good Concrete, that it affords perfect protection against rusting; hence what is true of the resistance of plain Concrete to atmospheric changes, is equally true in reference to reinforced Concrete.

The present confidence in Concrete (a material largely employed by the Romans for Buildings still existing) is evidenced by the vast number of great Engineering Works, in England and on the Continent, such as Reservoirs, Dams, etc., requiring *unquestionable durability* and for which Concrete has of late years been chosen in preference to rock or Masonry—a proof of the well recognized resistance of Concrete to atmospheric changes.

2. Resistance to Fire.

Before quoting foreign opinions as to the resistance of reinforced concrete to fire, attention should be drawn to the misuse of the term *"fire-proof"* and to the following Universal Standards of Fire-resistance adopted at the International Fire Prevention Congress, London, 1903.

The following were the Congress Resolutions referring to the subject:

Re the term "Fire-proof."

The Congress having given their consideration to the constant misuse of the term "fire-proof," and its indiscriminate and unsuitable application to many building materials and systems in use, have come to the conclusion that the avoidance of this term in the general business and technical vocabulary is essential.

Re the term "Fire-resisting."

The Congress considers the term "Fire-resisting" more applicable for general use, and that it more correctly describes the varying qualities of the different materials and systems of construction intended to resist the effect of fire for shorter or longer periods, at high or low temperatures, as the case may be; and it advocates the general adoption of this term in the place of the term "fire-proof."

Re Standards of Fire-resistance.

The Congress confirms the British Fire Prevention Committee's proposed standards of fire-resistance, and hereby resolves that the universal standards of fire-resistance shall in future be:

1. Temporary protection;
2. Partial protection;
3. Full protection;

in accordance with the Committee's schedule.

Abroad the only *independent* tests undertaken to show the fire-resistance of materials of construction are those conducted by the British Fire Prevention Committee, No. 1 Waterloo Place, Pall Mall, London, S. W., and those of the Testing Station at the Royal Technical High School at Gross-Lichterfelde-West near Berlin.

From the official fire-tests conducted by these two Independent

Stations, as well as from actual fires (notably the Baltimore Conflagration), it has been proven that Concrete is eminently satisfactory wherever suitable aggregates were used.

The *degree* of the fire-resistance of Concrete is however dependent upon its aggregates, but where "full protection" to fire is essential, official tests have shown that a concrete can be readily furnished meeting the Standard requirements.

To reinforce such a concrete with steel does not lessen its fire-resistance, provided the steel is sufficiently embedded. Tests and Experience have established the rule Abroad, that the reinforcing bars or wire must be protected by at least two inches of concrete.

The *non-conductivity* of the concrete thus insures protection to the steel.

The effect of fire or water-quenching on unprotected or partly embedded structural steel is too well known to be commented upon, as is also the loss in the strength of the steel under high temperature.

Concrete and steel have practically the same coefficient of expansion and hence will be similarly affected by like changes of temperature. The actual figures for each degree Fahrenheit are .0000055 and .0000066 respectively.

The concensus of foreign opinion is well expressed in the following quotation.

> "If *reinforced concrete* is really well designed and carefully executed from a fire point of view, with a suitable specification of the aggregate, the aggregate size, the thickness of the covering to the steel, and the nature of the finely-ground Portland Cement, *no more practical form of fire-resisting construction could be desired than that of reinforced concrete.* But great care is necessary both in the correct specification and the execution of the work."

The importance of care, in every particular when "full-protection" against fire is desired, is brought out by the two following quotations:

INTERNATIONAL FIRE SERVICE CONGRESS, MILAN, 1906.

> "That the Congress considers that no reinforced concrete construction should be permissible in buildings intended to be fire-resisting, unless the aggregate be most carefully selected and applied in such a manner as to give substantial protection to all metal parts.
>
> That it is advisable where reinforced concrete is intended to be

fire-resisting, that every portion of the metal rods or bars contained therein be covered by not less than two inches of concrete, the aggregate of which must be able to pass through a sieve having a mesh of not more than one inch diameter, and that Portland cement of great fineness only be used.

That where feasible all external angles should be rounded.

That any angle iron needed for mechanical protection should be held in position independently of the concrete."

REPORT OF THE JOINT COMMITTEE ON REINFORCED CONCRETE, 1907.

"3. Fire-resistance.—(a) Floors, walls, and other constructions in steel and concrete formed of incombustible materials prevent the spread of fire in varying degrees according to the composition of the concrete, the thickness of the parts, and the amount of cover given to the metal. (b) Experiment and actual experience of fires show that concrete in which limestone is used for the aggregate is disintegrated, crumbles and loses coherence when subjected to very fierce fires, and that concretes of gravel or sandstones also suffer, but in a rather less degree.* The metal reinforcement in such cases generally retains the mass in position, but the strength of the part is so much diminished that it must be renewed. Concrete in which coke-breeze, cinders, or slag forms the aggregate is only superficially injured, does not lose its strength, and in general may be repaired. Concrete of broken brick suffers more than cinder concrete and less than gravel or stone concrete.

(c) The material to be used in any given case should be governed by the amount of fire-resistance required as well as by the cheapness of, or the facility of procuring, the aggregate.

(d) Rigidly attached web members, loose stirrups, bent-up rods, or similar means of connecting the metal in the lower or tension sides of beams or floor slabs (which sides suffer most injury in case of fire) with the upper or compression sides of beams or slabs not usually injured, are very desirable.

(e) For main beams a covering of 1½ inches to 2 inches of concrete over the metal reinforcement appears from experience in actual fires to afford ample protection to the structural parts. In floor slabs the cover required may be reduced to 1 inch. All angles should be rounded or splayed to prevent spalling off under heat.

(f) More perfect protection to the structure is required under very high temperature, and in the most severe conditions it is desirable to cover the concrete structure with fire-resisting plastering which may be easily renewed. Columns may be covered with coke-breeze concrete, terra-cotta, or other fire-resisting facing."

* The smaller the aggregate the less the injury.

3. Resistance to Sea Water.

Reinforced Concrete which has been used in several Countries for Sea Defences, has, of late, after a thorough investigation, been largely adopted in Holland for this purpose,—a proof that it is the best material available. The constructions in Holland include Dyke-Walls; Protection of the Slopes of Dykes; Protection of the Slopes of "Sand Dunes;" Piers and Breakwaters; and Foundations.

In England large Coal-Jetties, Wharves, Piers and Breakwaters have been built of reinforced concrete in preference to other materials.

Most of the early foreign failures of Concrete for Sea-Walls, Breakwaters, Jetties and like structures were due to the *voids* in the aggregate, or else to its not having been properly rammed.

Some failures however cannot be thus explained and while foreign engineers agree that it is evidently the best material at hand, earnest efforts are being made to discover the true action of sea-water on Portland Cement, Mortar and Concrete so as to make the material uniformly more resisting. In France, this subject has been studied by Feret, Michaelis, Candlot and Deval, and in Germany, by the German Portland Cement Manufacturers' Association.

4. Resistance to Abrasion.

The daily increasing use, by Foreign Engineers, of reinforced Concrete for bridges, the piers and abutments of which are exposed to *abrasion* by running waters, and its use in Sea Defences exposed to the abrasive action of tidal waters, are evidences of the satisfactory resistance of reinforced concrete to abrasion, in comparison with stone masonry and other available materials.

5. Resistance to Vibration.

That reinforced Concrete can withstand *vibration* is evidenced by the fact that it has been used Abroad for a large number of Machine Shops, Factories, Engine and Power Houses, because it has become generally recognized that, owing to the monolithic character of the structure, no detrimental vibration occurs. The reinforced concrete Posts and Beams of Machine Shops are used to carry the Shafting, in the same manner as Steel Stanchions and Girders.

6. Resistance to Shock.

The Engineers of the Paris and Orleans Railway Company made the following Test of the *Resistance to Shock* of a Floor made of Steel Beams with brick arches and of a Floor of reinforced Concrete, weighing only 60 per cent. per square foot of that of the other Floor.

A given Weight was dropped a certain height on the *Steel and Brick-arched Floor* and the amplitude and time of vibration was noted.

Another weight twice as heavy was dropped from a height twice as great on to the *Reinforced Concrete Floor,* and the amplitude of vibration was only *one-fifth* as much, and the vibration lasted only *one-third* as long as in the case of the *Steel and Brick-arched Floor.*

The fact that Reinforced Concrete *Piles* are driven without injury is a positive evidence of its ability to withstand *shock* as is also the success Abroad with which reinforced Concrete Dykes for Shore Protection have withstood the beating of heavy waves.

7. Resistance to Earthquakes.

At the Leland Stanford University at Palo Alto near San Francisco there was a Museum Building consisting of three wings, the central one of reinforced concrete, and the two side wings of brickwork, with reinforced concrete floor systems.

The building was not far from the line of the fault which caused the earthquake and it received a very severe shaking.

Capt. Sewell, Corps of Engineers, U. S. Army, stated that externally, the reinforced concrete wing appeared to be absolutely uninjured, except that some statues were shaken down from the front parapet wall, whereas the two *brick* wings were practically in a state of collapse.

An examination of the interior showed that some damage had been done in the reinforced concrete wing, in the shape of a few cracks here and there but he estimated that one thousand dollars would cover all the damage to this wing, whereas the two *brick* wings were damaged at least from *50 to 75* per cent.

The report of the Amer. Soc. of Civil Engineers on the San Francisco Disaster points most emphatically to the advantages of concrete and reinforced concrete under earthquake shock, not only for Buildings but in civil engineering work.

At Kingston, Jamaica, the concrete and reinforced concrete residence of Mr. Alfred Mitchell is reported to have withstood their earthquake shock. It is stated that although water in the baths and tanks was splashed over the sides of these receptacles by the shock, indicating the severity of the vibration, and the rooms containing such baths and tanks were, in fact, partly flooded, not a single crack or fissure was to be found in the concrete and reinforced concrete portions of the building.

8. Resistance of the Embedded Steel to Corrosion.

This subject could be truthfully dismissed with the statement that the metal is so perfectly protected, that rusting is not a factor in the endurance of proper reinforced concrete construction, so that none of the care and cost of maintenance required to prevent oxidation in a steel structure are necessary.

Some evidence supporting such a positive assertion should however be quoted, but out of many proofs it is thought that the following quotations of foreign experience and opinions will be sufficient:

THE SECRETARY OF THE ROYAL INST. OF BRITISH ARCHITECTS

in a letter, written Dec. 9, 1907, in answer to a Parliamentary inquiry and speaking for their Committee on Reinforced Concrete, gave this very positive testimony:

"It is sometimes thought that the *metal* may perish, but all experience shows that concrete is the best preservative for iron or steel known to us. A bar of iron or steel slightly rusty embedded in properly made concrete may be taken out after some months, or after hundreds of years, brighter than when it was put in. Perhaps I may quote an instance—the experience of Mr. Somers Clarke, late Surveyor to St. Paul's Cathedral, who, being anxious as to the condition of the great chain tie which binds the dome at its base, caused an opening to be made in the concrete in which it has been embedded for over two hundred years, and found the iron bright and perfect notwithstanding the fears which had naturally been felt because of the percolation of water from the gallery over it. This is but one of many examples, showing not only that metal reinforcements and concrete have been used by architects for many years back, but that their confidence in the durability of concrete and metal in combination is justified.

The many instances of the anchor chains of suspension bridges being embedded in concrete as a provision against their deterioration through the action of moisture, may also be cited as showing the reliance placed on concrete by engineers for the protection of steel from corrosion."

MARSH AND DUNN'S REINFORCED CONCRETE, 1906, PAGE 6.

"It is undoubted that in reinforced concrete the skeleton is perfectly protected against rusting. It must be remembered, however, that for this form of construction the best material must be used, and the concrete properly and thoroughly mixed, and well worked and rammed around the reinforcement, so as to be free from cracks and voids.

Sometimes where the larger diameter rods, etc., are used, the iron is brushed over with a cream of neat cement before being embedded to ensure the thoroughness of the protecting coat, but when small sections are used and the concrete is rammed thoroughly around the skeleton with iron rammers, so that it is of very close and impermeable nature, this precaution is omitted.

That reinforced concrete requires special care is a fact admitted by all, but the same applies more or less to all forms of construction, and this special care is well compensated for by the durability obtained. There appears to be a chemical action between the cement and the iron, forming a coat of silicate of iron on the reinforcement, which not only protects it from oxidation, but also removes any rust that may be on it when placed in the concrete, and gives a greater adhesion between the two materials. The coating protects the reinforcement against oxidation, even when there is a slight passage of water through the concrete.

It is not to be denied that steel and iron embedded in concrete have in some few cases been known to have become rusted, but in such cases it will always be found that the concrete is of a porous nature, and that it has not been well rammed around the iron, and consequently the protective coating has in places not been formed. Even with porous concrete of furnace ashes, if this layer is obtained, the metal will remain perfectly protected though the concrete is exposed to continuous moisture.

When steel and iron are employed alone, however well they may be maintained, there are always places where moisture lodges, causing oxidation, and the extra care required in the maintenance of a steel or iron structure very greatly exceeds that for the proper initial protection of the metal in a structure of reinforced concrete.

Many instances might be cited proving the thorough protection of metal embedded in concrete. Perhaps the most remarkable is the case mentioned by Herr von Emperger, of the discovery of rods embedded in concrete under water for *four hundred years* coming out free from rust. An interesting experiment was conducted by Mr. E. Ransome of New York to test the preservation of metal when embedded in concrete. He partly embedded some hoop iron in concrete blocks which were left exposed to sea air for many years. When the exposed iron had rusted completely away, the blocks were cut open and the embedded metal was found to be entirely free from rust.

The experiments carried out by M. Breuillie at La Chainette and described in the Annales des Ponts et Chaussees are extremely interesting, proving conclusively the protection of metal when embedded in concrete. Description of these tests was published in the Engineering Record, September 20, 1902."

J. HANNY THOMPSON.

In the discussion at the Engineering Conference of the Inst. of Civil Engineers, London, June, 1907, he quoted the following important experiments.

"My experience in reinforced concrete work has been principally in connection with wharves and jetties.

With regard to the rusting of the rods, I have taken up several heads of piles which have been cut off, after having been subjected to very heavy driving and which had been left in the water about three years, and on stripping the concrete the steel was found to be perfectly blue.

One experiment I made was to test the effect on steel-work that had been put into concrete bracings just above low water. I made two blocks of concrete about 5 feet long, and I put into the concrete two rods similar to those that had been used in the construction, just as they came from the works, and two very rusty bolts which had been corroded very much indeed, and very much pitted, just as bad as I could find them. One of these blocks I had made in the dry, and after it was set it was put under water. The other block I made just above low water level, and as soon as ever the concrete was put into the mould the tide came over the block.

I allowed these blocks to remain in the water about three years and took them up last week. As to the one that was made in the dry, the new steel rods were quite blue, and from the very rusty rods I found that the rust had gone entirely, leaving the bars free from rust. The block that was made at low water level, and over which the water was allowed to flow at once, when broken up I found exactly the same thing there.

One very interesting point with regard to this is, that I found the concrete was damp right through. There did not appear to be any sign of honeycombing at all, but the concrete itself was damp. But notwithstanding that, the whole of the steel was quite free from rust in every way."

CHARLES SCOTT MEIK

In the course of this same important discussion in June, 1907, stated:

"My experience, as far as it extends, proves that the deterioration of the steel in concrete, provided the latter is properly made, is a negligible quantity.

A pile-end which has been in the sea for 8 years at Southampton, was lately on view at Paddington Station. The exposed steel work on this specimen was much corroded, whereas the bars in the body of the concrete, on being cut open, were found to be quite free from any rust and as fresh as the day they were put into the pile."

EXPERIMENTS AT THE NATIONAL PHYSICAL LABORATORY, ENGLAND.

At the request of Sir John Brunner, some tests were undertaken "On the Effect Produced on Samples of Mild Steel Embedded in Concrete," and the following is the official report of these experiments:—

"A strong wooden box was made and divided into five partitions, each partition being 12 in. long, 7½ in. wide, and 7½ in. deep. Specimens of mild steel of the following dimensions were prepared: (1) One inch diameter 8 in. long, turned all over. (2) Eight inch lengths cut from a 1½ in. by 1½ in. bar with the scale left on. The partitions were half filled with good Portland cement concrete and a specimen of each kind laid on the top, and the partitions were then filled up. This was done on December 21, 1906. The blocks were covered with water several times a week for a year, and for three months afterwards were left in the open, subject to the weather. On April 20, 1908, one of the blocks was removed from the box and broken up, and the specimens removed. On examining the specimens carefully no trace of any action by the cement could be detected. The turned specimen was practically as bright as when it was put in, and the scale on the rough specimen was undisturbed. To test the possibility of any slight action, the surface of the turned specimen was polished and etched and examined under the microscope side by side with a specimen of the same material cut from the centre of the bar. No difference in the micro-structure of the two specimens could be detected and the conclusion is that in 16 months no action has taken place between the metal and the concrete. It is proposed to immerse one of the ramming blocks in the comparatively warm water of the cooling pond for six months and then to examine the specimens."

WATER PIPES AT GRENOBLE, FRANCE, AFTER 15 YEARS' SERVICE.

A reinforced concrete water main, on the Monier System, at Grenoble, France, 12 in. diameter, 1-6/10 in. thick, containing steel framework of ¼ and 1/16 in. steel rods, was taken up after 15 years' use in damp ground.

One of the conclusions of the Official Inquiry is as follows:—

"There existed no trace of oxidation from the metal. The binding-in wire which connected the longitudinal rods was *absolutely free from oxidation.*"

CONCLUSION.

As stated above, these six quotations give ample evidence that foreign experience, covering many years, shows that concrete is the best known preservative for iron and steel.

9. Causes of the Accidents and Failures in Reinforced Concrete Construction.

UNITED STATES.

There are some parties whose interests lie with the manufacture of standard structural steel shapes, who are inclined to look upon reinforced concrete construction as a dangerous menace to the future consumption of standard steel shapes for buildings, bridges, etc.

These parties have taken a certain amount of comfort from each failure or collapse of a reinforced concrete structure, when reported by the technical press, or daily newspapers.

Among the collapses which have occurred during the past two years during the erection of reinforced concrete structures in the United States, may be mentioned the two upper floors of a five storied building at No. 58 East 102nd. Street, New York, Dec. 30, 1905,—Reed's Bathing Establishment, Atlantic City, March, 1906,—Bixby's Hotel, Long Beach, California, Nov. 9, 1906,—Eastman's Kodak Building, Rochester, N. Y., Nov. 21, 1906,—Bridgman Bros.' three story building, Phila., Pa., July 9, 1907, and several chimneys, on the failures of which, S. E. Thompson has recently addressed a Report to the Association of American Portland Cement Manufacturers.

FOREIGN COUNTRIES.

Although errors in design have caused some failures on the continent, notably, in 1900 the foot bridge over the Ave. de Suffren at the Paris Exhibition; in 1901 a restaurant and hotel at Basel, Switzerland; in 1905 the roof of the Madrid reservoir; in 1906 a store at Berne in Switzerland; and in 1908 a building in Milan;—the failures due to the use of unsuitable materials and to ignorant or dishonest workmanship are less frequent on the continent than in America, because the Government rules and the city building laws governing the approval of designs and the erection of buildings, bridges, etc., are rigidly enforced, and thus prevent the erection of reinforced concrete structures by incompetent and unscrupulous contractors, whose work has caused the collapse of a number of buildings in the United States. This is particularly true in Prussia, Austria, Hungary, and France.

In Great Britain, failures are now much less frequent than five years and more ago, because this form of construction is now mainly intrusted to reliable firms.

The writer's study of the facts in connection with each of the failures Abroad in reinforced concrete construction, of which he could find any record, has led him to the following conclusions:—

1. The number of failures Abroad has been very few, in comparison with the multitude and variety of structures in reinforced concrete which have been erected in Great Britain and in all the continental countries since about 1870, when this form of construction was begun in a practical way in France.

2. The failures almost invariably occurred during construction.

3. No accident or failure, has been traced to any lack of *durability* or *inherent weakness* in reinforced concrete construction, on the contrary, it has been definitely proved that the strength of concrete increases with age, up to three years at least.

4. *Defective designs** have caused a number of failures Abroad; the usual errors are insufficient provision against shear, and insufficient dimensions in the design. Ignorance of the theories and principles involved is not an argument against this latest form of construction.

Similar mistakes in the design of buildings or bridges built entirely of steel have also led to failure,—witness the following quotations, from the Report of the Royal Commission of Inquiry on the collapse of the Quebec steel bridge occurring on August 29, 1907.

"(*a*) The collapse of the Quebec Bridge resulted from the failure of the lower chords in the arch or arm near the main pier. The failure of these chords was due to their defective design.

(*e*) The failure cannot be attributed directly to any cause other than errors of judgment on the part of these two engineers (P. L. Szlapka of the Phoenix Bridge Co., and Theodore Cooper, Consulting Engineer).

(*l*) The work done by the Phoenix Bridge Co. was good, and the steel used was of good quality. The serious defects, were fundamental errors in design."

5. The use of *unsuitable materials* has been the cause of some failures Abroad in reinforced concrete construction. The danger of using inferior qualities of cement is now so thoroughly appreciated Abroad, that the recommended specifications in England and the Government rules of the continental countries, all prescribe that only Portland cement, meeting their standard specifications, shall be used in reinforced concrete construction.

The quality of the aggregates, including sand, and broken stone, and in some cases sand with ashes, or sand with coke breeze are of equal importance because a weak aggregate will make a weak concrete, and the strength of such a concrete can not be increased by increasing the proportion of the Portland cement.

* Under this head, the writer includes the error in adopting, under some circumstances, for important reinforced Columns, a special form of Bar obviously designed especially for beams, floors, and other horizontal constructions, instead of choosing another "System" particularly adapted to Column reinforcement.

The ingredients of the concrete must also be of a *uniform quality* as otherwise the concrete will be of different strengths, in different parts of the structure.

The only failures traced to the *metal reinforcement,* were cases of careless welding at critical points.

The use of *sea water* or water containing ingredients which act chemically upon the cement or the aggregates, has caused subsequent disintegration of the concrete. All current foreign specifications now emphasize that only clean water, free from such chemical agents must be used.

An inferior quality of *timber* may, by twisting or shaking disturb the concrete while setting and thus damage the structure to such an extent as to cause subsequent failure.

6. *Careless or inexperienced workmanship,* even when the design was good and the best materials were used has caused some early failures Abroad.

Under this heading the usual mistakes have been:

(*a*) Incorrect proportions, or the failure to maintain the correct proportions of the ingredients of the concrete, including the water.

(*b*) The insufficient mixing of the ingredients.

(*c*) Careless "punning" or ramming, thereby leaving voids in the concrete, and failing to make the concrete slush against the steel, and adhere at every point.

(*d*) Displacement of the reinforcing bars by careless ramming or puddling.

(*e*) Vibrations of the concrete while setting.

(*f*) Badly designed or constructed centering and falsework, deficient in rigidity.

(*g*) The too early striking of the centres and falsework, that is, before the concrete had properly set.

7. Failures have occurred by overstraining and weakening a properly designed and erected reinforced concrete construction, either by applying the *test load* for acceptance, before the concrete has had time to thoroughly harden, or by the too early use, of a floor for instance, up to the *maximum load* for which it has been designed.

In England it is now considered that two and one-half to three months should elapse before the test load is applied, and which load naturally should not exceed the maximum calculated load.

It is manifestly unfair to this method of construction, to subject it to tests before the concrete has completely hardened and set.

8. *Long prior notice of the approach of failure.* A valuable property of reinforced concrete construction is that a finished properly designed structure, if overstrained, gives ample warning before giving way.

For example a reinforced concrete T-beam has been under an endurance test at Calais in France, since 1898. The beam was designed to carry a load of 4 tons. In November, 1898, it was loaded with 34 tons, or 8½ times its calculated load; this overweight caused cracking in the centre of the span, consisting of 4 fissures extending well up into the upper portion of the beam. This overload of 34 tons has since remained on the beam, which to date, Sept., 1908, has not developed new cracks, or enlarged the old ones, nor increased the deflection beyond that produced when the beam was first overloaded.

The following series of tests on arches, carried out by the Commission of the Society of Austrian Engineers and Architects also prove that reinforced concrete fails only gradually. The four arches which were constructed of ashlar, brick, ordinary concrete and reinforced concrete were each of 23 meters (75½ feet) span. The excess of load producing failure, in proportion to the load which produced the first crack was as follows:—

For ashlar arches........................30 per cent.
For brickwork arches....................59 per cent.
For concrete arches ....31 per cent.
For reinforced concrete arches...........85 per cent.

9. *Conclusions.* The foregoing outline of the factors which have caused failures in reinforced concrete construction Abroad, shows that in no case can this economic form of

construction be blamed when, in *all* respects, properly executed.

Within the last few years, the passing and rigid enforcement of good building laws Abroad, has practically eliminated the chief former element of danger in reinforced concrete construction, namely, the incompetent and unscrupulous contractor, whose criminal negligence would cause the failure or collapse of any form of construction.

Furthermore, in all foreign countries, the possible economies in reinforced concrete construction are now so thoroughly recognized that two influences are actively at work which will eliminate the other possible causes of failure, defective design and unsuitable material.

The writer refers to the large number of foreign scientific institutions and bodies, in some countries under the support of the Government, which are now devoting their best energies to perfecting the theories and principles involved, and to the publicity which is now being given to the results of their studies both in periodic literature and in the recent books devoted entirely to this subject and to the publication of excellent rules and specifications by the trade.

Also to the increasing number of reliable foreign engineering firms, as well as companies controlling special "Systems," which has created a rivalry and commercial competition, which now insures at *low* cost, the necessary careful attention to materials and workmanship, and without which, failure is liable to occur, no matter how theoretically perfect the design may be. This eliminates the former practice of obtaining the designs from some specialist of high standing and then assigning the work to the lowest bidder in open competition.

The use of proper materials Abroad is now assured by the enforcement of the rules and specifications quoted in this report, and which in most countries have the official sanction and support of the Government.

FOREIGN SYSTEMS OF REINFORCED CONCRETE CONSTRUCTION.

Much time was occupied during the writer's personal visit to England and each of the principal continental countries, in complying with the request of the subscribers for full information as to the *systems* of reinforced concrete construction used Abroad. The following is a summary of the information collected and which is reported on more in detail in the pages immediately following.

INTRODUCTION INCLUDING:—

Definition of the term "System."

Non-patentability of reinforced concrete construction.

Discussion of the systems by countries in which they originated.

Alphabetical list of the 144 systems, with address of the inventor or owner.

ENGLISH SYSTEMS.

Twenty-two (22) systems of English origin, and thirteen (13) of foreign origin, are in use.

Forms of reinforcing bars used.

Alphabetical list of the twenty-two (22) English systems.

GERMAN SYSTEMS.

Fifty-four (54) systems of German origin.

Patents still valid for only 17 of these systems.

Valid German patents of systems not of German origin.

Forms of reinforcing bars used.

Alphabetical list of the fifty-four (54) German systems, with those marked for which the German patents are still valid.

German constructions not usually confined to one system.

FRENCH SYSTEMS.

Twenty-one (21) systems of French origin.

Only two systems use special forms of bars.

Alphabetical list of the twenty-one (21) French systems.

AUSTRIAN SYSTEMS.

Six (6) systems of Austrian origin.
None use special shaped bars.

HUNGARIAN SYSTEMS.

Four (4) systems of Hungarian origin.
None use special shaped bars.

SWISS SYSTEMS.

Four (4) systems of Swiss origin.
None use special shaped bars.

ITALIAN SYSTEMS.

Six (6) systems claimed to be of Italian origin.
None use special shaped bars.

DUTCH SYSTEMS.

Two (2) systems have been developed in Holland.
Neither use special shaped bars.

OTHER CONTINENTAL COUNTRIES, SYSTEMS OF

Spain.
Norway.
Belgium.
Denmark.
Sweden.
Russia.
Portugal.
Balkan States.

SYSTEMS OF DOUBTFUL ORIGIN, BUT DOUBTLESS MOSTLY GERMAN OR FRENCH.

Only one out of twenty-three (23) uses a special shaped bar.

Alphabetical list of twenty-three (23) systems.

FOREIGN AGENCIES OF AMERICAN SYSTEMS OF REINFORCED CONSTRUCTION.

Foreign addresses of the six (6) American systems used Abroad.

ALPHABETICAL LIST OF THE 144 FOREIGN SYSTEMS OF REINFORCED CONCRETE CONSTRUCTION.

With address of the inventor or owner of each system, and a concise description of its special features.

(See Appendix No. 1.)

2

FOREIGN SYSTEMS OF REINFORCED CONCRETE CONSTRUCTION.

INTRODUCTION.

In this report, for the sake of simplicity, the term "System" has been taken in its broadest sense, and every company, or individual that the writer found using a distinctly *special feature* in connection with this method of construction, has been included in the list of systems of reinforcement, now in use in each country, although the "feature" more often than not, should not be dignified as a "System."

Of course, the systems include those in which the parts are moulded, and allowed to harden before use, as well as those in which the work is built in place.

Some systems employ a specially shaped section of reinforcing metal, some adopt a peculiar arrangement of the ordinary rolled rounds, squares, flats and standard structural shapes, while others have both special sections and special methods of employing them.

NON-PATENTABILITY OF REINFORCED CONCRETE CONSTRUCTION.

The *main* principles of this form of construction are not patented, in fact they are impatentable. The patents on the older foreign systems, such for example as "Monier" have expired. There are so many methods of embedding steel in concrete, and by which the desired results are assured, that in each foreign country, an engineer or architect is practically free, or at most he need only apply for the rights to use some special feature in some detail of his work.

DISCUSSION OF THE SYSTEMS BY COUNTRIES IN WHICH THEY ORIGINATED.

The following pages discuss a total of 144 "Systems" of foreign origin for reinforced concrete construction.

The systems are classified according to the country in which they originated and in each case those using specially shaped reinforcing bars are mentioned.

Six American systems now having foreign agencies are also mentioned, and the addresses of the agencies are given.

ALPHABETICAL LIST OF THE SYSTEMS WITH ADDRESSES OF THE INVENTOR OR OWNER.

In addition to this discussion by countries, a list of these 144 foreign systems, arranged *alphabetically* has been prepared and with but few exceptions, where information could not be obtained, the address of inventor or owner and a concise description of the system is given. This alphabetical list will be found in Appendix I to this report, pages 119-147.

English Systems of Reinforced Concrete Construction.

A list is given below of 22 "Systems" of reinforced concrete construction known to be of English origin.

To complete the list of the systems actually in use in Great Britain, the following 13 systems of foreign origin must be added and which are described in Appendix No. 1.

FOREIGN SYSTEMS IN USE IN GREAT BRITAIN OF

French origin	German origin	American origin
Bonna	Custodis	Columbian
Coignet	Herbst	Expanded metal
Considere	Koenen	Indented bar
Hennebique		Kahn
		Simplex
		Weber

Forms of Reinforcing Bars Used.

Of the 22 English systems, 6 use special forms of bars for reinforcement, as follows: The other 16, use rounds, squares, flats and standard structural shapes; 2 of these 16 use a patented stirrup or clip.

HODKIN JONES.

Special rolled bars having 3 corrugations in their width and which bars fit vertically into pierced and bent plates.

HOMAN.

Waved T-bars.

METAL LADDER TAPE.

Steel strips split at intervals into a ladder-like form and furnished in coils.

PERFECTOR.

Round rod with flat flange below, slotted horizontally or at 45° for rigid insertion of stirrups at any spacing desired.

RIDLEY-CAMMEL.

Dove-tailed corrugated sheeting.

SKELETON.

Special skeleton split and expanded from bars or bands into girder-like forms.

Of the 13 Systems in Use in Great Britain, but of Foreign Origin, 6 use Special Forms of Reinforcing Bars as Follows:

BONNA.

Rolled steel in form of Latin cross.

HERBST.

Flat bars corrugated in rolling.

COLUMBIAN.

Specially rolled ribbed bars supported by special straps.

EXPANDED METAL.

Sheets or plates, slotted and pulled out laterally in one operation forming a diamond shaped mesh work.

INDENTED BAR.

Rolled steel bars of square section with corrugations extending across the whole width of all four sides.

KAHN.

A diamond section with the stirrup forming part of the bar, and made of sheared sections of two webs or wings of the rolled section.

This use in England of a total of 12 special forms of reinforcing bars, is in marked comparison to continental practice, where, as will be shown later, rounds, flats or standard structural shapes are almost universally used.

Alphabetical List of the 22 English Systems of Reinforced Concrete Construction.

Adamant
British

Chain concrete
Cruciform
Dawney
Ellis
Hodkin-Jones
Homan
Improved Construction
Johnson's Wire Lattice
Kleine
Lindsay
Metal Ladder Tape
Perfector
Potter
Ridley-Cammel
Skeleton.
Somerville
U. K.
Wells
Wilkinson
Williams.

German Systems of Reinforced Concrete Construction.

The following 54 "Systems" are known to the writer to be of *German* origin. Some of these however have never been introduced to any extent.

To this large number which is a striking evidence of the independence of the German engineer and the thorough study he has made of this subject, should undoubtedly be added quite a number of the 23 systems classified elsewhere as of "unknown" origin.

Contractors are free to use any of these "Systems" of construction except the 17 marked "Patented" and for which the German Patents are still (Sept. 1, 1907) valid.

There are 7 other valid German Patents of systems not of German origin and on which a royalty must also be paid. These are as follows:

Origin	Ger. patent No.	Date	Patentee
Hungary	83,939	Feb. 3, 1895	Matrai
"	176,885	Dec. 25, 1904	Kovacs
Austria	163,838	Sept. 9, 1902	Visintini
"	179,366	May 4, 1905	Visintini
France	126,312	Sept. 2, 1897	Hennebique
"	149,944	May 10, 1902	Considere
U. S. A.	173,118	Oct. 20, 1903	Kahn

Of the following 54 "Systems" of German origin only the following 6 cover special shaped bars. All the others use either rolled rounds, flats or some of the German standard shapes of structural steel.

German Systems with Special Shaped Bars.

DOUCAS.

A bar of round or in larger sizes of a diamond-shaped section with two opposite webs or wings attached, which are waved in the operation of rolling.

FRANKE.

Inverted T with top leg rolled into conical waves.

HABRICH.

Flat bars twisted when hot.

HERBST.

Flat bars corrugated in rolling.

POHLMANN.

Rolled bulbed section, in the web of which are cut octagonal holes at frequent intervals and in which are fitted hooped stirrups set at any angle or spacing desired.

MANNSTAEDT.

The rolling mills of L. Mannstaedt & Cie A. G. make 12 different special shapes, including one plain U; three special U's; one bent flat; three flats with patterned surfaces; two triangular bars with a patterned surface and two T-bars with a patterned surface.

These are illustrated in Beton-Kalendar, Part I, 1908, pp. 149-150.

Alphabetical List of the 54 German "Systems" of Reinforced Concrete Construction. The German Patents were Still Valid September 1, 1907, of the 17 Systems Marked "Patented."

Ackermann		Krauss	(Patented)
Bayer	(Patented)	Leschinsky	(Patented)
Becher		Lilienthal	(Patented)
Bramigk		Lolat	(Patented)
Bruckner	(Patented)	Luipold	
Bulla	(Patented)	Manke	(Patented)
Custodis		Mannstaedt	
Deumling		Möller	
Dietrichkeit		Müller	
Doucas		Pinkemeyer	
Ebert	(Patented)	Pohlmann	(Patented)
Eggert		Pötsch (Massivdecke "Germania")	
Franke		Prüss	
Fraulob		Rabbitz	
Gasterstädt		Ramisch	
Habrich		Sachse	
Helm	(Patented)	Schlüter	
Herbst		Schweitzer	
Holzer		Sohnius	
Kiefer		Strauss & Ruff (Drahtziegel)	
Kisse	(Patented)	Stolte	(Patented)
Klein		Wayss	
Klett		Weyhe (Victoria Decke)	(Patented)
Knauer		Wissel	(Patented)
Koenen	(Patented)	Wolle	
Kosten		Ziegler	
		Zimmer	
		Zöllner	(Patented)

German Constructions not Usually Confined to One System.

When using reinforced concrete for all portions of a building including the foundations, floor, walls, partitions and roof, it is not the custom in Germany to use any one so-called "System."

German engineers incline toward a greater freedom of design than is possible when using any single "System."

The following quotations from letters received from leading German contractors are characteristic of the replies received to inquiries as to the system used by them.

CEMENTBAU—A. G. HANNOVER, JULY 14, 1908.

"In Germany, we do not work to any one System, because of the Government Reinforced Concrete Regulations and because it is difficult to obtain German Patents for special systems."

FRANZ SCHLÜTER, DORTMUND, SEPTEMBER 9, 1908.

"Because of the Ministerial Regulations governing the calculation and erection of reinforced concrete constructions, we can no longer in Germany recognize certain systems of reinforcement. The constructions of the different firms differ only in small details as per example, in the use of stirrups, and in the methods of bending the rods."

KAMPMANN & CIE., GRAUDENZ.

"In Germany the use of the well known Systems of Hennebique, Considere, Koenen, Siegwart, etc., is now very limited because the erection of Reinforced Concrete Buildings must be in accordance with the Government Rules."

French Systems of Reinforced Concrete Construction.

A list is given below of 21 "Systems" known to the writer to be of French origin. To this, a number of the 23 systems classified elsewhere as of "unknown" origin should undoubtedly be added.

Of these 21 systems, only two use special shaped bars. The *Bonna* has a latin cross. The *Bordenave* uses a special small I section.

In the Monier system, the pioneer in this form of construction, a trellis of round rods or wire is used. Demay uses flat bars. The remaining 17 all use round rods, in 4 cases with the addition of T angles, flats and net work.

Alphabetical List of the 21 French Systems of Reinforced Concrete Construction.

Bonna
Bordenave
Boussiron et Garric

Chassin
Chaudy
Coignet
Considere
Cottancin
Coularou
Degon
Demay
Guillemet
Hennebique
Lang
Monier
Mollaret et Cuynat
Nivet
Harel de la Noe
Pavin de Lafarge
Piketty
Viennot.

Austrian Systems of Reinforced Concrete Construction.

There are but six "Systems" that can be classified as of Austrian origin. In the order of importance these are Melan, Visintini, Ast-Mollins, Milankovitch, Schnell and Thurl.

None of these six systems use any special form of rolled shapes.

The Visintini system is classified here because Visintini is an Austrian by birth, although he was located in Zürich when he took out his patents and his beams were first introduced in Hungary.

The reason why so few systems have developed in Austria is because of the early introduction of the Monier (French) system. Monier's Austrian patents were bought in 1880 by R. Schustler who was afterwards joined by G. A. Wayss.

The progress of reinforced concrete construction in Austria is largely due to Dr. F. von Emperger, who began writing on this subject in 1897. He is the compiler of the most recent and important work on this subject, and also the editor of "Beton & Eisen."

Hungarian Systems of Reinforced Concrete Construction.

There are four "Systems" of reinforced concrete construction of Hungarian origin.

The *Wünsch,* introduced in 1886, the *Matrai* in 1893, the *Kossalka* in 1902 and that of *Kovacs* & *Reszö* in 1904, which, in comparison with the other three systems, is of much less importance.

None of these systems use any special form of reinforcing bar.

The *Monier* (French) system was introduced in Hungary in 1887 by G. A. Wayss of Germany, and the *Visintini* (Austrian) system in 1903 by Joseph Schustler.

Swiss Systems of Reinforced Concrete Construction.

There are four "Systems" of reinforced concrete construction originating in Switzerland, all applicable to beam construction.—

The *Siegwart,* the *de Vallière,* the *Walser-Gerard* and the *Locher* systems.

The first three mentioned use round rods for reinforcement; the *Locher* uses plain flat bars.

Italian Systems of Reinforced Concrete Construction.

Although a patent was taken out in Italy in March, 1883, by Angelo Lanzoni of Pavia, this system of construction was not introduced in Italy until after Italians had seen the reinforced concrete construction at the Paris Exposition of 1900 and, as but little was also known in Italy of the theory before 1900, it is natural that most Italian construction so far has been by the systems of other countries

The claim is made that there are six "Systems" of Italian origin, *Lanzoni, Baroni-Lülung, Bianchi, Gabellini, Odorico* and *Maciachini.*

In none of these are any special forms of bars used.

So far the most important constructions in Italy have been by the systems of other countries.

Dutch Systems of Reinforced Concrete Construction.

For many years a strong and unjust prejudice has existed among these naturally conservative people, against this form of construction and in fact against the use of concrete alone. The constructions of the Paris Exposition of 1900 drew marked attention to the matter and now reinforced concrete has been used for many applications in Holland.

Two "Systems" can be said to have been developed. That of *Sanders* and that of *de Muralt.*

In the former round rods are used, in the latter "expanded metal."

Systems of Reinforced Concrete Construction in Other Continental Countries.

SPAIN.

One "System" devised by *Ribera,* a Spanish Engineer, in which angles and wire lattice are used.

NORWAY.

One "System" devised by *Lund*, and in which round rods are used.

BELGIUM.

The Hennebique system might be classified here, as he constructed floors in Belgium in 1879, long before his first patents. However, as his early applications of his patents were made in France, and as his head office has long been in Paris, the system is classified as French.

DENMARK.

No systems of reinforced concrete have originated in Denmark. This form of construction has been used in Denmark since 1891, the earliest applications being floors for the National Gallery at Copenhagen, a roof for a glass works and a breakwater outside the Copenhagen free harbor.

No special shapes of bars are used, the reinforcement being most often rounds of standard quality of soft steel.

SWEDEN.

The adoption of reinforced concrete for house and factory construction, and bridges, has been slow in Sweden, though of late years it has become a factor in some important constructions and it will find a field in future in hydro-electric installations.

No systems of reinforcement have originated in Sweden.

OTHER CONTINENTAL COUNTRIES.

No record could be found of any systems originating in the other continental countries, Russia, Portugal, and the Balkan states.

Systems of Doubtful Origin, but Doubtless Mostly German or French.

Besides the 121 "Systems" of reinforced concrete construction, known to have originated in England, Germany, France, Austria, Hungary, Switzerland, Italy, Holland, Spain and Norway, the writer has collected information from various sources, about the 23 following systems, so that no less than 144 foreign "Systems," using that term in its broadest sense, are described in this report.

It is safe to say that the majority of these 23 systems are of German or French origin.

In only one case, the *de Mann* system, is a special bar used, a twisted or crimped bar. All the others use wire, rolled rounds, flats or standard structural shapes.

Alphabetical List of the 23 Systems of Doubtful Origin, but Doubtless Mostly German or French.

Ambrosius
Beny
Bruno
Corradini
Cracoanu
Czarnikow
Donath
Dumas
Fichtner
Hugnet

Kemnitz
Kohlmetz
Kuhlmeyer
Lefort
De Mann
Neville
Opelt & Hennersdorf
Parmley
Perrand
Picq
Pratt
Rossi
Stapf

Foreign Agencies of American Systems of Reinforced Concrete Construction.

The writer is acquainted with 32 "Systems" of American origin, but as this Report is confined to foreign practice, mention will only be made of the present addresses of the foreign agencies of the *six* of these American systems which have so far been introduced in England and on the continent.

COLUMBIAN.

Columbian Fireproofing Co., Ltd., 37 King William St., London, E. C.

EXPANDED METAL

The Expanded Metal Co., Ltd., York Mansion, Westminster, London, S. W.

Société du Melat Deployé, 11 Place de la Madelene, Paris.

Schüchterman & Kremer, Dortmund, (Germany).

INDENTED BAR.

Patent Indented Steel Bar Co., Ltd., Queen Anne's Chambers, Westminster, London, S. W.

A. L. Johnson, 51 rue du Faubourg Poissoniere, Paris.

KAHN.

Trussed Concrete Steel Co., Ltd., 60 Caxton House, Westminster, London, S. W.

SIMPLEX.

Simplex Concrete Piles, Ltd., Caxton House, Westminster, London, S. W.

N. Devaux, 114 rue Mozart, Paris.

W. A. Groninger, Börsen Nebengebäude, Bremen (Germany).

WEBER.

Weber Concrete Construction Co., Ltd., Queen Anne's Chambers, Westminster, London, S. W.

MECHANICAL BOND AND FORMS OF BARS.

INTRODUCTION.

Of late years, there has developed a decided preference both in Great Britain and on the Continent, to no longer place entire reliance upon adhesion to care for the horizontal shear, but rather to follow the practice, already popular in America, of mechanical bonding. This statement applies particularly to beam reinforcement.

The feeling is that while it is safe to depend upon adhesion alone, where proper shearing values have been used, that there is no harm, and it is sometimes an advantage, to supplement this by some form of mechanical bond.

There are many methods, equally efficient, by which slipping can be prevented so that entire reliance need not be placed upon adhesion to care for the horizontal shear.

In the older systems, the necessary transverse reinforcement to insure mechanical bonding is obtained by the use of plain bars in the form of stirrups, usually rounds or flats.

Naturally the recognition of the necessity of mechanical bonding has brought into favor the so-called "deformed" bars and many forms of patented special shapes with supplementary vertical or oblique rods, straps, stirrups and clips, which are preferably either rigidly attached to or made a part of the main reinforcing bar, so as to prevent slipping.

Spacing bars and spacing chairs are also used for this purpose.

To summarize the diversity of opinions of how the necessary mechanical bonding can be *best* insured, is impossible. The only course left, in endeavoring to fulfill the writer's duty of reporting on foreign practice, is to present the following table showing the number of foreign systems of each country which use specially shaped reinforcing bars, and to supplement this table by quoting a few opinions from authorities in England, France, Germany, Austria, and Switzerland.

Table Showing the Number of Foreign Systems of Each Country which Use Specially Shaped, or "Deformed," Bars for Reinforcement.

Systems originating in	Total number	Number using specially shaped bars	Number using rounds, flats or profiles
Germany	54	6	48
France	21	2	19
Austria	6	0	6
Hungary	4	0	4
Switzerland	4	0	4
Italy	6	0	6
Holland	2	1	1
Spain	1	0	1
Norway	1	0	1
Origin doubtful, but mostly Continental	23	1	22
Total continental	122	10	112
England	22	6	16
In use in England but orginated elsewhere	13	6	7
Total for England	35	12	23
Grand total	157	22	135

This table includes the 144 foreign systems discussed elsewhere and also 13 systems (6 of them American) in use in England but originating in other countries.

The table shows to what a small extent on the continent, special shaped bars are used, the mechanical bonding being obtained by transverse reinforcement using plain bars.

In England, on the contrary, out of the 35 systems in use, 12 have special shaped or "deformed" bars.

As stated above, it was found impossible to summarize the diversity of opinions as to how the necessary mechanical bonding can be best assured.

The following opinions from leading authorities in each country, or quotations from government rules are therefore submitted:—

England.

CHARLES F. MARSH.

Author of "Reinforced Concrete, 1906" and "Manual of Reinforced Concrete, 1908."

Memoranda of an interview in July, 1908.

With regard to the resistance of deformed bars to sliding through the concrete, Mr. Marsh stated that although these undoubtedly offer greater resistance to sliding than plain bars, it has been clearly demonstrated that plain bars will not slide under ordinary working conditions, if bent over or split and opened at the ends. When considerable vibrations are to be resisted, Mr. Marsh considers that it may be advisable to obtain a greater factor of safety by the employment of deformed bars.

He considers the employment of small bars advantageous because they distribute the stresses through the concrete better than the same amount of metal centered in one or two larger bars, and because they furthermore give a greater perimeter for resistance to slipping through the concrete; and also because, in using small bars, they can be economically utilized to resist the diagonal tensile stresses by bending them up, as the bending moment decreases and the shearing stresses increase.

Mr. Marsh stated that the theoretical advantages attained by the use of "deformed" bars of a steel of high elastic limit for reinforcement, were in practice only actually realized, commercially, when the cost of such steel was not excessive, when provision was made for its careful inspection so as to avoid using brittle steel, when only first class concrete was used, and finally when rigid inspection was maintained during erection.

Furthermore, that reinforced concrete structures could be erected with mild steel reinforcements, offering equal resistance under the severest conditions, if ample provision against horizontal shear is provided by increasing the bond by supplementary oblique rods, straps, or stirrups, which, however, must be either rigidly attached to, or made a part of the main reinforcing bar so as to prevent slipping, and in this connection he also included the use of spacing bars and spacing chairs.

CHAS. S. MEIK, M. INST. C. E.

Quotation from his paper on "Ferro Concrete Structures." Eng. Congress of the Inst. of Civil Engineers, June, 1907.

"The form of the sections of bars, provided the area is sufficient, is of little moment, the friction of the steel in the concrete varying but little in all cases. A little rust on the bars is no objection, as it increases the friction. The round bar offers most facility for getting the steel thoroughly embedded in the concrete. The stirrups or iron bands for holding the round steel in place must be so formed as not to give, until the limit of elasticity has been reached."

France.

GOVERNMENT RULES FOR REINFORCED CONCRETE, OCTOBER, 1906.

When special sections are employed for reinforcement instead of round bars, arrangements must be made to provide for the perfect encasing of the bars around their entire perimeter and particularly at all re-entering angles.

Under the heading "Adhesion" the rules in part state:

"If stirrups or other transverse reinforcements are sufficiently connected with the longitudinal reinforcement so as to prevent any slipping of these latter in the casing of concrete, then the shearing stress in tranverse reinforcements is to be deducted from the stress. Mere ties connecting the transverse with the longitudinal reinforcement are not sufficient. These ties are necessary, but their assistance to adhesion is not to be considered."

Under the heading "Shearing" the Rules state:

"If transverse reinforcement efficiently resists the longitudinal slipping, it is permitted to take it into account, as stated above for adhesion."

GÈRARD LAVERGNE.

Author of "Etude des divers Systemes de Construction en Ciment Armé."

"The section of the metal does not play an important role. Round iron should be preferred as being of greater regularity in manufacture, more homogeneous, and lending itself better to the operation of the filling of the mortar, than other shapes, and in addition to its adherence with the iron, and its good preservation of the latter, the iron presents no obstructions liable to cut the cement or the metallic attachments. For these last, annealed wire is employed."

Germany.

GOVERNMENT REGULATIONS ON REINFORCED CONCRETE CONSTRUCTION.

The present Prussian government regulations, governing the construction of all reinforced concrete buildings, as revised on May 24, 1907, contain the following clauses in reference to shearing and adhesive stresses.

"Shearing stresses are to be ascertained, unless the form and construction of the members are such that they are at once seen to be insignificant. When no means of taking them up are provided in the arrangement of the members, they must be taken up by suitably shaped steel reinforcement.

So far as possible, the steel for reinforcement is to be of such form that displacement relatively to the concrete is prevented by its form. The adhesive stresses must however always be calculated."

O. KOHLMORGEN, GOVERNMENT SURVEYOR, BERLIN.

"Even a general comparison of the arrangement of the reinforcement in different countries shows that in Germany the method of increasing the adhesion between iron and concrete by the use of indented bars is not employed. Such bars are much used in America, but some authorities argue that they defeat the object aimed at, since, on account of the varying section of the iron and the consequent varying elongation and contraction, the concrete is sheared off from these expansions. Stress is therefore laid by prominent German investigators on giving each reinforcing rod a constant section. They consider that only in this way is it assured that the adhesive stresses at the surface of the metal are in accordance with the statical laws. But this point is, of course, still very much of a controversial character. Many English authorities of high standing, for instance, favor indented bars in a very marked manner."

Austria.

R. JANESCH, BAUINGENIEUR, VIENNA.

Translation from special article in Beton-Kalender for 1908, edited by F. von Emberger.

"In Europe rolled rounds from 3-50 mm. (0.118 to 1.969 inches) dia. are generally used. They can be easily obtained from all merchants, and they have the advantage over other rolled shapes that owing to their uniform section, there is the least possible distance from all parts of the surface to the center of gravity. But it is also true that the surface of contact between the round bars and the concrete is the smallest.

When using profiles, such as T's or Flat-Iron placed on edge, the center of gravity of such sections is further from the under edge, than when using a round bar of equal area in cross section.

All forms of reinforcing bars require either a greater weight of steel or else more concrete, than when round bars are used."

Switzerland.

PROF. F. SCHÜLE.

Chairman, Committee on Reinforced Concrete, Inter. Asso. Testing Materials. Prof. in Swiss Federal Station for Testing Materials, Zürich.

"An important difference exists between European and American construction in concrete-steel; in Europe, the armature bars generally have a constant section and a smooth surface; in the United States the bars used have variable forms of section. It seems that tests give a greater strength with beams having bars of the American type. The difference practically cannot be very great, because adhesion between steel and concrete is ended when the elastic limit of the metal is reached. Bars with a constant form of section will slide if their ends are not fastened; the other types of bars cannot slide suddenly, and the concrete will give some resistance against sliding."

METAL USED FOR REINFORCEMENT. FOREIGN SPECIFICATIONS, RECOMMENDATIONS AND OPINIONS COMPARED.

INTRODUCTION.

The writer is familiar with American practice in reinforcement, in the use, to a considerable extent, of high carbon steel both in plain rounds and squares, such as is furnished by Chas. D. Crandall of Warren, Pa., and in the form of Johnson's corrugated or "indented" bar, controlled in the United States by the Expanded Metal and Corrugated Bar Co. of St. Louis.

Also the use of the cold twisted bar first introduced by Ernst L. Ransome in 1884 on the Pacific Coast, and now specially advocated by the Turner Construction Co. of New York, and advertised as a specialty by the Jones & Laughlin Steel Co., the Buffalo Steel Co., Inland Steel Co., Wm. B. Hough Co., Chas. D. Crandall and others and in which "Ransome" bar, the normal tensile strength and elastic limit of the 20 carbon open hearth steel, which is the grade generally employed, is materially increased by the cold twisting operation and in fact under control by varying the number of turns per foot*; and finally to the lock woven wire fabric, made of high carbon steel wire.

The general opinion among American Engineers in reference to the use of high carbon steel for reinforcement is reflected in the following quotation from Taylor & Thompson's Treatise published in 1906. On pages 38-40 they give specifications covering the inspection of high carbon steel, and on page 293 refer to its use as follows:

> "It may be stated, then, if the stretching of high steel when pulled to its allowable working stress is proved not to form dangerous cracks in the concrete, that high carbon steel, say 0.56 to 0.60 per cent. carbon, of the quality used in the United States for making locomotive tires, is always better than mild steel for reinforced concrete, provided the steel is well melted and rolled, and is comparatively free from impurities, such as phosphorus. However, a high carbon steel, unless limited by chemical analysis, and made under careful

* Tests and Proposed Specifications for Cold Twisted Rods for Reinforced Concrete, by J. J. Shuman, Amer. Soc. for Testing Materials, June, 1907.

inspection, is in danger of being more brittle than low carbon steel. Its use, therefore, should be limited strictly to work important enough to warrant the ordering of a special steel and the taking of sufficient trouble on the part of the purchaser to insure strict adherence to the specification. Under such circumstances, the use of high steel is attended with much economy. In other words, since manufacturers cannot always be depended upon to exactly follow specifications of this nature, it is necessary that an inspector be sent to the works, or else that the steel be purchased from a reliable dealer who has had it thus carefully tested.

The specifications for first-class steel on page 38 are sufficiently explicit so that steel which comes up to them can be safely used. A steel which can be employed with safety for all the locomotive and car wheels of the country certainly cannot be discarded as unsafe for concrete, provided similar precautions are taken in its purchase."

Also in the following quotations from Homer A. Reid's "Concrete and Reinforced Concrete Construction," published in 1907.

"Steel is used exclusively for reinforcement in America. This is undoubtedly because it is cheaper than wrought iron. Unfortunately, authorities differ as to the quality of steel to be used for reinforcement, soft, medium and high steel being used by different engineers. If a steel of good quality be employed, it is immaterial which be used, as first-class structures have been built with each. However, soft and medium steel are better fitted for some classes of structures than high steel, while in others the high steel will answer just as well, with greater economy.

"When the concrete is to be subjected to a moist atmosphere or to corrosive gases, steel with lower working stresses should be employed or a different form of construction adopted. In many classes of structures there is no doubt high steel may be used with economy and without in any way endangering the structure.

"When high steel of a satisfactory quality can be secured at a price not greatly in excess of that of medium steel, considerable saving may result. Thus a saving of as much as 25 per cent. over mild steel may ensue if the high steel rods be secured, as is often the case, at an advance of about 10 per cent. in price over mild steel."

Foreign Practice.

GENERAL.

It was particularly requested by the parties to whom this Report is addressed, to include foreign practice in Great Britain and on the continent, in reference to the *metal used*. The following summary is the net result of many personal interviews and of much correspondence with the foreign authorities on the subject, and no pains or expense have been spared to obtain an accurate reflection of present foreign opinions and practice.

IMPORTANCE OF THE METAL USED.

As shown elsewhere in this Report, reinforced concrete construction must be recognized as an important factor in the future consumption of steel for structural purposes, but it is universally admitted that the best results, all interests considered, can only be attained by dependence upon the metal to take care of the dangerous stresses. Hence foreign experience, being of older date, deserves consideration.

COUNTRIES FROM WHICH INFORMATION WAS COLLECTED.

Information as to the metal used was collected from the following countries as well as from International Associations and Congresses.

Great Britain	Austria
France	Hungary
Germany	Switzerland
	Italy

In each case the official or the recognized standard specifications for reinforced concrete and for the metal used was purchased and the following pages contain full translations of the references in each of such specifications to the metal used.

In addition to this, opinions were obtained, largely by personal interview and partly by correspondence, from consulting engineers, contracting engineers, owners and agents of systems of reinforced concrete and authors of books and editors of journals.

SUMMARY OF INFORMATION OBTAINED.

The result of this thorough inquiry shows:

1. That WROUGHT IRON is still used to a limited extent both in Great Britain and in the six countries on the continent.
2. That SOFT STEEL of a tensile strength of 51,000-

64,000 lbs. per square inch, is the ONLY grade used in AUSTRIA, ITALY, SWITZERLAND and HUNGARY.

3. That in FRANCE, SOFT STEEL is also the only grade used with the single exception of A. L. Johnson's indented bar of high carbon steel, which has so far only been used to a very limited extent.
4. That in GERMANY, SOFT STEEL is also practically the only grade used, as the only exception found was one firm of contracting engineers, who occasionally use a medium steel (tensile 85,000 lbs.) in some classes of work, and one other firm of contractors who had used medium steel only once.
5. That in GREAT BRITAIN, where there is no official specification, MEDIUM STEEL rounds and shapes are sometimes used; also the high carbon indented bar and cold drawn steel wire lattice are used to some extent, but in by far the majority of constructions SOFT STEEL is used, meeting the recognized Specification of the Engineering Standards Committee.

Use of Wrought Iron Abroad.

As introductory, mention must first be made that in all early reinforced concrete constructions, in Great Britain, but especially on the continent, wrought iron instead of steel was used.

Naturally the ordinary forms of rounds, squares and flats were employed.

The fact that until comparatively recently, the cost in Europe of wrought iron and steel has been about the same, has led to the continuance of the use of wrought iron, where no special shapes of reinforcement were specified, and while the greater strength of steel was recognized, the ability to easily weld wrought iron with perfect safety has kept it in favor.

It has been the custom to specify that the wrought iron should be of good quality, with a tensile strength of about 50,000 lbs. per sq. inch, and an elongation of from 8 to 12 per cent. in 8 inches.

As evidence that wrought iron is still in favor, in foreign practice, the following is quoted from the catalogue of the 1907 edition of a leading firm of British engineers and contractors, D. G. Somerville & Co., specialists in reinforced concrete construction.

"The best class of steel or wrought iron must be employed, and we calculate these figures being well within the elastic limit of good class material.

For wrought iron in tension 10,000 lbs. per sq. inch.

For steel in tension 16,000 lbs. per sq. inch.

For wrought iron in shear 8.000 to 11,000 lbs. per sq. inch.

For steel in shear 12,000 to 17,000 lbs. per sq. inch.

Reinforced with steel having an elastic limit of 50,000 lbs. per sq. inch, the amount of metal required per sq. foot of section to prevent temperature cracks is 0.6 sq. inch."

International.

Up to date, (May, 1909) neither the International Association for Testing Materials nor any International Congress, has either discussed or passed resolutions as to the physical or chemical properties of the steel best suited for reinforcement.

England.

RECOMMENDATIONS OF THE JOINT COMMITTEE ON REINFORCED CONCRETE AS TO METAL TO BE USED.

In Great Britain, so far, only one general recommendation has been issued; namely, by the "Joint Committee on Reinforced Concrete," formed in 1906 under the auspices of the Royal Institute of British Architects. Their Report, adopted by the Institute on May 27, 1907, contains the following Specifications, in reference to the steel to be used for reinforcement.

"The *Metal* used should be steel having the following qualities:

(a) An ultimate strength of not less than 60,000 lbs. per sq. inch.

(b) An elastic limit of not less than 50 per cent., or more than 60 per cent., of the ultimate.

(c) An elongation of not less than 22 per cent. in the lengths stated below.

(d) It must stand bending cold 180 degrees to a diameter of the thickness of pieces tested without fracture on outside of bent portion.

In the case of round bars, the elongation should not be less than 22 per cent., measured on a gauge-length of eight diameters. In the case of bars over one inch in diameter, the elongation may be measured on a gauge length of four diameters, and should then be not less than 27 per cent. For other sectional material the tensile and elongation tests should be those prescribed in the British Standard Specification for Structural Steel.

Before use in the work, the metal must be clean and free from scale or loose rust. It should not be oiled or painted, but a wash of thick Portland Cement grout is desirable.

Welding should in general be forbidden; if it is found necessary, it should be at points where the metal is least stressed, and it should never be allowed without the special sanction of the architect or engineer responsible for the design.

The reinforcement ought to be placed and kept exactly in the positions marked on the drawings, and, apart from any consideration of fire-resistance, ought not to be nearer the surface of the concrete at any point than 1 inch in beams and ½ inch in floor slabs or other thin structures.

Engineering Standards Committee's Specification for Structural Steel.

The *"British Standard Specification"* above referred to, is that issued in June, 1906, by the Engineering Standards Committee, to cover "Structural Steel for Bridges and General Building Construction," and the principal requirements of which, reprinted by permission, are as follows*:—

"Process of Manufacture. Sectional material for general building construction shall be made by open hearth or Bessemer process, acid or basic, as may be approved in writing by the engineer (or by the purchaser), and must not show on analysis more than .06 per cent. of sulphur, nor .07 per cent. of phosphorus.

The maker shall supply an analysis of each cast when required to do so. Samples may also from time to time be subject to complete analysis by a metallurgist appointed by the engineer (or by the purchaser), at his expense.

Tensile Tests. Plates and Sectional Material:—For plates, angles, etc., a standard test piece having a gauge length of 8 inches (Test Piece A, see Appendix, page 8), and for round bars (other than rivet bars) a standard test piece having a gauge length of not less than 8 times the diameter (Test Piece B, see Appendix, page 8) must show a tensile breaking strength of 28 to 32 tons per sq. inch, (62,720 to 71,680 lbs. per sq. inch) with an elongation of not less than 20 per cent. For material under 5/16th of an inch (.312 inch) in thickness, bend tests only are required.

* The full Text of this Specification, Report No. 15, with illustrations of the Forms of the British Standard Tensile Test Pieces, can be purchased from the Offices of the Engineering Standards Committee, No. 28 Victoria Street, London, S. W. Price, post prepaid, 2/8.

Bend Tests. Cold Bends:—Test pieces shall be sheared or cut lengthwise or crosswise from plates or lengthwise from sectional material, and shall be not less than 1½ inches wide, but for small sections or bars the whole section may be used.

Temper Bends. The test pieces shall be similar to those used for cold bend tests. For temper bend tests the samples shall be heated to a blood red and quenched in water at a temperature not exceeding 80 degrees Fahr. The color shall be judged indoors in the shade.

In all cold or temper bend tests, the sheared edges may be removed by milling, planing, grinding, or other method. The test pieces shall not be annealed unless the material from which they are cut is similarly annealed, in which case the test pieces shall be similarly and simultaneously treated with the material before testing. For both cold and temper bend tests the test piece must withstand, without fracture, being doubled over until the internal radius is not greater than 1½ times the thickness of the test piece, and the sides are parallel.

Bend tests may be made by pressure or by blows.

Tensile Specimens. The tensile strength and ductility shall be determined from Standard test pieces cut lengthwise or crosswise from the rolled material in the case of plates, and lengthwise in the case of sectional material and bars. When material is annealed or otherwise treated before despatch, the test pieces shall be similarly and simultaneously treated with the material before testing.

Any straightening of test pieces which may be required shall be done cold.

Number of Tensile and Bending Specimens. One tensile test shall be made from every cast or every 25 tons, whichever is less.

Should a tensile test piece break outside the middle half of its gauge length, the test may, at the maker's option, be discarded and another test made of the same plate, section or bar.

One cold or one temper bend test shall be made from each plate, section or bar as rolled.

Should the test pieces first selected by the representative of the engineer (or of the purchaser) not fulfill the test requirements, two further tests may be made; but should either of these fail, the plates or sectional material from which the test pieces were cut shall be rejected. In all such cases further tests shall be made before any material from the same cast can be accepted."

Interview with Chas. F. Marsh (London), as to Steel Used.

During an interview in London, in July, 1908, the writer obtained the following information from Mr. Chas. F. Marsh, M. Inst. C. E., as to the character of steel now used in Great Britain for reinforcement, and also Mr.

Marsh's recommended Specification and his opinion in reference to the use of high carbon steel.

He stated that in Great Britain, mild steel is most frequently employed for reinforcements, the usual Specification under which it was supplied, prior to the publication in June, 1906 of the British Engineering Standards Committee's Specification for Structural steel, being as follows:—

Tensile strength, 64,000-72,000 lbs. per sq. inch.

Elastic limit, not less than one-half the ultimate strength.

Elongation, not less than 20 per cent. in 8 inches.

Cold bending test, 180 degrees, flat on itself, without fracture on the outside of the bent portion.

This Specification practically coincides with that of the British Standard Specification, just quoted, except that the latter only requires that the steel shall bend without fracture, to 1½ times the thickness of the test specimen.

In Mr. Marsh's opinion the ultimate tensile strength of steel for reinforcement should not be limited to 72,000 lbs.

He favors the following specification:—

Ultimate Tensile Strength, not less than 60,000 lbs. per sq. inch.

Elastic Limit, not less than 50 nor more than 60 per cent. of the ultimate strength.

Elongation, not less than 22 per cent. in 8 inches, or for round bars a gauge length of eight times their diameter.

Cold Bending Test, 180 degrees, flat on itself, without fracture on outside of bent portion.

He thinks it should be further specified that *welding* should be avoided as far as possible, and only permitted after the sanction of the consulting engineer, and that it is often better practice to lap the joints for a length of about 24 to 30 diameters and bind with annealed wire where joints are necessary.

In reference to the use of a *higher carbon steel* of an elastic limit of not less than 50,000 lbs. per sq. inch, with a minimum elongation of 15 per cent. in 8 inches, which is recommended by the British Representatives of the "Corrugated" or "Indented" Bar (the invention of Mr. A. L. Johnson of America), it is Mr. Marsh's opinion that, in order to get full advantage of such a steel, it is necessary either to use a smaller percentage of reinforcing metal or a very strong quality of concrete.

Mr. Marsh explained that when designing a reinforced concrete beam, the resistance of the concrete becomes the ruling factor when high percentages of reinforcement are used and this is entirely independent of the resistance which the steel is able to offer. As a consequence, the economy in the use of steel having a high elastic limit is only obtained for small percentages of metal.

With regard to the resistance of deformed bars sliding through the concrete, Mr. Marsh stated that although these undoubtedly offer greater resistance to sliding than plain bars, it has been clearly demonstrated that plain bars will not slide under ordinary working conditions, if bent over or split and opened at the ends. When considerable vibrations are to be resisted, Mr. Marsh considers that it may be advisable to obtain a greater factor of safety by the employment of deformed bars.

He considers the employment of small bars advantageous because they distribute the stresses through the concrete better than the same amount of metal centered in one or two larger bars, and because they furthermore give a greater perimeter for resistance to slipping through the concrete; and also because, in using small bars, they can be economically utilized to resist the diagonal tensile stresses by bending them up, as the bending moment decreases and the shearing stresses increase.

He stated that as a precaution against failure by sliding of the bars through the concrete, a large perimeter in proportion to the area of reinforcement is a very desirable feature and that this is obtained by the use of small bars.

As off-setting these theoretical advantages gained by the employment of small bars, Mr. Marsh called attention to the usual increased cost of these smaller sections and the extra labor necessary in putting such reinforcement into position and in keeping it in place, while the concrete is being deposited and rammed. He stated that small bars are readily displaced in the process of ramming, unless they are formed into a framework by being secured together by reinforcements in the vertical plane and that such displacement utterly vitiates the results of theoretical calculations based on the positions of the metal.

In conclusion Mr. Marsh stated that the theoretical advantages attained by the use of "deformed" bars of a steel of high elastic limit for reinforcement, were in practice only actually realized, commercially, when the cost of such steel was not excessive, when provision was made for its careful inspection so as to avoid using brittle steel, when only first class concrete was used, and finally when rigid inspection was maintained during erection.

Furthermore that reinforced concrete structures could be erected with mild steel reinforcements, offering equal resistance under the severest conditions if ample provision against horizontal shear is provided by increasing the bond by supplementary oblique rods, straps, or stirrups, which, however, must be either rigidly attached to, or made a part of the main reinforcing bar so as to prevent slipping, and in this connection, he also included the use of spacing bars and spacing chairs.

He referred to the use, notably for slab reinforcement, of "expanded metal," which in Great Britain was made from very mild steel, the tensile strength of which was materially increased by the operation of expanding, say from 50,000 to 60,000 lbs. per sq. inch, and he expressed the opinion that the effect of the closing up of the meshes under tensile strains added to the resistance by the compression of the concrete induced by such closing up.

Mr. Marsh also referred to the use of various lattice systems, made of cold drawn steel wire, of an average elastic limit of 65,000 lbs. per sq. inch.

Interviews with British Consulting Engineers and Contractors as to Steel Used.

The writer also interviewed several of the most prominent Consulting Engineers in London, who make a specialty of reinforced concrete construction, but who are not tied to any one system.

The opinions expressed were practically unanimous in favor of the use of a mild or medium steel for reinforcement, with a preference for open hearth, over Bessemer steel.

While admitting that the yield point (or elastic limit) should be taken as the point of failure of the steel in a reinforced beam, the engineers pointed out that the high carbon steel had substantially the same *modulus of elasticity* as ordinary mild or medium structural steel and hence the same deformation under any given load.

They considered that in the majority of cases, little or no economy resulted from the use of high carbon steel, on account of the expense incident to the careful inspection which is imperative to insure uniformity and freedom from brittleness.

Interviews with British Agents of Systems of Reinforcement as to Steel Used.

In order to thoroughly cover all sources of information, inquiries were also made, by interview and letters from the agents of each of the 35 "Systems" of reinforcement, which careful preliminary inquiries had shown were to-day in use in Great Britain. As shown elsewhere some of these cannot properly be dignified as true "Systems" of reinforcement.

Out of the total of thirty-five (35) systems, information as to the character of the metal used was obtained from 34 agents.

In *31 cases,* an open hearth or Bessemer steel is used meeting the British standard specification for structural steel for bridges and general building construction, recommended in June, 1906, by the Engineering Standards Committee.

In 3 of the 31 cases, it is specified in addition, that the elastic limit shall not be less than ½ the tensile strength. As shown elsewhere, the tensile strength of this standard specification is 28-32 tons (62,720-71,680 lbs.) per sq. inch.

In *2 cases* a softer steel is used, of a tensile strength of 50,000 and 58,000 lbs. respectively.

In other words, the use of high carbon steel in Great Britain for reinforcement is confined to the English agent of the "Indented" or "Corrugated" bar, the invention of Mr. A. L. Johnson, of St. Louis, and to the use of cold drawn 20 per cent. carbon open hearth steel wire, by the British Company who developed the "Johnson wire lattice" system.

The British agents of the "Indented" bar lay great stress on the advantages, both in strength and economy, obtained by the use of a steel of an elastic limit of 50,000 lbs. per sq. inch rolled into their special shapes; they, however, advertise that they roll their indented bar from ordinary structural steel, meeting the British standard specifications, if preferred.

Messrs. Richard Johnson, Clapham & Morris, Ltd., state that the elastic limit of 64,000 lbs. per sq. inch, in the wire used in their "Johnson wire lattice" system, is obtained by "cold drawing through a die and not by the dangerous practice of adding carbon to the steel." They use a 20 per cent. carbon open hearth steel.

J. S. E. de Vesian, one of the Directors of L. G. Mouchel & Partners, the British representatives of the Hennebique system, stated that

"It is very important that the steel used in ferro-concrete should be of suitable quality for its intended purpose. Most experts in this class of work are now agreed that mild steel produced by the basic open-hearth process, with a tensile strength of from 28 to 32 tons (62,720-71,680 lbs.) per sq. inch, and an elongation of 20 per cent. in a length of 8 inches, is the best for general employment. High carbon steel is unsuitable, as is also any metal of variable quality, such as some kind of Bessemer steel. Apart from the fact that high carbon steel is apt to break unless bent with great care after suitable heat treatment, there is no economy in such metal because, as its coefficient of elasticity is not higher than the coefficient for mild steel, the higher elastic limit cannot be utilized fully without causing excessive stresses in the surrounding concrete, resulting in the cracking of the material and the consequent corrosion of the metal."

France.

GOVERNMENT RULES OF 1907, NOW IN FORCE.

The Government rules for reinforced concrete construction signed by the Ministry of Public Works on October 20th, 1906 and republished in 1907 with the correction of some errors, contain no definite reference to the physical properties of the metal to be used for reinforcement. They, however, include the following instructions in reference to the working stresses which must be used in calculations:—

"*B. Safe Working Stresses.*

7. The safe limit of tensile, as well as of compressive stresses allowed for the reinforcement shall not exceed one-half the value of the elastic limit of the metal employed, and as specified in the contract. However for members, such as slabs subjected to alternating shocks or stresses, this limit is to be reduced to 40 per cent. instead of one-half of the elastic limit.

For members subject to stresses varying within wide limits, the safe working stresses specified above are to be reduced in accordance with the importance of such variations, but this decrease need not exceed 25 per cent.

The safe limits of the working stresses are to be reduced also for members subject to weakening causes not considered in the calculations, particularly to dynamic action, and especially for members directly supporting railway lines."

The writer was surprised at the absence in the Government rules of definite requirements for the metal used, until he became familiar with actual French practice, from the information collected by many personal interviews in Paris and considerable correspondence.

INFORMATION OBTAINED FROM THE AGENTS OF THE 21 FRENCH SYSTEMS OF REINFORCEMENT.

As shown elsewhere in this report, there are 21 systems of reinforcement in use in France. Inquiry from the agents of each of these systems showed that only soft or medium steel is used and to some extent wrought iron has not yet been replaced by steel.

INFORMATION OBTAINED FROM 27 FRENCH CONSULTING AND CONTRACTING ENGINEERS.

Inquiries from 27 French consulting and contracting engineers, a list of whom follow, also proved the uniform adoption of ordinary structural steel for reinforcement.

INFORMATION OBTAINED FROM 11 FRENCH STEEL COMPANIES.

Finally 11 steel companies, making a specialty of bars for reinforcement, were consulted and the only exception to the rule was found at the Paris office of A. L. Johnson who has succeeded in introducing the "Indented" or corrugated bar of higher carbon steel, to some extent.

SUMMARY OF THE REASONS FOR THE USE OF SOFT OR MEDIUM STEEL IN FRANCE.

The following is a summary of the *reasons* given for the uniform adoption of soft or medium steel in France for reinforcement, and it will be admitted that owing to the many parties consulted by the writer, all shades of opinions and interests were included.

The high carbon steel costs more than soft steel and requires much extra care in inspection and testing to insure freedom from brittleness. To obtain the full advantages of its higher elastic limit, the concrete must be stronger than that usually employed. The high carbon steel has substantially the same modulus of elasticity and hence the same deformation under any given load, as the soft steel.

A yield point of 30,000 lbs. per sq. inch corresponds to a stretch of 0.0010 of the length of a piece of soft steel and a yield point of 50,000 to a stretch of 0.00167. Although some experiments have proved the contrary, many French engineers still fear in practice that the stretching of high carbon steel when loaded to its full allowable working stress, might produce cracks in the concrete which would expose the steel to corrosion.

French Consulting Engineers and Contractors in Reinforced Concrete Construction.

BOUBES, GEORGES,

15, place des Quinconces, Bordeaux (Gironde), Bureaux et magasins, 11, rue Ségalier, Bordeaux.

BOULLANGER, ET SCHUL,

29, rue de Londres, Paris.

BRAUNSHAUSEN, APPAY ET FILS,
65, boulevard de Picpus, Paris.

BRUEDER,
115, Faubourg Poissonnière, Paris.

CHAUSSIVERT,
140, rue du Chemin Vert, Paris.

DEBOSQUE BONTE,
Armentières (Nord).

DEGAINE,
9, rue de Lagny, Paris.

DUCLOUX, AMÉDÉE,
212, rue Michel Bizot, Paris.

FERRAND ET PRADEAU,
138, rue de Tocqueville, Paris.

FERRE,
27, rue de Tolbiac, Paris.

FORESTIER, VICTOR,
57, rue de l'Aqueduc, Paris.

FRANCE, LANORD ET BICHATON,
Nancy (Meurthe et Moselle).

GIROS ET LOUCHEUR,
69, rue de Miromesnil, Paris.

GROUSELLE,
10, rue Chasseloup-Laubat, Paris.

PASTRE, D.,
Dreux (Eure et Loir).

LEMOUE,
114, rue de Rennes, Paris.

LOUP ET FILS,
188, rue Saint-Charles, Paris.

PEREGO, L.,
29, rue Théophile Gautier, Paris.

PERROL ET SADRIN,

Le Mans (Sarthe).

PROTHEAU,

Chalon sur Saône (Saône et Loire).

ROQUEREE ET CIE,

7, rue Saint Luc. Paris.

ROUVEROL ET TEISSIER,

19, rue Durand, Montpellier (Herault).

SAINRAPT ET BRICE,

36 et 36 bis, rue du Moulin des Prés (3 place Paul Verlaine), Paris.

SOCIETE DE FONDATIONS PAR COMPRESSION DU SOL,

1, rue Danton, Paris.

SOCIETE GENERALE DE CONSTRUCTIONS EN BETON ARME (Mr. Dumesnil),

167, avenue Victor Hugo, Paris.

SOCIETE DES GRANDS TRAVAUX EN BETON ARME, Tricon et Cie,

85, rue de Prony, Paris.

SOCIETE DES CIMENTS DE CRECHES,

près Macon (Saône et Loire).

French Companies Furnishing Steel for Reinforcement.

Besides the large steel producers of Creusot, Saint Chamond, Montlucon, Firminy, etc., the following companies make a specialty of furnishing steel for reinforced concrete construction.

In each case the address of the Paris office is given.

With exception of the last mentioned, personal inquirv showed that all furnish a low carbon soft or medium steel. A. L. Johnson has recently established a Paris office for the introduction into France of his "Indented" bar rolled from high carbon steel, but so far it has not made much headway.

SALMON ET CIE,

96, rue Amelot ronds acier, Feuillards, Fils pour ciment armé.

L. NOZAL, FILS AÎNÉ.

LASSON, L.,

(dépôt des aciéries de Micheville) 122, faubourg Saint-Martin.

H. COURTOIS, FERS ET ACIERS RONDS,

42, rue Bréguet prolongée.

SOCIETE ANONYME DES HAUTS-FOURNEAUX, FORGES ET ACIERIES DE POMPEY,

Aciers ronds, spéciaux brévetés, à grande adhérence, pour ciment armé.

85, rue Saint-Lazare.

CHAUMONT ET BATAILLE,

99, rue Petit.

P. BLOCH ET CIE,

60, rue du Vivier à Aubervilliers, (Seine).

CANTOIS ET CIE,

Saint-Dié (Vosges) dépôt à Paris, 43, boul. Magenta.

MULATIER ET DUPONT,

Lyon (Rhône) Agent à Paris, H. Graff, 92, rue d'Hauteville.

SOCIETE DU METAL DEPLOYEE,

11, place de la Madeleine.

A. L. JOHNSON,

51, rue du Fauborg Poissonnière barres crénélées à limite d'élasticité très élevée pour constructions en béton armé.

Germany.

GOVERNMENT REGULATIONS OF MAY 24, 1907, NOW IN FORCE.

The Prussian Government regulations for the employment of reinforced concrete construction in buildings, issued by the Ministry of Public Works on April 16, 1904, make no mention of the physical qualities of the metal to be used for reinforcement, nor does the revised edition of these regulations, dated May 24, 1907.

The first edition limits the permissible tensile and compression stresses in the steel to 1200 kilos per qcm. (17,068 lbs. per sq. inch) and this is reduced in the revision of May 24, 1907 to 1000 kilos per qcm. (14,223 lbs. per sq. inch.)

The reason why the physical properties of the metal were omitted is that they are given in the Prussian Government Regulations of November 25, 1891, covering the "Manufacture, Delivery and Erection of large Steel Constructions" and which requirements still current are quoted below.

The regulations of May 24, 1907 give the following instructions in reference to the reinforcing metal.

"The reinforcement must be carefully cleaned, before using, from dirt, grease, and loose rust.

It must be placed correctly, and at the right distances apart, and held in place by special arrangements.

It must be well grouted with a specially fine concrete mixture. In beams where the reinforcement is placed in layers, one upon another, each layer must be separately grouted.

Beams must be covered with at least 2 cm. (0.79 inch) of concrete. Plates with at least 1 cm. (0.39 inch)."

The following table shows that the prescribed physical requirements of the Government regulations of November 25, 1891 for soft steel are in harmony with those adopted in 1893 by a Joint Committee of the three prominent societies:—"The Society of German Architects and Engineers," "The Society of German Engineers" and the "Association of German Iron Masters" and later in March, 1901, by the "Association of German Iron Masters" acting independently.

Comparison of the Three Principal Current German Specifications for Soft Steel Structural Shapes, Rounds and Squares in Thicknesses of 7 to 28 mm. (0.276-1.102 inches).

		Tensile strength		
Name of specification	Direction of testing	Kilos per mm^2.	Lbs. per sq. in.	Elongation, per cent. in 200 mm.
Government Rules, Nov. 25, 1891......	Longitud.	37 to 44	52,625 62,582	20
	Transverse	37 to 44	52,625 62,582	20

Joint Committee of the German Soc. of Architects and Engineers. Soc. of Engineers and Assoc. of German Iron Masters, 1893..	Longitud.	37 to 44	52,625 62,582	20
	Transverse	36 to 45	51,203 64,004	17
Association of German Iron Masters, March 1901	Longitud.	37 to 44	52,625 62,582	20
	Transverse	36 to 45	51,203 64,004	17

Inquiries, as to the metal actually used in Germany for reinforcement were addressed to two prominent authorities, C. Kersten and H. Haberstroh who replied as follows:—

C. Kersten furnished the following information about the reinforcing metal. He is a contracting engineer of Zittau, Germany, has been appointed "Royal Teacher" for schools devoted to building construction and is the author of two excellent recent books on reinforced concrete, one for buildings and the other for bridges. He stated:—

"The best material for reinforcement is soft steel (Flusseisen). Wrought iron is now seldom used because soft steel is stronger and no more expensive than wrought iron. The extra expense of using high carbon steel is not offset by the less quantity required owing to the possibilities in reducing the cross section of the reinforcing rods."

H. Haberstroh, head teacher in the Ducal school for building construction at Holzminden, and author of a book on reinforced concrete published in 1908, wrote as follows in reference to present German practice:

"Although wrought iron is still used to some extent in Germany for reinforcement, soft steel, which now costs about the same, is preferred by most constructors because of its higher tensile strength and its greater uniformity and freedom from impurities.

Medium soft steel of a higher tensile strength is more expensive and its use is only warranted when a concrete of extra high strength is also employed.

It is not the practice in Germany to use the still higher carbon steels for reinforcement."

Summary of Fourteen Replies to Letters Addressed to Prominent German Constructors in Reinforced Concrete.

In order to thoroughly canvass the question of the character of metal being used to-day in Germany for reinforcement, the writer addressed letters to prominent Constructors in Reinforced Concrete and received 14 replies from Firms located in 11 different Cities in all parts of the German Empire, as follows:

Berlin, Hannover, Dortmund, Düsseldorf, Graudenz, Halle a.S., Dresden, Leipsig, Strassburg, Mülhausen, Freiburg.

The letter requested a reply as to which of the following Grades of steel were used by them for reinforcement.

Grade of steel	Tensile strength: Kilos per mm.²	Tensile strength: Lbs. per sq. inch	Elongation, per cent. in 200 mm.-7.87 inches
"Flusseisen" (soft steel)	37 to 44	52,625 62,582	20
"Flussstahl" (medium steel).....	45 to 60	64,004 85,338	10
	Elastic limit		
"Stahl" (high carbon steel).....	35 to 37	49,781 52,625	—

Out of 14 Firms replying to the letters, 12 stated that they used nothing but Soft Steel for reinforcement.

One firm replied that they had used Medium Steel once, because it was specified, but that otherwise they had always used Soft Steel.

One firm stated that although they usually employed Soft Steel, they still sometimes used a Medium Steel of a tensile strength of 60 kilos (85,338 lbs. per sq. inch) and an elongation of 10 per cent.

A list of the 14 Firms replying is as follows:

Steffens & Nölle, A.-G., Berlin, W. 9., Köthenerstrasse 33.

Allgemeine Beton & Eisen Gesellschaft m.b.H., Berlin, W. 57, Bülow-Strasse 55.

Cementbau-Actiengesellschaft, Hannover, Artilleriestrasse 28.

W. F. K. Lehmann, Hannover, Haltenhoffstr. 9.

Robert Grastorf, G.m.b.H., Hannover, Lemförderstrasse 12.

Spezial-Geschäft für Beton und Monierbau Franz Schlüter, Dortmund.

Allgemeine Hochbau-Gesellschaft m.b.H., Düsseldorf, Kreuzstrasse.

Weber Eisenbeton G.m.b.H., Halle a.S., Landwehrstrasse 9.

Kampmann & Cie., Graudenz.

Johann Odorico, Dresden-n, Leisniger Strasse 74.

Cementbaugeschäft Rud. Wolle, Leipzig, Gottschedstrasse 17.

Ed. Züblin & Cie., Strassburg i.E., Kuhngasse 12.

Alfred Münzer, Mülhausen i.E., Hübnerstrasse 15.

Brenzinger & Comp., Freiburg i.B.

Austria.

GOVERNMENT SPECIFICATIONS OF NOV. 15, 1907, NOW IN FORCE.

In Austria the current standard specification for Stamped Concrete and Reinforced Concrete Buildings and Street Bridges was issued by the Ministry of the Interior in Nov. 15, 1907.

Prior to this date, the Prussian Government Regulations of April 16, 1904 and afterwards as revised on May 24, 1907, were most often used although several independent Specifications were issued such as the Special Rules issued in 1903 by the Building Department of the Imperial Royal Railway entitled "Special Rules for the calculation and erection of reinforced concrete. Open Constructions over Standard Railway Lines."

In the above current Government Specifications for Reinforced Concrete Construction of Nov. 15, 1907, the requirements for the Metal used for reinforcement, are those issued by the Minister of the Interior on March 16, 1906 and entitled: "Regulations for the Erection of Street Bridges with Iron or Wooden Beams."

These requirements are as follows:

Soft Steel (Flusseisen) for Bridges, when made in an open-hearth furnace must have a tensile strength of between 36-45 kilos per mm^2. (51,203-64,004 lbs. per sq. inch) and a coefficient of quality of 100 (longitudinal) and of 90 when figured on the transverse elongation. This equals 19.5 per cent. - 15.6 per cent. and 17.5 per cent. - 14.1 per cent. respectively.

Information Obtained from Six Leading Contracting Engineers.

When the Soft Steel is made by any other than the open-hearth process the maximum allowable tensile strength is 42 kilos per mm^2. (59,737 lbs. per sq. inch)

In a letter dated July 10, 1908 from *Janesch & Schnell,* a leading Vienna firm of Contracting Engineers, they state that it is impracticable in Austria to use a Steel of higher physical qualities than Soft Steel (Flusseisen) because the prescribed Government Rules do not permit taking any advantage of the extra strength of Medium Steel of 45 to 60 kilos per mm^2. (64,004-85,338 lbs. per sq. inch), or of high carbon steel of an elastic limit of 35 to 37 kilos per mm^2. (49,781 to 52,625 lbs. per sq. inch).

ED. AST & CO.

This prominent and long established firm of Contracting Engineers with Offices in six of the principal Cities of Austria, have their own System of reinforcement. but also use the Systems of Hennebique, Mollins, Considere, etc.

They wrote on Aug. 29, 1908 that in all cases they used Soft Steel round bars for reinforcement.

FRANZ VISINTINI.

Consulting and Contracting Engineer of Vienna, is the Inventor of the Visintini System of Hollow Beams introduced in several Countries, and the American Patents for which are controlled by The Concrete Steel Engineering Co. of New York.

Under dates of July 20, and Aug. 28, 1908 he wrote that he never used high carbon steel for reinforcement, that he only used medium steel (Flussstahl) of a Tensile Strength of 45 to 60 kilos per mm^2. (64,004-85,338 lbs. per sq. inch) on one occasion, *viz.*, in a building in Holland. Other than this, it is his uniform practice in all Countries to use first quality Soft Steel (Flusseisen) of a guaranteed tensile strength of 4,000 kg. per cm^2. (56,892 lbs. per sq. inch).

PITTEL & BRAUSEWETTER,

Of Vienna, Contracting Engineers, who have used the Melan System since 1892 also use Soft Steel (Flusseisen) for reinforcement as do also

N. RELLA & NEFFE,

Of Vienna and

WESTERMANN & CO.,

Of Innsbruck.

Hungary.

SPECIFICATIONS OF THE HUNGARIAN SOCIETY OF ENGINEERS AND ARCHITECTS.

In Hungary the only specifications for reinforced concrete construction recognized and in use are those issued by the Hungarian Society of Engineers and Architects.

These Specifications, which are printed in the Hungarian language, stipulate that only Soft Open Hearth Steel shall be used for reinforcement. They only permit a working stress of 10 kilos per mm^2. (14,223 lbs. per sq. inch).

Information Obtained from Eight Leading Consulting and Contracting Engineers.

In the Catalog of

ROBERT WÜNSCH,

a leading Specialist of Budapest on Reinforced Concrete Construction, and inventor of the "Wünsch" System for Floors, Beams, and Bridges in use in Hungary and Austria since 1892, Wrought Iron is specified for reinforcement.

Under date of August 2nd, 1908, he wrote that the advantages of the additional strength of Medium Steel or the higher grade of Soft Steel, to say nothing of High Carbon Steel, could not be taken advantage of in Hungary in reinforced concrete construction because the Government Specifications only permit using a working stress of 10 to 12 kilos per $mm.^2$ (14,223 to 17,068 lbs. per sq. inch) in calculations.

He further explained that inasmuch as many of the Iron and Steel Works in Hungary were either owned by the Government or by persons with influence in government circles, there was no likelihood of obtaining any better material than that actually required by the Official specifications.

JOSEF SCHUSTLER,

a leading Contracting Engineer of Budapest, wrote on July 12, 1908 that he uses only Soft Steel for reinforcement and that as far as he knew, Medium or High Carbon Steel had only been used experimentally in Hungary for reinforcement.

PROF. DR. CONSTANTIN ZIELINSKI,

a Consulting Engineer of Budapest, and who has issued a System of calculation used as a basis for reinforced concrete construction by many of the leading Hungarian Contractors, wrote under date of July 27, 1908 that he always specifies Soft Steel of the following physical properties for the reinforcing metal:

Tensile Strength.

36 to 45 kilos per mm^2. (51,203 to 64,004 lbs. per sq. inch).

Elongation.

For 36 kilos Steel, Longitudinal 27 per cent.
Transverse 25 per cent.
For 45 kilos Steel, Longitudinal 22 per cent.
Transverse 20 per cent.

Inquiries from the following leading Hungarian authorities on reinforced Concrete Construction, all of Budapest, confirmed the above statements in reference to the universal use in Hungary of Soft Steel for reinforcement:

PROF. DR. ING. JOHANN KOSSALKS.

OBERINGENIEUR ALEX HAIM.

ING. EUGEN J. KIS.

ING. KOLOMAN v. BALIGH.

ING. DR. BELA v. BRESTOVSZKY.

Switzerland.

SPECIFICATIONS OF THE SWISS ENGINEERING AND ARCHITECTURAL SOCIETY OF AUG., 1903, NOW IN FORCE.

The Specification for Reinforced Concrete Construction, at present officially recognized as a standard in Switzerland, was prepared and adopted in August, 1903, by the Swiss Engineering and Architectural Society. It is entitled "Provisional Specification for the Designing, Construction and Inspection of Reinforced Concrete Buildings."

A Commission appointed by the State is now engaged in Preparing a Specification, which it is expected will be finished and issued by the Federal authorities in 1909.

The current Specification stipulates that the metal for reinforcement shall be Soft Steel (Flusseisen) meeting the requirements of the Steel Specifications issued by the Swiss Federal Board on August 19, 1892 and entitled "Proclamation in reference to the Calculation and Testing of Steel Bridge and Floor Constructions for the Swiss Railways."

The Physical Properties of the Soft Steel used for Structural Shapes, Rounds, Squares and small Flats are as follows:

Tensile Strength and Elongation.

36 to 45 kilos per mm^2. (51,203 to 64,004 lbs. per sq. inch).

Product of the Tensile Strength and the percentage of Elongation after rupture measured in 200 mm. 0.90.

This is equivalent to 25 per cent. Elongation for a Tensile Strength of 51,203 lbs. per sq. inch and 20 per cent. Elongation for a Tensile Strength of 64,004 lbs. per sq. inch.

The specification further states that the *Soft Steel* must be homogeneous, free from blisters and not hot-short; it must stand cold bending both in the condition delivered and after hardening. Rods with cracks, burned places, ridges produced by rolling, or evidences of having been reworked must be rejected for Bridge and Floor Constructions.

In proof that the above Specifications are in common use in Switzerland, the following statements obtained by interviews and correspondence in Zürich, Lucerne and Lausanne are submitted.

Information Obtained from Four Leading Consulting and Contracting Engineers.

PROF. F. SCHÜLE

is the recognized independent authority in Switzerland on Reinforced Concrete Construction. He is in charge of the Station for Testing Materials connected with the Swiss Polytechnic at Zürich. He is Chairman of the Commission on Reinforced Concrete, appointed by the International Association for Testing Materials, and the Author of many technical Papers on this subject.

Prof. Schüle stated that pending the Report of the Swiss Federal Commission on Reinforced Concrete in 1909, that the two above Specifications governed all Reinforced Concrete Construction in Switzerland.

INTERNATIONAL SIEGWARTBALKEN-GESELLSCHAFT.

The central Office and Works of this Company, who control the patented Siegwart Beam, are located in Lucerne. They have 21 Agencies in 10 different Countries.

They wrote under date of July 9, 1908:

"We use for reinforcement a Low Carbon Steel of the following physical properties":—

Tensile Strength.

40-50 kilos per mm.² (56,892-71,115 lbs. per sq. inch).

Elastic Limit.

22-25 kilos per mm.² (31,291-35,558 lbs. per sq. inch).

LOCHER & CIE.

These prominent Contracting Engineers of Zürich, have their own patented System for Floors, Roofs and Beams, but use Considere's System as well as others. They wrote on July 16, 1908.

"For reinforcement we use Soft Steel (Flusseisen) of the quality prescribed in the Specification of the Swiss Federal Board dated Aug. 19, 1892, and of a minimum tensile strength of 4000 kilos per cm.^{2} (56,892 lbs. per sq. inch).

BUREAU TECHNIQUE DE VALLIÈRE & SIMON.

These Consulting and Contracting Engineers of Lausanne, own the patented de Vallière System of Beam Reinforcement, but use the Melan and other systems as well. Under date of July 31, 1908 they stated:

"We use Soft Steel (Flusseisen) in all our reinforced concrete constructions."

Italy.

SPECIFICATION OF THE ITALIAN ASSO. FOR THE STUDY OF MATERIALS OF CONSTRUCTION OF MAY 3, 1905, NOW IN FORCE.

In Italy the current standard specification for Reinforced Concrete Construction is that adopted on June 30, 1906 by the "Italian Association (of Bologna) for the Study of Materials of Construction". This specification was drafted by a Committee of seven appointed by the Association on May 3, 1905.

In this specification the metal for reinforcement must fulfill the following conditions.

"A homogeneous basic open-hearth steel of a tensile strength of 36 to 45 kilos per mm.^{2} (51,203 to 64,004 lbs. per sq. inch) and a 'coefficient of quality' of at least 900. This is equivalent to an elongation of from 20 to 25 per cent.

The Italian Ministry of Public Works issued on Feb. 29, 1908, Official Standard Specifications for the Testing and Acceptance of Steel Constructions. These specify the following qualities for rolled structural shapes rounds and squares, such as are used for reinforcement, which are practically the same as those used for the Soft Steel of the previous Specification."

Tensile Strength.

Longitudinal, 38 to 46 kilos per mm.^{2} (54,048 to 65,426 lbs. per sq. inch). Transverse, 38 to 46 kilos per mm.^{2} (54,048 to 65,426 lbs. per sq. inch).

Elongation.

Longitudinal, 20 per cent.
Transverse, 17 per cent.

Coefficient of Quality.

Longitudinal, 920.
Transverse, 780.

Information Obtained from Ten Leading Consulting and Contracting Engineers as to Metal Used in Italy.

Through interviews and correspondence with the following ten firms, it was ascertained that no grade of steel is used in Italy for reinforcement other than that meeting the above Specification, which calls for a Soft Steel.

The list includes the principal Italian Consulting and Contracting Engineers in Reinforced Concrete Work located in Milan, Rome, Turin and Brescia.

Società Ing. H. Bollinger, Milan. (System Baroni-Lüling)
Società Domenighnetti e Bianchi, Milan. (System Bianchi)
Società del Cemento armato Gabellini, Rome. (System Gabellini)
Società Ing. G. A. Percheddu, Turin. (System Hennebique & Siegwart)
Società Odorico & Cie., Milan. (System Odorico)
Societa Italiana costruzioni e cementi armati, Milan.
Ing. Leonardi et Cie.
Societa Bresciana cementi e costruzioni, Brescia.
Societa Gianassi e Pollino, Turin.
Societa Italiana Chini, Milan.
Societa Romana di Costruzioni, Rome.

CEMENT USED IN REINFORCED CONCRETE. THE CHIEF REQUIREMENTS OF FOREIGN CEMENT SPECIFICATIONS COMPARED.

INTRODUCTION.

In Appendix No. 2, the chief requirements copied from 14 Specifications for Artificial Portland Cement are Classified under 13 Headings. As space would not permit including all Foreign Specifications, the following selection was made representing the principal *current* specifications and Recommendations of England, France, Germany, Austria, Switzerland, Russia, and those of the International Association for Testing Materials.

For ENGLAND seven (7) Specifications are quoted, so as to include all shades of opinions.

1. The British Standard Specification for Portland Cement, as revised and adopted by the Engineering Standards Committee in June, 1907.
2. Certain changes in the above British Standard, recommended during a personal interview in July, 1908, with Bertram Blount, F. I. C., the representative of the institute of Chemistry on the Committee. In his opinion these changes make the Standard Specification particularly applicable for cement for reinforced concrete.
3. Certain changes in the above British Standard, recommended during a personal interview in July, 1908, with David B. Butler, author of "Portland Cement, Its Manufacture, Testing and Use" and member of the firm of Henry Faija & Co's London Cement Testing Works and Chemical Laboratory. Mr. Butler is a recognized authority but was not a member of the British Cement Committee. In his opinion these changes make the Standard Specification better adapted to Cement for Reinforced Concrete.
4. Specifications for Portland Cement for Reinforced Concrete suggested by J. S. de Vesian, a Director of the British Hennebique Co., in a paper read November 6,

1907 before the Civil and Mechanical Engineers' Society of London.

5. Specifications for Portland Cement adopted in May, 1903, by the Canadian Society of Civil Engineers.
6. Specifications for Portland Cement for Reinforced Concrete, recommended by D. G. Somerville & Co., a leading English firm of constructing engineers, in their Catalog of 1907.
7. Specifications for Portland Cement for Reinforced Concrete quoted from Marsh and Dunn's "Manual of Reinforced Concrete," London, Feb., 1908.

NOTE ON THE IMPORTATION INTO ENGLAND AND ITS COLONIES OF BOGUS PORTLAND OR "NATURAL" CEMENT.

There is a well-founded prejudice among British Engineers against the use for Reinforced Concrete of any but well known and reliable brands of Artificial Portland Cement ground very fine, and these are, in large jobs, subjected to periodic testing to insure that there is no variation in quality.

This prejudice against any but the best Portland cement for Reinforced Concrete work, and the stipulations as to makers branding their cement bags or barrels, have been brought about by the shipment of inferior grades of British Cement in the bags of well known standard brands, but particularly by the importation into England and especially into the British Colonies, of low and variable grades of Belgium "Natural" Cement in bags labelled with slight variations of the Trade Marks of British Standard Brands of Artificial Portland Cement.

Largely through the publicity given to the Reports of 1906 and 1907 from the British Consul-General for Belgium, and the protests of British Engineers supervising concrete and reinforced concrete work in the Colonies, the importation of Belgium fictitious Portland Cement under false representation, has materially declined, since 1906, although in 1908, some 100,000 tons of this imported material was used in Great Britain.

Several failures of Reinforced Concrete Structures have been directly traced to the unintended use of Belgian natural cement.

For FRANCE, only one (1) Specification is quoted; that issued by the Ministry of Public Works in June, 1902, because this virtually governs the acceptance in France of all the Artificial Portland Cement used in Reinforced Concrete construction.

For Government work this Specification of course governs and is now in force, but for private work, French Engineers often simply specify that a certain well known and reliable Brand shall be used, in which the setting time is known to be convenient for the class of reinforced concrete construction contemplated.

A personal inquiry in Paris, showed that out of 25 manufacturers of Cement, 15 are members of the "Chambre Syndicate des Fabricants de Ciment Portland de France," and for which Syndicate the Journal "Le Ciment" is the official organ.

For GERMANY, two (2) Cement Specifications are included in the Comparison of the requirements. First, the Government Standard, covering the "Uniform Delivery and Testing of Portland Cement" and originally issued with an Official letter from the Ministry of Public Works dated Berlin, July 28, 1887. A second letter accompanying a revised Specification was issued on April 23, 1897 and this was again revised and issued on February 19, 1902, and which second revision is still in force (September, 1908).

Second, the Specification adopted by the Association of German Portland Cement Manufacturers, at its Annual Meeting in February, 1908.

This Association, originated in 1865, now includes by far the majority of the German Portland Cement Makers in its membership. It holds meetings annually, issues prizes to stimulate investigation, and has its own Laboratory at which the Cement made by each member is periodically tested. Members are bound by the following agreement:—

> "The members of this association are permitted to bring into the market under the term 'Portland cement' only such material as is prepared from an intimate mixture of lime and clay materials as essential ingredients, burning to sintering and subsequently grinding to the finest of flour. They obligate themselves not to recognize as Portland cement any material which is prepared otherwise than above stated, or which during or after the burning has been mixed with foreign bodies, and to look upon the sale of other material under the name of Portland cement as deceiving the purchaser. These requirements are not to forbid the addition of not more than 3 per cent. of other material to the Portland cement for the purpose of regulating the setting time.

"The members of the association further obligate themselves to furnish Portland cement which will in all respects meet the requirements of the Prussian minister of public works.

"When a consumer requires cement for a particular purpose, coarser ground than the requirements, or colored, its preparation is allowable.

"If a member of the association offends the above given obligation, he shall be expelled from the association. His expulsion is made known publicly.

"The manufactured product of each member of the association is tested yearly in the laboratory of the association at Karlshorst, near Berlin, and the results are given out at the general meeting of the association."

For AUSTRIA, one (1) Cement specification is quoted and is now in general use, *viz.*:—the "Rules for the Uniform Delivery and Testing of Portland Cement adopted on April 27, 1907, by the Austrian Engineering and Architectural Association."

For SWITZERLAND, one (1) Specification, the only one in force today, *viz.*:—"Standard Specification for the Uniform Nomenclature, Classification and Testing of Hydraulic Binding Materials, issued by the Testing Station of the Federal Polytecknic, 4th Edition, 1901."

For RUSSIA, one (1) Specification, that issued by the Ministry of Public Highways on April 15, 1905, and still in force.

THE INTERNATIONAL ASSO. FOR TESTING MATERIALS, recommended at their IV Congress held in Brussels, September 3-6, 1906, Methods of Testing Hydraulic Cements. While these are subject to revision at the next Congress to be held in Copenhagen in Sept., 1909, the chief requirements are included in the following Comparison.

COMPARISON OF FOREIGN CEMENT SPECIFICATIONS. (See Appendix No. 2).

In the comparison of fourteen (14) Foreign Specifications for Artificial Portland Cement, the requirements are classified under thirteen (13) Headings.

For brevity, references were omitted to instructions relating to the *manufacture*, the *sampling* and the *preparation* of the sample for testing and analysis, and which details should form a part of every Cement Specification; also references to the *packing, branding, storage* and the conditions governing the *acceptance* of the consignments which the sample represents.

Under each of the 13 Headings no mention is made of the Specifications which do not contain a clause referring to requirement mentioned in the Heading.

The Headings are as follows:

1.—Fineness.
2.—Chemical Composition.
3.—Specific Gravity.
4.—Weight.
5.—Soundness or Constancy of Volume.
6.—Distortion in Cold and Hot Water.
7.—Setting Time.
8.—Mode of Gauging.
9.—Neat Test (Tensile Strength).
10.—Sand Test (Tensile Strength).
11.—Compressive Strength.
12. Blowing Test.
13.—Coolness.

CONCRETE USED FOR REINFORCED CONCRETE. THE CHIEF REQUIREMENTS OF FOREIGN SPECIFICATIONS COMPARED.

Foreign Specifications and Recommendations Compared, Including the Ingredients, their Proportioning and Mixing and the Placing of the Concrete in Reinforced Concrete Construction.

INTRODUCTION.

The Specifications for Portland Cement, which is universally recommended as the only Proper matrix for Concrete for Reinforced Concrete Construction, have been compared elsewhere in this Report.

In all Countries, the specified requirements for the other ingredients of Concrete are so similar that it is not necessary to compare them by classifying under certain Headings, actual quotations from each Specification, and the Recommendations of the leading authorities, as was done in the case of Cement.

All authorities unite in emphasizing the importance of using only the best quality of Sand and of the other Aggregates which make up the Concrete used for different kinds of Work.

The importance of properly proportioning the ingredients, and thoroughly mixing them, and using care in placing the concrete is also universally recognized.

DISCUSSION OF THE FOREIGN CONCRETE SPECIFICATIONS UNDER THE FOLLOWING HEADINGS:—

In the pages immediately following, the principal specified Requirements are discussed under the following Headings, but without, in most cases, actually quoting the text of the current Specifications for England, France, Germany, Austria and Switzerland, and all of which have been studied in preparing this discussion.

1.—Sand.

2.—Aggregates.

3.—Water.
4.—Proportions of the Ingredients.
5.—Mixing.
6.—Placing.

1. Sand.

The Sand should be composed of hard and coarse grains of all sizes instead of one uniform size, as is the "Standard" sand referred to in Cement Specifications. Fine sand alone is not suitable, and the finer the sand the greater is the quantity of cement required for equal strength of mortar.

The British Joint Committee recommended "hard grains of various sizes up to particles which will pass a quarter-inch square mesh, but of which at least 75 per cent. should pass ⅛ inch square mesh".

The sand should be clean and free from ligneous, organic, or other earthy matter. The value of a sand cannot always be judged from its appearance, and tension tests, of the mortar prepared with the cement and the sand proposed, should always be made. To insure uniformity, these tests should be continued at intervals of 7 days, 28 days, and 3 months both in the natural state and after washing the sand. If the natural sand gives higher tensile strength, washing can be dispensed with.

Washing does not always improve sand, as the finer particles which may be of value to the compactness and solidity of the mortar are carried away in the process. Washing is however often necessary to properly clean the sand from objectionable impurities.

Sea sand, if used should be freed from salt, or the concrete will effloresce. In Marine reinforced concrete construction this objection does not apply and sea sand is almost invariably used. Salt does not affect the strength.

2. Aggregates.

The nature of the "Aggregate" has a direct influence on the quality and strength of the concrete. While the selection is ordinarily governed by the materials obtainable in the locality, careful consideration should be given to the character of the work and the desired qualities in the finished construction.

Local materials should be carefully tested and not employed if found unsuitable, unless their inferior quality is taken into account in making the calculations.

When considerable fire-resistance is essential, limestone and like materials liable to disintegrate or become calcined under the action of fire must not be employed.

Flints are also liable to disintegrate under the action of fire and the application of jets of water on the hot surface, but if they are broken before being used as an aggregate this tendency is much less marked.

The British Joint Committee summarize the choice of the aggregate from the point of fire-resistance, as follows:

> "The material to be used in any given case should be governed by the amount of fire-resistance required as well as by the cheapness of, or the facility of procuring, the aggregate.
>
> Experiments and actual experience of fires show that concrete in which limestone is used for the aggregate is disintegrated, crumbles and loses coherence when subjected to very fierce fires, and that concretes of gravel or sandstone also suffer, but in a rather less degree.* The metal reinforcement in such cases generally retains the mass in position, but the strength of the part is so much diminished that it must be renewed. Concrete in which coke-breeze, cinders, or slag forms the aggregate is only superficially injured, does not lose its strength, and in general may be repaired. Concrete of broken brick suffers more than cinder concrete and less than gravel or stone concrete."

Other conditions being similar, the aggregate should consist of the hardest local stone obtainable, other than limestone and flint.

Both *Broken Stone* and what is known as *"Shingle"*, that is gravel with the sand screened out, are used. In either case it must be clean and perfectly free from earthy or organic matters of any kind. Shingle that has come in contact with acid or alkaline solution, must in no case be used.

In some cases the rounded "Shingle" is preferable to broken stone as so many stones have a flaky cleavage and the rounded pebbles make a more even and sounder concrete than these flaky pieces, owing to the ease with which the sand and cement can fill the voids.

The aggregate should vary in size as much as possible between the limits of size allowed for the work. In all cases, material which

* The smaller the aggregate the less the injury.

passes a sieve of a quarter-inch square mesh should be reckoned as sand. The maximum allowable size is usually ¾ inch. The maximum limit must always be such that the aggregate can pass between the reinforcing bars and between these and the centering. The sand should be separated from the gravel or broken stone by screening before the materials are measured.

When the use of *Furnace Ashes* or *Coke Breeze* is allowable, only such qualities should be employed as are free from dust and unburnt coal and are thoroughly burnt. They should be as free as possible from sulphur and other impurities. *Pan Breeze* or *Slack Coal* should not be used as a substitute for, nor should it be mixed with, Coke Breeze.

When using *Ashes* and *Breeze* as aggregates, the metal reinforcements should be thoroughly coated with cement grout before they are embedded. Plenty of water should be used in mixing, as severe ramming will crush these materials and thus the particles will not be thoroughly surrounded with the mortar.

Allowance for the smaller resistance of these two materials must be made in the designs, when they are employed.

Broken Slag, unless free from Sulphur, should not be used. Judging a slag from the analysis of a small sample is not safe, because its composition varies with changes in the operation of the furnace or in the nature of the materials being smelted.

What is known as *"twice burnt slag"* for concrete is a furnace slag broken to the specified size and then burnt in heaps to free it from sulphur. It should afterwards be well washed and weathered in the open air.

3. Water.

The water used in mixing should be fresh and clean, and free from organic and inorganic matter, oil, acids and strong alkalies. Sea water should not be used. The use of water strongly impregnated with lime weakens the strength of the concrete.

As the amount of water to be added depends upon the temperature at the time of mixing of the materials and the state of these, and on other factors, no definite general recommendation can be made. In all cases, however, a sufficient quantity to thoroughly hydrate all the cement, must be used. Furthermore the water must be measured so that exactly the same amount is used for each batch, and it should not be put into the "Mixer" with a hose, as this invariably results in a lack of uniformity in the fluidity of the mix.

There is much difference of opinion as to the quantity of water that should be used. Some constructors mix very dry, and trust that ramming will make a homogeneous concrete and a thoroughly protective coating on the reinforcements, while others use a fairly wet mixture, as less ramming is required.

Marsh and Dunn summarize recent practice in this regard as follows:

"It seems that in a general way, the amount of water may vary within certain limits, both too wet and too dry concretes being dangerous. It is certain that the employment of moderately wet concrete better ensures the protection of the reinforcements and cheapens the production, both on account of the smaller amount of ramming required and the consequent need for less rigid falsework.

In certain cases it may be better to use "wet" and in others "dry", but there must be always sufficient water to hydrate all the cement. Where the work is easily gotten at, and the ramming can be thoroughly effected around the reinforcements, a "dry" concrete is probably the better, but care is necessary that it must not err on the side of excessive dryness. The broken stone should always be thoroughly well wetted before gauging, so as not to absorb the water from the mortar. There is also danger with the use of "dry" concrete of forming lines of cleavage between the successive layers.

Where the piece is of small dimensions and the space around the reinforcements not easily gotten at for ramming, it is advisable to employ a "wet" concrete, but in this case care must be taken to avoid the use of excessive water, and a certain amount of working and ramming should be done to eliminate the air and to prevent voids being left.

In some cases where pipes, etc., are formed by running grout of quick-setting cement into moulds, ramming is entirely dispensed with."

4. Proportions of the Ingredients for Concrete.

The best proportions for the different materials necessarily vary somewhat with the character of the reinforced concrete construction.

The question of expansion and contraction must be considered, as the richer the mixture, the more liable it is to expand and contract under changes of temperature.

Where entire impermeability to liquids is a requisite such as in Reservoirs and for Sea Walls, Quays, etc., a larger proportion of cement must be used.

The British Joint Committee makes the following recommendations:

"Proportions of the Concrete. In all cases the proportions of the cement, sand, and aggregate should be separately specified in volumes.

As the strength and durability of reinforced concrete structures depend mostly on the concrete being properly proportioned, it is desirable that in all important cases tests should be made as described herein with the actual materials that will be used in the work before the detailed designs for the work are prepared.

In no case should less dry cement be added to the cement when dry, than will suffice to fill its interstices, but subject to that, the proportions of the cement and sand should be settled with reference to the strength required, and the volume of mortar produced by the admixture of sand and cement in the proportions arranged, should be ascertained.

For convenience on small works the following figures may be taken as a guide, and are probably approximately correct for medium silicious sand:

Parts cement		Parts sand		Parts mortar
1	+	½	=	1.20
1	+	1	=	1.50
1	+	1½	=	1.90
1	+	2	=	2.35
1	+	2½	=	2.70
1	+	3	=	3.00

The interstices in the aggregate should be measured and at least sufficient mortar allowed to each volume of aggregate to fill the interstices and leave at least 10 per cent. surplus.

For ordinary work a proportion of one part cement to two parts sand will be found to give a strong, practically water-tight mortar, but where special water-tightness or strength is required the proportion of cement must be increased.

The amount of cement added to the aggregate should be determined on the work by weight. The weight of a cubic foot of cement for the purpose of proportioning the amount of cement to be added may be taken at 90 lbs."

D. G. Somerville & Co., London, recommend for general work a mixture of 1 of cement, 2 of sand and 3 of broken stone or shingle; For beams or stanchions 1:2:4 and for floor slabs 1:2½ with 5 of shingle or broken stone or else 3 parts of coke breeze, ashes or clinker.

Marsh & Dunn state that "an ordinary mixture of concrete is in the proportion of 610 lbs. of cement to 13½ cubic feet of sand and 27 cubic feet of stone. This is approximately 1:2:4 mixture. Any other mixture by volume can be altered into a mixture by weight by assuming the cement to weigh 90 lbs. per cubic foot. The proportioning should be effective by using the weight of cement in one bag or barrel, as delivered by the manufacturers, as a unit and adjusting the amount of sand and shingle to this weight. If the cement is turned out of the bags or barrels for the purposes of storing, it should be weighed again as rebagged or packed, and each bag or barrel must contain no less weight of cement than the above mentioned unit. Every facility must be given to any inspector or clerk of works, representing the engineer or architect, to properly supervise the process of weighing.

The sand and stone must be measured in gauge boxes of the capacity necessary to contain the proper amounts for mixing with the cement as specified above.

Cement Mortar.—The cement mortar, where used for uniting surfaces should be composed of 1,220 lbs. of cement to 27 cubic feet of sand, this is approximately a 1 : 2 mixture, the proportioning being effected in the same manner as described above. It must be thoroughly mixed, until of an even color throughout, with a sufficiency of water on clean close-boarded platforms of sufficient size."

J. S. E. de Vesian, a Director of the British Hennebique Company, states that the average mixture adopted in ferro-concrete construction is as follows:

Portland cement....................6 cwt.
Sharp sand........................13½ cu. ft.
Washed gravel.....................27 cu. ft.

These quantities when properly rammed yield about 31 cu. ft. of concrete.

Marsh & Dunn give the following method for determining the proper *proportions* of the ingredients:

1. "Find the percentage of decrease of volume of the stone by ramming. (This may be taken in most cases as 5 per cent., being a sufficiently near approximation).

2. Find the percentage of voids in the broken stone or shingle.

3. Decide on the percentage of mortar in excess of voids that shall be employed. (For such stone as is used in reinforced concrete with a moderately wet mortar will be about 20 per cent.)

4. Find the weight of cement and volume of sand in a unit volume of mortar as described (M. & D. p. 137).

5. Find from (1) the volume of stone when rammed to the unit volume loose, and by adding to this the extra volume caused by the percentage of mortar which is in excess of the voids, the volume of the concrete produced by a unit volume of loose stone will be obtained.

6. The volume of loose stone to form a unit volume of concrete is then obtained by dividing 1 by the volume of concrete found above, and the volume of rammed stone will be less than this quantity by the percentage found in (1).

7. Find the volume of mortar which will be required for this volume of rammed stone, from which may be determined the amount of cement and sand required for a unit volume of concrete.

As an example: Suppose—

1. That the stone decreases 5 per cent. of its volume by ramming.
2. That it has 45 per cent. of voids when rammed.
3. That we use 20 per cent. of mortar in excess of the voids in the stone.
4. That 1,000 pounds of cement and 24 cubic feet of sand are found to make 1 cubic yard of mortar.
5. As the stone decreases 5 per cent. by ramming, 1 cubic yard of loose stone will make 0.95 cubic yard when rammed, and will have 45 per cent. of voids, therefore—$0.95 + (0.95 \times 0.45 \times 0.20) = 1.03$ cubic yards of concrete.
6. As 1.03 cubic yards of concrete are made from 1 cubic yard of loose stone, we shall require $1/1.03 = 0.97$ cubic yard of loose stone to make 1 cubic yard of concrete. The volume of the stone when rammed will be $0.97 \times 0.95 = 0.92$ cubic yard.
7. The mortar is 20 per cent. in excess of the voids in the rammed stone; we have therefore for the volume of mortar required to make 1 cubic yard of concrete $0.92 \times 0.45 \times 1.20 = 0.50$ cubic yard. But there are 1,000 pounds of cement and 24 cubic feet of sand in 1 cubic yard of mortar; we must therefore have $1{,}000 \times 0.50 = 500$ pounds of cement and $24 \times 0.50 = 12$ cubic feet of loose sand to make one cubic yard of concrete.

We have, then, for 1 cubic yard of concrete:—"

Cement		Sand.	Stone.	Proportions by volume			Proportions in cubic feet of aggregate per bag of 224 pounds of cement	
Weight pounds	Cubic feet at 90 lbs. per cubic foot	Loose. Cubic feet	Loose. Cubic feet	Cement	Sand	Stone	Sand	Stone
500	5.55	12.0	26.2	1	2.16	4.72	5.38	11.74

5. Mixing.

The proper mixing of the concrete is of the greatest importance, as the strength of the reinforced Structure depends greatly on the evenness of the concrete employed.

In all cases the concrete should be mixed in small batches and in accurate proportions, and should be laid as rapidly as possible. Retempering is not permissible.

Whenever practicable the concrete should be mixed by machinery, and "batch" machines are considered to give more uniform results than "continuous" machines.

The mixture of the ingredients should be such that the resulting concrete is of an even color throughout and of a consistency that when placed in the work it shall quake slightly when rammed.

A competent foreman should be in constant attendance to give his approval of every batch before it is used.

Marsh and Dunn recommend that if the concrete is mixed by hand, the operations must be performed on a clean close-boarded platform of sufficient size, the sand and cement being first thoroughly incorporated in a dry state by rakes and shovels until the color of the cement is uniformly distributed throughout the sand; after which the proper quantity of water should be added and the mortar thoroughly remixed; the stones, which must have been previously well wetted, must then be added and the whole well mixed by rakes and shovels until of an even color throughout.

D. G. Somerville & Co., London, state that where possible they mix concrete by machinery, but when mixing by hand they always turn the material at least twice while dry and twice when water has been added, the actual turning while the water is being added, not being counted.

6. Placing of Concrete.

The British Joint Committee state that the efficiency of the structure depends chiefly on the care with which the laying is done. They make the following recommendations:

"The thickness of loose concrete that is to be punned should not exceed three inches before punning, especially in the vicinity of the reinforcing metal. Special care is to be taken to ensure perfect contact between the concrete and the reinforcement, and the punning to be continued till the concrete is thoroughly consolidated. Each section of concreting should be as far as possible, completed in one operation; when this is impracticable, and work has to be recommenced on a recently laid surface, it is necessary to wet the surface; and where it has hardened it must be hacked off, swept clean, and covered with cement grout. Work should not be carried on when the temperature is below 34 degrees F. The concrete when laid should be protected from the action of frost, and shielded against too rapid drying from exposure to the sun's rays or winds, and kept well wetted. All shaking and jarring must be avoided.

The Trussed Concrete Steel Co. of Detroit have issued excellent instructions governing the proper placing of Concrete in reinforced concrete construction."

REINFORCED CONCRETE. FOREIGN SPECIFICATIONS AND RECOMMENDATIONS COMPARED UNDER THE CHIEF SPECIFIED REQUIREMENTS.

INTRODUCTION.

In the pages immediately following, the chief requirements of 7 Specifications for Reinforced Concrete are classified under 10 Headings.

The principal Specifications for England, France, Germany, Austria, and Switzerland are included in the Comparison.

As the Specifications governing the acceptance of the different *materials* used in reinforced concrete construction, *viz*: the Portland Cement, the Matrix and the Metal, have each already been discussed, all references to these materials, given in the Specifications for Reinforced Concrete discussed below, have been omitted.

Under each of the ten Headings, quotations from the 7 Specifications are limited to important references to the particular requirements.

For *England,* the Comparison includes three Specifications.

The Recommendations of the Joint Committee on Reinforced Concrete appointed under the auspices of the Royal Institute of British Architects, and whose Report was adopted at a General Meeting of the Institute held on May 27, 1907. The Specifications issued, in their Catalog of 1907, by D. G. Somerville & Co., a leading English firm of Contracting Engineers. The recommendations made by Marsh & Dunn either in their Treatise on "Reinforced Concrete" published in 1906, or in their "Manual of Reinforced Concrete" dated February, 1908.

For *France,* the Government Rules, signed by the Ministry of Public Works on October 20, 1906, and republished in 1907 with the correction of some errors contained in the first draft as issued. The history of the "Commission du Ciment Armè," is given elsewhere when discussing the various Technical and Official Bodies of each Country interested in this Subject. From personal interviews with the leading French Engineers of Reinforced Concrete, the Writer learned that these are practically the only Specifications on Reinforced Concrete now recognized in France, and that in cases where they are not used, the Contractor is made responsible for the entire work under a heavy forfeit in case of accident.

For *Germany,* the Prussian Government Regulations issued by the Ministry of Public Works on May 24, 1907, are included in the Comparison. These represent a revision of the Regulations issued on April 16, 1904, and they will doubtless be again revised as soon as the important "Commission on Reinforced Concrete," appointed in 1905 by the Prussian Ministry of Public Works, and elsewhere referred to, have finished their deliberations.

In the erection of Reinforced Concrete Constructions throughout Prussia, the requirements of these current Government Specifications of May 24, 1907, are obligatory.

For *Austria,* only the Government Regulations issued on November 15, 1907, by the Ministry of the Interior, are included. These now govern the erection of Stamped Concrete and Reinforced Concrete Buildings and Street Bridges in Austria. Prior to their adoption, the Prussian Regulations were generally used, although the Building Department of the Imperial Royal Railway issued in 1903, "Special Rules for the Calculation and Erection of Reinforced Concrete for Open Constructions over Standard Railway Lines". These Special Rules were applied mainly in the construction of a new Alpine Railway.

For *Switzerland,* the Comparison includes the "Provisional Specifications for the Designing, Construction and Inspection of Reinforced Concrete Buildings" drawn up by the Swiss Engineering and Architectural Society in August, 1903. This specification is still in force (May, 1909), although it will be superseded by those to be recommended later in 1909, by a Commission on Reinforced Concrete appointed by the State.

The *International Commission* on Reinforced Concrete, as elsewhere referred to, will make an official report, through Prof. F. Schüle at the fifth Congress of the International Association for Testing Materials to be held in Copenhagen, Denmark, in September, 1909.

Headings.

The requirements of the above seven Specifications are compared under the following headings:

1. Erection.
2. Precautions against Fire.
3. Water Proofing.
4. Surface Finish.
5. False Work.
6. Striking Centers.
7. Testing.
8. Loads.
9. Bending Moments.
10. Allowable Working Stresses.
11. Rules for Calculation.
12. General Regulations.

Summary of Requirements.

1. ERECTION.

Quotations from the seven foreign Specifications show that the importance of keeping the reinforcing Metal in position, and the constant intelligent supervision of every detail during the placing of the Concrete, including the extra precautions to be taken in cold weather, are fully recognized.

2. PRECAUTIONS AGAINST FIRE.

Under "Resistance to Fire," a reference will be found on page 7 to tests of the German Government, and the work accomplished by the British Fire Prevention Committee, with a list of their publications, will be found on page 200 of Appendix III.

The Resolutions of the International Fire Service Congress of 1906 are quoted in Appendix III, Page 189; the Rules of the Fire Offices Committee of London, on Page 202, and the Recommendations of the "Joint Committee on

Reinforced Concrete" as to Fire-Resistance, on Page 9.

The Continental Specifications contain no special reference to precautions against fire, but quotations from three British Specifications referring to this subject, are given.

A review of the above references together with the accompanying quotations, shows that Reinforced Concrete is recognized Abroad as the best known resistance to fire, if the metal is properly protected and if the Concrete is made up of proper ingredients.

In this connection, the definition of the terms "Fire-Proof" and "Fire-Resisting," adopted by the International Fire Prevention Congress of 1903, and given on Page 7, should be consulted.

3. **WATER PROOFING.**

The four Continental Specifications reviewed, do not refer to the water-proofing of Reinforced Concrete, but foreign opinion and practice are concisely outlined in the quotation given from Marsh and Dunn's Manual of 1908.

Foreign practice in the water-proofing of Concrete is discussed by W. Lawrence Gadd in "Concrete and Constructural Engineering," London, Vol. III, pp. 154-157, May, 1908, under the following subdivisions:

"1. By painting the surface of the concrete, or cement, with bituminous compounds, such as asphalt or other water repellant, the object being to prevent water from coming in actual contact at all with the work.

2. The application of washes to the surface of the hardened concrete, the one wash to react with the other, with the object of filling the surface pores with a precipitated insoluble compound.

3. The addition of small quantities of insoluble substances to the cement or concrete itself, in order to fill the pores of the entire mass, or of the surface coat or rendering, with finely divided insoluble matter."

4. **SURFACE FINISH.**

Naturally, the four Official Continental Specifications reviewed, do not treat of this detail of Reinforced Concrete Construction.

It is common practice on the Continent to finish off the exposed surfaces of Concrete by promptly applying to the rough surfaces, a more or less thin Mortar, depending upon the character of the finish desired.

Many other more elaborate methods of finishing are in successful use Abroad, but a discussion of them is outside the limits of this Report.

The well-known dilapidated appearance of the Concrete and Stone Dwellings, coated with pink colored plaster, and noticeable in every Village throughout France and Germany, has tended to emphasize the importance of care in the method of finishing important permanent Reinforced Concrete Structures.

The quotation under the above Heading is confined to the Coloring of Concrete Facing.

5. FALSE WORK.

Foreign practice, as indicated by the quotations given, fully recognizes the necessity of substantial and unyielding Forms, and suggests that they be so designed, if possible that they may be re-used wholly or in part. The necessity is also recognized of maintaining inspection of the false-work during construction, of retaining it in place until some competent and responsible inspector authorizes its removal, and in exercising care in its removal so that the remaining supports are not disturbed.

6. STRIKING CENTERS.

On Page 19, in discussing the causes of the accidents and failures in Reinforced Concrete Construction, reference is made to the premature striking of the centers and false-work, that is before the Concrete had properly set. In foreign practice, as is shown by the quotations from each of the seven Specifications on Reinforced Concrete, the necessity of intelligent judgment in this important matter is fully recognized.

7.—TESTING.

The quotations from each of the seven foreign Specifications, under this heading, include provisions for the testing of the Concrete used and the test-loading of the finished structure after the Concrete has thoroughly hardened and set.

Current foreign practice is to allow two and one-half to three months to elapse before applying the test-load which naturally should not exceed the maximum calculated load.

8. **LOADS.**

From six of the seven Specifications reviewed, a reference to the loads or forces to be resisted by the structure is quoted.

The *dead* load includes the weight of the structure itself with any external permanent loads due to the coverings, etc. To the *live* load, or superimposed load, which is variable, an addition must be made in calculating the total load, in order to allow for the effects of shock and vibration.

9. **BENDING MOMENTS.**

Six of the seven Specifications reviewed, contain provisions under this Heading, which are quoted in full.

10. **ALLOWABLE WORKING STRESSES.**

Quotations under this Heading, are given, from all seven of the foreign Specifications reviewed.

11. **RULES FOR CALCULATION.**

Under this Heading condensed references are given to the Rules and Formulae governing the design, in each Country, of Reinforced Concrete Construction.

12. **GENERAL REGULATIONS.**

From five of the seven foreign Specifications for Reinforced Concrete, a few general regulations are quoted.

1. Erection.

BRITISH REINFORCED CONCRETE COMMITTEE, MAY, 1907.

"Reinforcements to be placed and kept in proper position. Apart from fire-resisting the bars to be not nearer than 1 inch from surface of beams, and ½ inch from surface of floor slabs or other thin structures.

Metal to be properly coated with cement.

Layers of Concrete before ramming not to exceed 3 inches.

Recently laid concrete should be wetted before adding fresh layer.

Hardened surfaces to be hacked up, swept clean and covered with cement grout before adding new concrete.

No concreting to be carried on when temperature is below 34° F.

All shaking or jarring to be avoided.

Fresh work to be protected from frost and sun rays."

D. G. SOMERVILLE & CO., 1907.

"Concrete to be placed in layers not exceeding 6 inches thick, and whenever possible, each section is to be finished completely at end of each day's work. Where new work is started the exposed section of old concrete, or concrete finished on previous day, must be cleaned and covered with a thin grout of neat cement."

MARSH & DUNN'S BOOK ON REINFORCED CONCRETE, 1906.

"The falsework requires special care and forethought, so that it may be as economical as possible, since it forms a large item in the total cost of a reinforced concrete structure. The concrete must be thoroughly well rammed, especially around the reinforcement, as it is very essential that there shall be no pores, and that the concrete shall be thoroughly homogeneous.

Great care is necessary in placing and keeping of the reinforcement in position, as the strength of the structure mainly depends on the skeleton being in its calculated position. Welding should be avoided if possible, and any bending must be done with great care, so that no appreciable strength is lost thereby.

Sufficient thickness of concrete should be allowed on all sides of any reinforcement, except where any parts are tied or otherwise connected. This thickness should never be less than the diameter or width of the bar.

Both foremen and laborers must be carefully selected, and the foreman especially trained to apply the care and thought required, in order that he may see that the structure is exactly as designed, and that all fixtures, etc., are properly moulded in the places assigned to them. A careless laborer should be dismissed at once, as there must be no risk of bad workmanship."

FRENCH GOVERNMENT RULES, OCT. 20, 1906.

"Fixing in position of reinforcement to be of sufficient rigidity to resist shocks and loads during construction.

Concrete, except when poured into moulds, to be rammed in layers suitable to size of aggregate and spacing of reinforcements, but never greater than 2 inches after ramming except when stones are used as aggregate.

Reinforcements to be so spaced from each other and sides of moulds that ramming may be perfect and the concrete be forced into contact with them.

Thickness of concrete outside reinforcements never to be less than 0.6 to 0.8 inches.

Stopping of concreting to be avoided as much as possible. When it is necessary, hardened concrete is to be cleaned, roughened, and watered before fresh concrete is added.

Concrete to be kept moist for 15 days after moulding.

Work to be stopped in frosty weather unless efficaciously protected. If any part of work is injured by a frost it must be cut out."

PRUSSIAN GOVERNMENT REGULATIONS, MAY 24, 1907.

"The concrete to be mixed exactly in the specified proportions. When measuring vessels are used, they are always to be filled in exactly the same way.

The concrete to be used immediately after mixing and before setting has begun. It is not to remain unused longer than one hour in warm and dry weather, or more than two hours in cold and wet weather. To be protected before use from sun, wind or heavy rain, and to be turned over just before use.

The ramming must be continued without a break.

The concrete to be put in place in layers not more than 15 cm. (6 inches) thick, and rammed to an extent proportioned to the wetness of the mass.

For ramming, properly shaped stamps of appropriate weight must be used. Reinforcing rods to be thoroughly cleaned from dirt, grease and loose rust. Care to be taken that all reinforcing rods are properly spaced and tightly packed in concrete. When the reinforcement is arranged in several layers, each layer to be packed separately in concrete.

A thickness of at least 2 cm. (0.8 inches) of concrete to be left beneath all reinforcing rods in beams, and at least 1 cm. (0.4 inches) in floors.

Further layers of concrete should as far as possible be put in place while the earlier layers are still fresh; in all cases the surface of the earlier layer must be roughened.

Hardened surfaces to be roughened, swept, wetted, and covered with a thin cement grout immediately before adding a fresh layer.

In the construction of columns, the concrete must be introduced from one side, remaining open for inspection as long as possible.

In the construction of walls and columns, the upper story not to be commenced until the lower has hardened sufficiently. Three days' notice to be given to the authority before commencing the upper story.

During frost, only such work to be done as can be protected from the effects of frost by suitable precautions.

After prolonged frosts, work not to be recommenced without official permission. Frozen materials must not be used. Until sufficiently hardened, concrete to be protected from frost, premature drying, shaking and overloading.

Time book to be kept. Days of frost to be entered with record of temperature."

AUSTRIAN GOVERNMENT REGULATIONS, NOV. 15, 1907.

"Minimum distance of reinforcements for side of moulds to be 0.4 inch.

Only skilled workmen and experienced formen to be employed.

Concrete of consistency of moist earth in layers not greater than 6 inches.

Wet concrete in layers not exceeding 8 inches. Concrete not dropped from greater height than 6 feet.

Reinforcements to be carefully placed and fixed, and well covered by the mortar of the concrete.

Interruption of concreting only where concrete is not exerting full allowable resistance.

Hardened concrete to be roughened, cleaned and wetted with 1 to 1 neat cement grout before more is added.

Concrete not to be laid in frosty weather unless precautions are taken.

Concrete to be kept wet until sufficiently hardened.

Use of members moulded in advance not allowed without special permission.

Provision for protection against penetration of water."

SWISS ENGINEERING & ARCHITECTURAL SOCIETY. PROVISIONAL SPECIFICATION OF AUG., 1903.

"Reinforcements to be placed in exact position shown on the drawings and their sizes must be carefully checked.

If metal is rusty it must be cleaned before putting in place.

Work of erection only to be entrusted to those thoroughly conversant with this method of construction.

Only trustworthy foremen having experience in this class of work to be employed."

2. Precautions Against Fire.

BRITISH REINFORCED CONCRETE COMMITTEE, MAY, 1907.

"No limestone to be used.

Best materials for fire-resistance:

1. Coke breeze, cinders or slag.
2. Broken Bricks.
3. Gravel or stone.

Rigidly attached web members, loose stirrups, bent-up rods or similar means of connecting the metal in the lower or tension sides of beams or Floor Slabs with the upper or compression sides, are very desirable.

Metal to be covered by concrete 1 inch thick for floor slabs, 1½ to 2 inches thick for other parts—all angles to be splayed or rounded.

For highest Fire-Resistance the Concrete should be covered with special fire-resisting materials."

D. G. SOMERVILLE & CO., 1907.

"All reinforcing Steel must be protected by at least ¾ inch of concrete, and must not be painted."

MARSH & DUNN'S MANUAL, FEB., 1908.

"The following is a suggested standard for a Floor which is fire-resisting in the highest degree likely to be required in buildings.

(a) It should be capable of withstanding the effects of a continuous fire at a temperature of 1,700° to 2,000° F., for three or four hours without more than surface damage.

(b) It should prevent the passage of flames through it under these conditions and during that time.

(c) It should not suffer more than surface damage by such fire, followed by the application of a powerful stream of water from a fire hose while the material is still hot.

(d) It should sustain its proper load without excessive deflection during and after the fire.

In general, reinforced concrete construction depends for its fire-resistance not on the style of reinforcement, but chiefly on the nature of the concrete and its ability to withstand cracking or disintegration and to its heat insulating value as a steel protection."

3. Waterproofing.

MARSH & DUNN'S MANUAL, FEB., 1908.

"The proper and efficient waterproofing of Concrete structures is a matter which requires very special consideration.

Walls not exposed to a great range of temperature or variation in humidity should not crack, especially if reinforced. Soap and alum solutions will probably be quite efficient in such cases, and some slaked lime mixed with the concrete may be sufficient to produce watertightness; even untreated concrete if sufficiently dense may prove impervious.

Ordinary asphalt tar, or other mastics frequently employed, may become hard and brittle, and eventually crack and allow the moisture to penetrate.

Burlap is frequently used with asphalt and tar to give them elasticity, and although such waterproofing layers are frequently effective, particularly to resist small heads, the burlap is not waterproof of itself, and if the asphalt or tar becomes cracked its employment offers no additional protection.

Ordinary asphalt and tar are liable to be attacked by the alkalis in the cement and the salts always found in the earth.

Washes, paints and coatings will resist the penetration of moisture temporarily, but if cracks occur their value is entirely lost.

A very good method of waterproofing is the "Hydrex," which consists in inserting in the substance of the wall or floor, layers of strong, flexible felt, so coated in manufacture that all the pores are closed, the layers of felt being cemented together with an impervious, elastic compound, generally high grade waterproofing asphalt specially prepared.

Four or five layers thus cemented together are usually sufficient for ordinary cases, although from 6 to 10 layers may be necessary for reservoirs and similar structures.

The waterproofing layer should not be attached to the concrete, but should be perfectly free to move under the expansion and contraction of the structure. It should be placed on the side against which the water pressure will act, or from which the moisture may gain admission, and be covered with a protecting layer of concrete, mortar or bricks.

An excellent method to adopt is to secure one layer of the water-proofed felt against the surface to be protected, then place the required number of layers of felt cemented together as described above, covering these with another layer of felt which is secured to the outer protecting covering of concrete. The waterproof stratum is thus left entirely free and is well protected."

4. Surface Finish.

MARSH & DUNN'S MANUAL, FEB., 1908.

"A colored facing mixture is sometimes applied to concrete, in which case the sand for the colored mortar must be perfectly dry and the cement, sand and coloring matter should be mixed dry before the water is added. The coloring of the mixture when freshly made must be deeper than that actually required in the finished surface as the colors will bleach considerably on drying out.

Mr. H. G. Richey gives the following proportions for the coloring matter.

Color of facing	Coloring matter to be employed	Weight to be used with one barrel or 376 lbs. of cement
Black	Manganese dioxide	45
Brown	Best roasted iron oxide	25
Brown	Brown Ochre	15 to 20
Blue	Ultramarine	19
Buff	Ochre*	51
Green	Greenish-blue ultramarine	23
Grey	Germantown lamp-black (boneblack)	2
Red	Raw iron oxide	22
Bright red	Pompeian or English red	22
Purple	Prince's metallic	20
Violet	Violet iron oxide	22
Yellow	Ochre	22

Common lamp-black or venetian red should not be used as they are liable to run and fade.

* This will considerably reduce the strength.

5. False Work.

BRITISH REINFORCED CONCRETE COMMITTEE, MAY, 1907.

"To be rigid and unyielding during laying and ramming of concrete.

To be easily removed without jarring concrete.

Timber to be covered with limewash."

D. G. SOMERVILLE & CO., 1907.

"All centering to be carefully erected by our men, and to be absolutely rigid and true. All joints must be close so as not to allow leakage of grout."

MARSH & DUNN'S MANUAL, FEB., 1908.

"All timbering used for temporary purposes in connection with reinforced concrete work should be strongly and firmly erected, and all faces against which the exposed surfaces of the concrete will be deposited must be planed smooth and free from knot holes and other imperfections, and covered with a suitable material to prevent the concrete adhering to the surface of the timber. If at any time it is found that the falsework or moulds are insufficiently rigid or in any way defective, the contractor should strengthen or improve the strutting, shuttering, moulds or non-adhesive covering if risk of injury to the work is to be avoided. For moulds and falsework it is advisable to select a timber which is not too dry, as such material swells in an irregular manner, but under no circumstances should a green timber be used.

The moulds and falsework used in the erection of concrete structures should be:

1. Rigid.
2. Simple in construction.
3. Easily erected and removed.
4. So constructed that the surfaces should not deform the concrete by reason of the expansion due to moisture.
5. So designed, if possible, that they may be re-used either wholly or in part in various portions of the work.
6. So prepared that the concrete will not become attached to the surfaces, and that the face left requires no patching up.
7. Carefully cleaned before the concrete is deposited."

FRENCH GOVERNMENT RULES, OCT. 20, 1906.

"To be of sufficient rigidity to withstand without noticeable deflection loads and shocks occurring during construction and in removal of moulds, etc."

PRUSSIAN GOVERNMENT REGULATIONS, MAY 24, 1907.

"To possess sufficient resistance to bending and shaking during ramming, and to be arranged so as to be removable without danger to the necessary supports remaining in place.

At least three days' notice of the completion of false-work and commencement of concreting in any story to be given to the authority.

All shaking to be avoided during removal."

AUSTRIAN GOVERNMENT REGULATIONS, NOV. 15, 1907.

"To be rigid and unyielding during laying and ramming concrete. To be removable without shock. Proper cambers to be provided. No appreciable loading until forms and supports are removed."

SWISS ENGINEERING & ARCHITECTURAL SOCIETY. PROVISIONAL SPECIFICATION, AUG., 1903.

"Care to be given to design and erection, so that it is capable of allowing ramming of concrete in thin layer without injury."

6. Striking Centers.

BRITISH REINFORCED CONCRETE COMMITTEE, MAY, 1907.

"Depend on dimensions or thickness of structure, amount of water used in mixing, state of the weather during deposition and setting, and whether or not it is to be loaded directly after removal of centering.

Casings for columns and sides of beams and bottoms of floor slabs not more than 4 ft. span not to be removed under 8 days.

Bottoms of beams or floor slabs of greater span than 4 ft. to remain up at least 14 days.

For large span arches centering not to be removed under 28 days.

If frost occurs during setting of concrete, period to be extended by time of duration of frost."

D. G. SOMERVILLE & CO., 1907.

"Unless otherwise specified, all centering for columns and ceilings to be of dressed timber with close joints, the concrete being left from centering. The surface of floors and roofs, unless specified, being left from spade finish.

Frost: All concrete work to be entirely suspended in frosty weather, and all new work to be covered up at night when frost is expected, and centering must be left in position at least 14 days longer than usual, and is on no account to be removed until frost has entirely disappeared.

Floor centering must not be removed under 10 days, and bottom of beams and sides of columns under 21 days."

MARSH & DUNN'S BOOK ON REINFORCED CONCRETE, 1906.

"A large percentage of the accidents which have occurred in this form of construction have been due to the premature striking of the falsework."

FRENCH GOVERNMENT RULES, OCT. 20, 1906.

"Moulds, etc., to be removed without shocks by purely static forces, and only after the concrete has sufficient resistance to sustain without injury the stresses to which it will be subjected."

PRUSSIAN GOVERNMENT REGULATIONS, MAY 24, 1907.

"The time between moulding and removal of casings and falsework to depend on the weather, and on the span and weight of the structural members. The casings for columns, centering for floors, and side casings for beams may be removed not less than 8 days, that for the bottoms of beams not less than 21 days, after moulding. For large spans and sections, the time may be extended in certain cases up to 6 weeks.

Special care to be taken in removal if concrete is finished shortly before commencement of a frost.

If frost occurs during the setting of concrete, the above periods are to be increased by the time of duration of the frost."

AUSTRIAN GOVERNMENT REGULATIONS, NOV. 15, 1907.

"Supporting parts are not to be removed until concrete has sufficiently hardened and never before 4 weeks after completion of ramming, but sides of forms are to be removed after 4 days.

If frost occurs during setting of concrete, period to be extended by time of duration of frost. Shocks to be avoided."

SWISS ENGINEERING & ARCHITECTURAL SOCIETY, PROVISIONAL SPECIFICATION, AUGUST, 1903.

"Before striking it must be ascertained that concrete is sufficiently set.

Centering for slabs or beams not exceeding 10 ft. span not to be removed in less than 10 days after moulding.

For beams of 10 to 20 ft. span, and for columns, falsework to remain for 20 days, and for longer spans, 30 days.

In buildings with several floors, the removal of supports to begin on the top floor and proceed downwards.

Before striking, report to be made stating if all parts of the work have been properly carried out."

7. Testing.

BRITISH REINFORCED CONCRETE COMMITTEE, MAY, 1907.

"Test pieces of concrete in forms of cubes not less than 4 inches on edge, or cylinders, not less than 4 inches diameter, and having length not less than diameter, should be tested before designing important work and during erection.

Average of not less than 4 cubes or cylinders for each test. Test to be made 28 days after moulding.

1 : 2 : 4 concrete to have strength of not less than 2,400 lbs. per sq. inch.

Loading tests not to be made till 2 months after completion.

Test load not to exceed 1½ times superimposed loading.

Consideration to be given to adjoining parts of structure in case of partial-loading.

No test load to be applied which would cause metal to be stressed more than 2/3 of its elastic limit."

D. G. SOMERVILLE & CO., 1907.

"The Architect or Engineer in charge of the work to have the right to test any unit area of the floor one month after centering has been removed."

MARSH & DUNN'S BOOK ON REINFORCED CONCRETE, 1906.

"Acceptance test should never be so severe as to endanger the structure tested. A moderate test loading, not more than the maximum load for which the structure has been designed should be employed and the deflection carefully taken.

It must be remembered that in a reinforced concrete structure, unlike one of steel, the resistance increases with the age up to periods of 3 years or more, and that it is unfair to the materials to strain them severely during the initial stages of the hardening of the concrete.

No test loading should be attempted until the structure has been completed for three months, nor should the full loading come upon it until after this period.

A structure properly designed and erected will, after three months, bear the maximum load for which it was calculated with very small deflection, and this deflection will practically disappear on the removal of the load. A test of this description is quite sufficiently severe for acceptance purposes, especially when we know that the resistance must increase with the age of the concrete."

FRENCH GOVERNMENT RULES, OCT. 20, 1906.

"Conditions of test and time that shall elapse before structures are brought into use must be inserted in contract, and also the maximum deflections, as far as practicable.

The time to elapse before use of structures must be 90 days for structures of primary importance, 45 days for ordinary constructions and 30 days for floors.

Measurements to be taken during tests which are likely to be of scientific interest to engineers.

Test loads on floors shall be the dead and superimposed loads acting over the whole area of the floor, or at least upon a complete panel.

The loads to be left on for at least 24 hours, and deflection to cease after 15 hours."

PRUSSIAN GOVERNMENT REGULATIONS, MAY 24, 1907.

"Compression cubes to be provided, 30 cm. (12 inches) side, to be dated and sealed. Tests may be made by the authority in any approved manner. Tests may be made on the works by means of an officially controlled press.

Portions of building in positions determined by building authority are to be exposed if desired, so that the mode of construction can be seen. Special tests may be made to determine hardness and strength.

Should doubt exist as to hardness and correct mixing, test pieces may be cut out of the finished building.

If loading tests are considered necessary, they are to be carried out under the instructions of the building authority. Loading tests are not to be made in less than 45 days after setting, and are to be strictly limited to what is considered necessary by the authority.

When a floor is tested, the load added is not to exceed one-half the weight of the floor and one-and-a-half times the evenly distributed working load. When the working load is more than 1000 kg. per sq. m. (205 lbs. per sq. ft.), this may be diminished down to once the working load.

When a strip in a floor or decking is to be tested, the load is to be evenly distributed in the midst of the floor, over a strip of length equal to the span and width one-third of the span, but in any case not less than 1 m. (39 inches). In this case the test load must not exceed the weight of the strip and twice the working load. The weight of floors is to be reckoned as defined below. In testing columns or piers, unequal loading of the building, and loading of the foundations beyond the permissible limit, are to be avoided."

AUSTRIAN GOVERNMENT REGULATIONS, NOV. 15, 1907.

"Breaking tests of whole or part to be made on request.

No test before expiration of 6 weeks after completion of ramming.

Loading to be such that effect is same as dead load plus 1½ specified superimposed load. No cracks or permanent deformations.

For breaking tests, load to be gradually increased.

Breaking load not to be less than 3½ times the total dead and superimposed load, less the weight of the member."

SWISS ENGINEERING & ARCHITECTURAL SOCIETY, PROVISIONAL SPECIFICATION, AUGUST, 1903.

"Test loads to be at least 50 per cent. greater than working loads allowed in calculations.

Test loads not to be put on until 45 days have been allowed for setting.

If possible, deflections at different stages of loading to be noted."

8. Loads.

BRITISH REINFORCED CONCRETE COMMITTEE, MAY, 1907.

"Weight of concrete to be taken as 150 lbs. per cu. ft.

Weight of any covering to floors must be added to dead load.

Superimposed load should be multiplied by 1½ for public halls, factories, workshops, etc., and by 2 floors carrying machinery, roofs of vaults under passage ways, courtyards, etc.

In the case of columns or piers in buildings, which support three or more floors, the load at different levels may be estimated in this way. For the part of the roof or top floor supported, the full accidental load assumed for the floor and roof is to be taken. For the next floor below the top floor 10 per cent. less than the accidental load assumed for that floor. For the next floor, 20 per cent. less, and so on to the floor at which the reduction amounts to 50 per cent. of the assumed load on the floor. For all lower floors the accidental load on the columns may be taken at 50 per cent. of the loads assumed in calculating those floors."

D. G. SOMERVILLE & CO., 1907.

"The floors shall be of sufficient strength to carry load specified in addition to their own weight.

The floors to take twice the calculated safe live load, and show a deflection of not more than 1/360 of the span, such deflection to disappear after the removal of the test load."

MARSH & DUNN'S MANUAL, FEB., 1908.

"When designing any structure the total load will consist of the weight of the structure itself (the weight of reinforced concrete may be taken as 150 lbs. per cu. ft.) with any external permanent loading due to the coverings, etc., and the imposed loading.

Where, in addition to the imposed load, the effects of shock or vibration must be provided for, it is usual to increase the actual load by a coefficient as follows:—

For varying loads with vibration as for floors of assembly rooms, factories, workshops, highway or foot bridges or similar cases, 1.50.

For considerable vibration such as is produced by moving machinery on floors, on railway bridges or for heavy rolling traffic .... 2.00"

FRENCH GOVERNMENT RULES, OCT. 20, 1906.

"The loads on roofs to be in accordance with Ministerial regulations of Feb. 17, 1903, dealing with metallic roofs for railways, unless exceptions are justifiable.

Floors and other parts of buildings, retaining walls, walls of reservoirs or conduits under pressure where affecting public safety, to be designed for maximum loads they may have to carry."

PRUSSIAN GOVERNMENT REGULATIONS, MAY 24, 1907.

"Weight of concrete shall be taken as 2,400 kg. per cu. m. (150 lbs. per cu. ft.) unless a different weight is definitely determined.

The weight of any covering to floor must be added to dead load.

For parts of structures subjected to considerable vibration or to greatly varying loads, such as floors of public and dancing halls, factories or workshops, the superimposed load to be multiplied by 1½.

For parts subjected to heavy shocks, such as roofs of vaults under passages or courtyards, the superimposed load to be multiplied by 2."

SWISS ENGINEERING & ARCHITECTURAL SOCIETY, PROVISIONAL SPECIFICATION, AUGUST, 1903.

"Weight of any covering, etc., to be added to dead load.

In determining superimposed load allowance to be made for any shock or vibration it may produce."

9. Bending Moments.

BRITISH REINFORCED CONCRETE COMMITTEE, MAY, 1907.

"Spans. These may be taken as follows:— For beams the distance from center to center of bearings. For slabs supported at the ends, the clear span plus the thickness of slab. For slabs continuous over more than one span the distance from center to center of beams.

Bending Moments. In the most ordinary case of a uniformly distributed load of -w- lbs. per inch run of span the bending moments will be as follows:—

(a) Beam or slab simply supported at the ends. Greatest bending moment at center of span of -l-inches is equal to wl2/8 inch lbs.

(b) Beam continuous over several spans, or encastrè or fixed in direction at each end. The greatest bending moments are at the ends of the span, and the beam should be reinforced at its upper side near the ends. If continuity can be perfectly relied on, the bending moment at the center of the span is wl2/24, and that over the supports -wl2/12. If the continuity is in any way imperfect, the bending moment at the center will in general be greater, and that at the supports less, but the case is a very indefinite one. It appears desirable that generally in building construction the center bending moment should not be taken less than wl2/12. The bending moment at the ends depends greatly on the fixedness of the ends in level and direction. When continuity and fixing of the ends, whether perfect or imperfect, is allowed for in determining the bending moment near the middle of the span, the beam or slab must be designed and reinforced to resist the corresponding bending moments at the ends. When the load is not uniformly distributed the bending moments must be calculated on the ordinary statical principles."

MARSH & DUNN'S MANUAL, FEB., 1908.

"In structures of reinforced concrete in which the beams or slabs are secured at their supports, the ends of these pieces are very seldom absolutely fixed, and consequently the bending moments will vary with the nature of the fixing. The variation of the moments from those of a freely supported beam according to the amount of fixing must of necessity be left to the judgment of the designer. For ordinary cases it will be sufficient if the bending moments are considered as the mean between those for freely supported and absolutely fixed at the ends. The shearing forces will not alter with the amount of fixing. Under this assumption the bending moments and shearing forces will be as given in Table XVI.

TABLE XVI.

	For a uniformly distributed load	For a load concentrated at the center
At the centre	$M_C = + \frac{wl^2}{12}$	$M_C = + \frac{3wl}{16}$
At the supports	$M_A = - \frac{wl^2}{24}$	$M_A = - \frac{wl}{16}$
At the supports	$K = \frac{wl}{2}$	$K = \frac{w}{2}$

For other loadings on pieces with partially fixed ends the maximum bending moment on the span may be found as for a freely supported piece multiplied by 2/3 for the central bending moment, and 1/3 for the bending moment over the supports. It must, however, be borne in mind that these values are only approximations and that if the security of the ends is considerable the bending moments over the supports will be higher than the values given above while those on the spans will be less."

FRENCH GOVERNMENT RULES, OCT. 20, 1906.

"For freely supported or continuous beams usual values may be applied.

For partially fixed ends the bending moment at center of span for uniformly distributed load to be $\frac{wl^2}{10}$.

If L and B are the spans of a rectangular slab the bending moment as for a beam of span B can be decreased by co-efficient $\frac{1}{1 + 2\frac{B^4}{L^4}}$, or span L the bending moment as for beam of span L with the coefficient of reduction of $\frac{1}{1 + 2\frac{L^4}{B^4}}$."

PRUSSIAN GOVERNMENT REGULATIONS, MAY 24, 1907.

"Span for beams to be free opening plus one support.

Span of continuous decking to be distance from center to center of supports.

For freely supported decking, the free span plus the thickness of the decking.

Bending moments and reactions to be determined by formulae for freely supported or continuous beams according to mode of support and distribution of load.

For continuous decking, the bending moment at center of span is to be taken as four-fifths of that which would exist in a freely-supported panel, unless the moments and reactions can be ascertained.

The above rule holds good for beams, excepting that no end moment is to be taken into account unless special arrangements have been made to fix the ends.

Decking and beams only to be reckoned as continuous if resting on solid supports in one plane, or on reinforced concrete beams.

Continuity not to be assumed over more than three spans."

AUSTRIAN GOVERNMENT REGULATIONS, NOV. 15, 1907.

"Spans for freely supported and continuous beams to be from center to center of support.

Beams extending over several supports must be computed as for continuous beams, incidental unfavorable loading being taken into account. Continuity not to be assumed as extending over more than three spans.

Elastic deformation in supports of continuous beams to be taken into account.

In beams the possibility of fixing moments at the supports must be provided for by suitable reinforcements.

If L and B are spans of rectangular slab, and L is not more than one and a half B, slab being reinforced with equal area of metal both ways bending moment as for beam of span B can be decreased by co-efficient $\frac{L^4}{L^4 + B^4}$."

SWISS ENGINEERING & ARCHITECTURAL SOCIETY, PROVISIONAL SPECIFICATION, AUGUST, 1903.

"Most unfavorable disposition of loading to be allowed for.

In continuous or encastre beams the bending moments at center of spans not to be less than 2/3 the moments at the supports, due to the loading and amount of fixing, and reinforcement over supports is to be provided.

If amount of fixing cannot be determined, the moment at center of span must not be less than 20 per cent. that for a freely supported beam and that at supports to be at least half of that at center."

10. Allowable Working Stresses.

BRITISH REINFORCED CONCRETE COMMITTEE, MAY, 1907.

"The British Reinforced Concrete Committee advise that the working stresses should be as follows:

If the concrete is of such a quality that its crushing strength is 2,400 to 3,000 lbs. per sq. inch after 28 days, and the steel has a tenacity of not less than 60,000 lbs. per sq. inch, the following stresses may be allowed—

	Lbs. per sq. in.
Concrete in compression in beams subjected to bending	600
Concrete in columns under simple compression	500
Concrete in shear in beams	60
Adhesion of concrete to metal	100
Steel in tension	15,000 to 17,000

When the proportions of the concrete differ from those stated above, the stress in compression allowed in beams may be taken at 1/4, and that in columns at 1/5 of the crushing stress of cubes of the concrete of sufficient size at 28 days after gauging. If stronger steel is used than that stated above, the allowable tensile stress may be taken at 1/2 the stress at the yield point of the steel.

The British Committee made no suggestion for the safe stresses on hooped compression members. See French Government Rules for these."

D. G. SOMERVILLE & CO., 1907.

"Safe compressive strength, 12,000 lbs. per sq. inch.
Safe tensile strength, 16,000 lbs. per sq. inch.
Ratio of modulus of concrete to steel 10: 1."

MARSH & DUNN'S MANUAL, FEB., 1908.

"Under this heading they quote the recommendations of the British Reinforced Concrete Committee and the French Government Rules."

FRENCH GOVERNMENT RULES, OCT. 20, 1906.

"$\frac{E_s}{E_c} = 8$ to 15.

Minimum when diameter of longitudinals 1/10 least dimension of member, ties or transverse reinforcements spaced apart a distance equal to least dimension of member. Maximum when diameters of bars equal to 1/20 least dimension of member and spacing of ties, etc., 1/3 least dimension of member.

Resistance of concrete in tension taken into account for calculation of deformations but not resistance.

Concrete in compression not to exceed 28 per cent. crushing strength of 8 inch cubes of plain concrete 90 days old.

When hooped or when transverse or oblique, reinforcement disposed to prevent swelling of concrete above resistance may be increased in proportion to volume of bars and their suitability of arrangement, but safe resistance to be never greater than 60 per cent. crushing strength.

Concrete in shear and adhesion of concrete to steel 28 per cent. of crushing strength of concrete.

Steel in tension and compression not more than 1/2 strength at elastic limit reduced to 40 per cent. for members such as slabs subjected to alternating stresses.

For members subjected to stresses, varying within wide limits safe resistances to be reduced, but not more than 25 per cent."

PRUSSIAN GOVERNMENT REGULATIONS, MAY 24, 1907.

"$\frac{E_s}{E_c} = 15.$

unless definitely determined to be different.

Resistance of concrete in tension to be neglected, except that in parts exposed to weather, moisture, corrosive gases or other injurious influences, it must be shown that the tensile stresses are insufficient to produce cracks in the concrete. The permissible stress is then 2/3 of the tensile strength. In the absence of tests as to tensile strength of concrete it is to be reckoned as not more than 1/10 the compressive strength.

Concrete in beams, 1/6 ultimate compressive resistance.

Concrete in simple compression, 1/10 ultimate resistance.

Concrete in shear, 64 lbs. per sq. inch or 1/5 ultimate.

Adhesion of concrete to steel same as in shear.

Steel in tension or compression not to exceed 1,000 kg. per sq. cm. (14,220 lbs. per sq. inch).

As far as possible, the reinforcements to be of such form that displacement relative to the concrete is prevented."

AUSTRIAN GOVERNMENT REGULATIONS, NOV. 15, 1907.

"Co-efficient elasticity of concrete in compression 1,990,000 lbs. per sq. inch.

Co-efficient elasticity of steel in tension or compression 29,850,000 lbs. per sq. inch.

$\frac{E_s}{E_c} = 15.$

Resistance of concrete in tension neglected in calculating strength.

		Concrete working stresses		
Weight of cement in lbs. to cubic yard of sand and stone		720	535	428
Proportions in Volume		1 : 3	1 : 4	1 : 5
Bending or eccentric loading		Lbs. per square inch		
Compression		570	512	454
Tension		341	327	305
Simple Compression		398	355	312
Shearing		64	64	50
Adhesion		78	78	64
Soft Steel Tension	13,500			
Medium Steel	14,200			
Steel Shear	8,530			

Stirrups or transverse connections must be provided in sufficient numbers.

Ends of reinforcing bars must be so shaped to ensure security against slipping unless the surface of the bar is so formed as to resist displacement relative to the concrete.

If any other proportions used for concrete safe resistance are to be calculated by rectilinear interpolation from the values for the weight of cement per cu. yd. of sand and stone as given above."

SWISS ENGINEERING & ARCHITECTURAL SOCIETY, PROVISIONAL SPECIFICATION, AUGUST, 1903.

"$\frac{E_s}{E_c} = 20.$

Resistance of concrete in tension neglected.

Concrete in compression 498 lbs. per sq. inch.

Concrete in shear 56 lbs. per sq. inch.

Steel in tension (in beams) 14,223 lbs. per sq. inch.

Steel in tension (in slabs) 17,068 lbs. per sq. inch.

Steel in compression 9,956 lbs. per sq. inch.

11. Rules for Calculation.

BRITISH REINFORCED CONCRETE COMMITTEE, MAY, 1907.

"The deformation in a piece subjected to bending directly proportional to the distance from the neutral axis—*i. e.* straight line stress—strain relation.

Width of slab acting with T-beam to be not more than 1/3 span or 3/4 distance center to center of reinforced ribs, whichever is least.

Shearing and adhesion stresses should be calculated and special provision made to resist these if necessary.

Calculations given for eccentrically loaded columns and for long columns vertically loaded when the length exceeds 18 times least diameter.

Calculations for long columns made by Gordon's formula with value for constant of 32,000.

In T-beams, when neutral axis falls below bottom of slab the resistance of the concrete in the rib is neglected.

The thickness of slab for T-beams determined by stiffness required for floor in general, is from 1/12 to 1/18 of the span."

MARSH & DUNN'S MANUAL, FEB., 1908.

"A condensation of the Rules given by them on pages 101-217, and covering each of the main applications of reinforced Concrete,, is impossible."

FRENCH GOVERNMENT RULES, OCT. 20, 1906.

"Straight line stress-strain relation.

Width of slab acting with T-beam to be not more than 1/3 span or 3/4 distance center to center of reinforced ribs, whichever is least.

Shearing and adhesion stresses to be calculated and special provision made to resist these if necessary.

Columns calculated for eccentric loading.

Calculations given for hooped columns.

Calculations for flexure to be made for columns when height exceeds 20 times least diameter.

Account to be taken of temperature and shrinkage stresses as well as loading if structure cannot expand and contract freely."

PRUSSIAN GOVERNMENT REGULATIONS, MAY 24, 1907.

"The deformation in a piece subjected to bending directly proportional to distance from neutral axis.

Width of slab acting with T-beam to be not more than 1/3 span.

Shearing and adhesion stresses to be calculated and special provision made to resist these if necessary.

In Columns, the possibility of eccentric loading is to be taken into account.

Beams and floors must not be assumed to be continuous over more than three spans. When the working load is more than 1,000 kg. per sq. m. (205 lbs. per sq. ft.) the most unfavorable distribution of load is to be taken into account.

In determining position of reinforcement, the possibility of negative moments is in all cases carefully to be considered.

Calculation for flexure of columns to be made whenever height exceeds 18 times least diameter.

Transverse connections in columns not to be further apart than 30 times diameter of rods. Euler's formula to be used for calculating flexure, a factor of safety of 5 being allowed for the reinforcement.

Slabs supported on all sides, with reinforcing rods crossing one another when the length a is less than 1½ times the breadth b, under evenly distributed load, to be calculated according to the formula $M = \frac{pb_2}{12}$.

The thickness of slabs, and of the flat portion of T beams in no case to be less than 8 cm."

AUSTRIAN GOVERNMENT REGULATIONS, NOV. 15, 1907.

"In pieces subject to flexure maximum tensile stress in concrete to be calculated on assumption of a modulus of elasticity of 796,000 lbs. per sq. inch for concrete in tension.

Shearing and adhesion stresses calculated, and special provision made to resist these if necessary. If deformed bars are used adhesive resistance may be assumed as exceeding values given above by 10 per cent.

Column reinforcement calculated separately for flexure, ties not spaced farther apart than least diameter of column.

Sectional area of metal in columns not less than 0.8 per cent. of total sectional area of column. If sectional area of metal exceeds 2 per cent. of total sectional area of column, the excesses beyond 2 per cent. only are to be taken into account to the extent of 1/4 its value.

Eccentric loading of columns to be taken into account.

Calculations for flexure made for columns when height exceeds 20 times least radius of gyration. Free length being that between fixed ends.

Hooped column formulae."

SWISS ENGINEERING & ARCHITECTURAL SOCIETY, PROVISIONAL SPECIFICATION, AUGUST, 1903.

"Straight line stress-strain relation.

Shearing stresses to be calculated and if exceeded reinforcement to be introduced by bending up bars or otherwise to resist it.

For columns any eccentric loading must be taken into consideration.

The reinforcement is to be calculated to resist bending as if unsupported by concrete by Euler's formula with factor of safety of 4, half distance between the bindings being assumed as the unsupported length."

12. General Regulations.

D. G. SOMERVILLE & CO., 1907.

"All materials and labor shall be of the best quality in every respect. Materials being submitted to the Architect for his approval before the work is commenced.

Dimensions of girders, columns, slabs, etc., shall be considered a minimum, and where we are responsible for the design all work actually connected with the reinforced concrete construction must be carried out by our own men, under our direct supervision, and no one is allowed to give any order in any way, altering the construction or method of construction without a written order from the Head Office."

MARSH & DUNN'S MANUAL, FEB., 1908.

"They quote the Specification of the Trussed Concrete Steel Co. of Detroit, Mich."

FRENCH GOVERNMENT RULES, OCT. 20, 1906.

"Quality and proportions of concrete to be specified in the contract."

PRUSSIAN GOVERNMENT REGULATIONS, MAY 24, 1907.

"Special authorization required for erection of any building or part of a building in reinforced concrete.

Application for permission must be accompanied by drawings, statical calculations and descriptions.

Description must state origin and nature of materials to be used in concrete, the proportion in which they are to be mixed, the proportion of water and the compressive strength to be attained by 30 cm. (12 inches) cubes after 28 days. If required by the authority, tests of compressive strength may be made before commencing work.

Application to be signed by the building owner, the designer, and the contractor charged with the erection. Any change of contractor to be at once notified."

SWISS ENGINEERING & ARCHITECTURAL SOCIETY, PROVISIONAL SPECIFICATION, AUGUST, 1903.

"Designs prepared so that drawings and calculations show clearly general arrangements, allowed loads, calculations of strength and details of parts.

It is permissible to depart from the regulations if the variations are based on actual trial and upon the opinions of competent persons."

LISTS AND DESCRIPTION OF FOREIGN GOVERNMENT AND PRIVATE TESTING STATIONS, CONGRESSES, TECHNICAL INSTITUTIONS, ASSOCIATIONS, AND COMMITTEES, WHO HAVE ENDORSED REINFORCED CONCRETE AS A MATERIAL OF CONSTRUCTION OR WHO HAVE ADOPTED RESOLUTIONS, SPECIFICATIONS, OR RULES RELATING THERETO.

INTRODUCTION.

Although a method of Reinforced Concrete Construction was patented in England as early as 1854, and although a Reinforced Concrete Boat was exhibited in Paris as early as 1855, and several Applications suggested by Coignet in 1861, and this form of construction actually applied by Monier in 1867, it has only been of late years commercially adopted, and its present universal recognition, as a safe and economic form of construction of wide applicability, may be said to be the development of the past five years.

Credit for the present popularity Abroad of Reinforced Concrete Construction is due to the concerted efforts of the Cement Makers of Germany, France, and England, resulting in the rapid improvement and maintenance of the strength, fineness, and quality of the artificial Portland Cement now delivered to meet the demands of those Engineers who have been foremost in extending the Applications of Reinforced Concrete.

Credit is also due to the active propaganda, of the past few years, maintained by the owners or agents of new forms of Reinforced Concrete Construction.

Its present universal recognition, as a safe and economic form of construction of wide applicability, has, however, been primarily due to the thorough study of late years of the theory underlying this form of economic construction, by the many Official and Scientific Institutions, to some extent in England, but to a greater extent on the Continent.

As, without the endorsement of these important Technical

Institutions of each Country, the other efforts to extend its applications could not have been so successful, this Report, written to reflect foreign opinion in practice, would be incomplete without including a List of the Official and Technical Institutions of each Country who have studied and endorsed Reinforced Concrete, as a safe and economic Material of Construction, or who have adopted Resolutions, Specifications, or Rules relating thereto.

A List of these important Bodies, arranged under each Country, immediately follows, and a description of the work accomplished by each Institution, will be found in Appendix No. 3.

International.

1. Congres International des Methodes D'Essai des Materiaux de Construction.
2. International Association for Testing Materials.
3. International Commission on Cement.
4. International Commission on Reinforced Concrete.
5. International Railway Congress of 1905.
6. International Congresses of Architects of 1906 and 1908.
7. International Fire Service Congress of 1906.

England.

1. Joint Committee on Reinforced Concrete.
2. Special Commission on Concrete Aggregates.
3. The Concrete Institute.
4. Government Department's Official Endorsement of Reinforced Concrete.
5. The British Fire Prevention Committee's Tests on Reinforced Concrete Construction.
6. Fire Officers Committee of London.
7. Local Government Boards; Rules of.
8. Municipal Building Laws.
9. Engineering Standards Committee on Cement.
10. Engineering Standards Committee on Structural Steel.
11. Commercial Testing Laboratories, a List of Six.

France.

LIST OF COMMISSIONS.

1. Commission Du Ciment Armé.
2. Commission des Methods D'Essai des Materiaux de Construction 1895 and 1900.
3. Ministere des Travaux Publics.

LIST OF TESTING LABORATORIES.

1. Laboratoire de L'Ecole des Ponts et Chaussees.
2. Laboratoire du Conservatoire National des Arts et Metiers.
3. Laboratoire Municipale D'Essais des Materiaux.
4. Laboratoire des Ponts et Chaussees.
5. Laboratoire De LeCampredon.

Germany.

SCIENTIFIC AND COMMERCIAL ASSOCIATIONS AND GOVERNMENT COMMISSION.

1. Deutscher Verein für Ton-, Zement-und Kalkindustrie, E. V.
2. Verein deutscher Portland Zement Fabrikanten E. V.
3. Deutscher Beton Verein (e. V.)
4. Verein deutscher Eisenhüttenleute.
5. Deutscher Architekten und Ingenieur Verein.
6. Verein deutscher Ingenieur.
7. Architekten Verein, Berlin.
8. Deutscher Beton Verein in Verbindung mit dem deutschen Architekten und Ingenieur Verein.
9. Verhand der Massivbau- und Deckenindustrie.
10. German Commission on Reinforced Concrete appointed by the Prussian Ministry of Public Works.

GOVERNMENT TESTING STATIONS.

1. Königliches Material-Prüfungsamt der Königlich Technischen Hochschule.
2. Königlich Sächsische technische Hochschule.
3. Königlich Technische Hochschule.
4. Materialprüfungsanstalt der Königlich technischen Hochschule.

5. Prüfungsanstalt für Baumaterialien an den technischen Staatslehranstalten.
6. Grossherzogliche chemisch- technische Prüfungsanstalt Abteilung für Baumaterialprüfung.
7. Prüfungsanstalt für Baumaterialien an der königl. Baugewerkschule.
8. Herzogliche Technische Hochschule.

COMMERCIAL TESTING STATIONS.

1. Chemisches Laboratorium für "Tonindustrie Verein" und Laboratorium des Vereins Deutscher Fabriken Feuerfester Produkte.
2. Laboratorium fur alle chemischen und technischen Untersuchungen von hydraulischen Bindemitteln.
3. Chemisch-technische Prüfungsanstalt.
4. Chemisch-technische Versuchsstation.
5. Laboratorium des Vereins deutscher Portland-Zementfabrikanten.
6. Chemische-technisches Laboratorium für hydraulische Bindemittel nebst Prüfungsanstalt für Baumaterialien.
7. Chemisch-technische Versuchsstation.

Austria.

1. Mechanische Versuchsanstalt der Kaiserlich königlichen technischen Hochschule.
2. Oesterreicher Ingenieur- und Architekten-Verein.
3. Allgemeiner Ingenieur Verein.
4. Prüfungsanstalt für Baumaterialien an der I Stadtgewerbeschule in Wien I.
5. Städtische Material Prüfungsstation.
6. Versuchsanstalt für Bau- und Maschinenmaterial des k. k. Technischen Gewerbe - Museums.
7. Oesterreichischer Beton Handels-Verein.

Switzerland.

1. Schweizerischer Ingenieur- und Architekten Verein.
2. Eidgenossenschaftliche Materialprüfungsanstalt am Schweizerischen Polytechnikum.
3. Anstalt zur Prüfung von Baumaterialien am Schweizerischen Polytechnikum.

Hungary.

1. The Hungarian Society of Engineers and Architects.

Italy.

1. Association italienne pour l'etude des materiaux de construction.
2. Laboratorio per experienze sui materiali da costruzione.

Spain.

1. Laboratoire d'etudes et d'essais des materiaux de construction.

Holland.

1. Proefstation voor Bouwmateriallen en Bureau voor chemisch Onderzoek Koning & Bienfait.

Denmark.

1. Prüfungsanstalt für Baumaterialien der königl. Technischen Hochschule.
2. F. L. Smidth & Co. techn. Bureau.

BIBLIOGRAPHY ON REINFORCED CONCRETE, CONCRETE AND CEMENT, INCLUDING THE BOOKS AND PERIODICALS PUBLISHED IN EACH COUNTRY.

Books.

In proof of the importance, and the rapidly increasing interest which is being taken in Reinforced Concrete, the writer begs to refer to his three lists of *Books,* (1) English and American, (2) French, and (3) German, Austrian and Swiss, forming Appendix No. 4 to this report. No such complete list has ever before been compiled, and much time was spent in obtaining the full title, date and price of each book, as far as it was possible to do so. The following summary shows that no less than 214 books dealing with Reinforced Concrete, Concrete and Cement have been published since 1905, or else are now in press.

Books printed in	Total No. issued	No. of books, 1905 to date, or in press
England and United States	126	88
France	61	18
Germany, Austria, Switzerland	155	108
Totals	342	214

Periodicals.

Thirty (30) periodicals are now published in England, France, Germany, Austria-Hungary, Switzerland, Holland, Denmark, Italy, Spain and in the United States devoted entirely or prominently to the interests of Reinforced Concrete, Concrete and Cement.

In addition there are eighty-one (81) periodical publications which frequently publish articles on these subjects.

Early in 1908 a "Concrete Institute" was incorporated in England on lines similar to that of the "Iron and Steel Institute."

In each of the above countries, the leading Engineering and Architectural Journals have of late years adopted the policy of regularly devoting either "Special Issues," or "Supplements" or else a considerable portion of their reading columns, to the subject of Reinforced Concrete.

The following is a summary of the carefully prepared lists of all these periodicals, the full titles, addresses and subscription prices of which will be found in Appendix No. 4 to this Report.

Country in which periodical is published	Devoted entirely or prominently to — Reinforced concrete, concrete and cement	Frequently publish articles on — Reinforced concrete, concrete and cement
International	1	0
England	5	4
France	2	15
Germany and Austria-Hungary	10	33
Switzerland	0	1
Holland	0	1
Denmark	0	1
Italy	1	2
Spain	2	0
United States	9	24
Totals	30	81

No better evidence could be submitted of the present importance and rapidly increasing popularity of Reinforced Concrete Construction, than the above tables showing the number of recent books, and the increasing mass of periodical literature, now devoted to this subject.

APPENDIX NO. 1.

ALPHABETICAL LIST OF THE 144 FOREIGN SYSTEMS OF REINFORCED CONCRETE CONSTRUCTION, WITH THE ADDRESSES OF THE INVENTOR OR OWNER OF EACH SYSTEM, AND A CONCISE DESCRIPTION OF ITS SPECIAL FEATURES.

ACKERMANN.

Ackermann, in Dohren-Hannover (Germany).

The Ackermann floor consists of concrete bricks, 25 x 15 x 10 c. m., with a groove on the under side in which fit hollow steel reinforcing beams.

ADAMANT.

The Adamant Company, Ltd., Birmingham.

Partitions with a reinforcement of round bars supported by secondary reinforcements when required.

AEROLITH.

Eugen J. Kis, Budapest, V. Pozsonyi et 9 (Hungary).

AMBROSIUS.

The main supports consist of angles of unequal legs, the longer leg being vertical and the shorter leg horizontal, and to which latter a metallic network is fastened which extends the whole width of the slab.

AST-MOLLINS.

Ed. Ast & Co., Lichtensteinerstr. 41, Vienna (Austria).

This system is similar to Hennebique, and consists in using round vertical bars, held in their correct position by flat or sometimes round iron stirrups. It is applicable to all forms of reinforced concrete construction.

BARON-LÜLING.

Societa Ing. H. Bollinger, Milan (Italy).

BAYER.

Hans Bayer, Breslau (Germany).

A system of ribbed floors, made up of V-shaped sections moulded in advance, and which are placed in a row and covered with a layer of concrete. The reinforcement consists of round bars located in a short projection from the point of the V.

German Patent No. 184,914, July 1, 1905.

BECHER.

M. Czarnikow & Co., Berlin, W. (Germany).

In this system, applicable to columns, the reinforcement consists of four or more round rods held in their position by plates containing holes. The columns are of cheaper construction than iron columns, and allow the adoption of any architectural effect.

BENY.

The Beny floor consists of concrete bricks with a groove on the under side and in which the steel strips fit.

BIANCHI.

Societa Domenighetti e Bianchi, Milan (Italy).

BONNA.

Establishment A. Bonna, 78 rue d'Anjou, Paris.

The inventor uses special steel sections like a Latin Cross, also double cross sections, and sometimes ordinary T's and angles.

All the reinforcements of the various elements (primary and secondary beams, columns and supports) are secured together. The columns are reinforced by profile bars tied together by horizontal flats secured to the main bars by bolts or rivets. The reinforcements, being thus all tied together, serve to support the falsework, men and materials during construction. The floors are usually reinforced in the same manner as the beams, with cross-shaped bars at the top and bottom secured together by verticals or flat iron, and held transversely by upright notched flat bars, extending across the whole width of the slab. For pipes and reservoirs, spiral or circular hooping is used against which are placed longitudinal distribution rods, which are notched out to receive the hoop bars.

BORDENAVE.

(No one has continued the exploitation of this system since the death of the inventor in Jan. 1905).

This system brought out in 1887, is applicable to pipes, sewers and reservoirs. Special small I-sections of steel are used for reinforcement, together with round rods for secondary reinforcements, and also for the floors and covers to reservoirs. The hooping of pipes is wound spirally, the distribution bars resting against the spiral and being tied to them with wire ties.

BOUSSIRON ET GARRIC.

S. Boussiron, 16 rue Milton, Paris.

This system is applicable to floors, beams, columns and reservoirs. The principal reinforcement is round bars, often bent up at the ends, the arrangement of the rods varying with each application. One special feature is the use in beams, of a hoop-iron V-shaped stirrup; with columns, wire loops are used.

BRAMIGK.

Bramigk (Bauinspector) in Germany.

This hollow floor is made up of a series of drain pipes, between each of which one or two round iron reinforcing rods are placed before filling in the intermediate space with cement mortar.

BRITISH.

The British Reinforced Concrete Engineering Co., Ltd, Royal London Buildings, 196 Deansgate, Manchester.

A system of universal application using plain round and square bars gripped with patented paragon stirrups made of rolled bar.

BRUCKNER.

A. Bruckner, Aachen (Germany).

A reinforcement for walls consisting of two triangular frames, spaced according to the desired thickness of the wall. Rods extend from one frame to the other and on these rods plates are hung.

German Patent No. 168,528, July 4, 1903.

BRUNO.

In this system of pressure pipes, the reinforcement is made by two spirals wound in opposite directions, and by which arrangement a network is formed which can be further strengthened by supporting rings if desired.

BULLA.

Artur Bulla, Werneuchen i/Mark (Germany).

A system of reinforced concrete floors, consisting of previously moulded inverted square topped U-shaped pieces which rest between ribs laid crosswise. These hollow pieces are spaced at bottom by perforated plates, and on which latter rest the reinforcing rods; above these rods are U-shaped stirrups to care for shearing stresses. The whole is covered with concrete.

German Patent No. 183,682, Nov. 5, 1905.

CHAIN CONCRETE.

The Chain Concrete Syndicate, 1 Basinghall Square, Leeds.

A system of universal application using round longitudinal bars, each three connected by McDonell's patent clips.

CHASSIN.

Chassin et fils, 151 rue de Bagnolet, Paris.

A system, chiefly used for water conduits and reservoirs, in which longitudinal round rods are supported by a strong circular frame of small T-sections, and further by U-shaped rods.

CHAUDY.

Société des Travaux en Ciment de la Plaine, 15 rue du Louvre, St. Denis (France).

F. Chaudy, 6 rue Gérando, Paris.

In this system of wide application, the reinforcements are always symmetrical, as in the calculations the concrete is neglected, except for tying the members together and resisting the compressive stresses due to shearing. Round rods, but sometimes angle iron are used; the stirrups are of round rods and always bent over the top rod, or where a series of upper and lower rods are used, they are embraced by a rectangular hooping of flat iron. For floors the tooth or rack system of arranging the round rods is employed.

COIGNET.

Edmund Coignet et Cie, 20 rue de Londres, Paris IX.

As early as 1861 Francois Coignet pointed out the advantages resulting from a combination of metal and concrete; later his son Edmund Coignet published his theory as to the disposition of the two materials, the metal to resist the tension, and the concrete the compression. His system developed with N. de Tedesco is of wide application. He always uses double reinforcement for beams, the upper longitudinals being of less diameter than the lower ones; the two are connected by stirrups of round iron, the branches being frequently twisted together over the tops of the upper rods, or the upper and lower bars are connected by a light zigzag web of hoop iron, fastened alternately to the upper and lower bars, thus forming a light truss. The patented arrangement of rods, small profiles and flats, and the methods of tying, differ for reservoirs, pipes, piles, walls, columns, etc.

CONSIDERE.

Considere, Pelnard & Losier, 103 & 128 Bd. du Montparnasse, Paris.

In this method of reinforcement particularly applicable to columns and piles, the compressive strength is augmented by preventing horizontal distortions by means of hoops or helicoidal spirals placed at or near the face of the column. Vertical rods are used in connection with this hooping to care for flexual stresses. The confined concrete carries all the direct compression. For beams, compression reinforcement, when required, is provided by spiral coils of steel rounds located near the top surface.

German Patent, 149,944, May 10, 1902.

CORRADINI.

A reinforced beam, similar to the Siegwart-beam, but having a hexagonal cross-section.

COTTANCIN.

Agencie General de la Construction P. Cottancin, 125 rue de Montreuil, Paris.

Manager: M. Lavesvre.

M. Cottancin, 47 Bd. Diederot, Paris.

American Cottancin Construction Co., 332 E. 35th Street, New York.

A. Vye-Parmintor, Archt. (Agent for Great Britain) 27 Ave des Acacias, Paris.

In this system patented in 1889, the inventor considers that the adherence between the metal and concrete is an entirely unreliable quality, which should be totally neglected. He uses a woven network of wire or round rods, acting in tension, with meshes varied according to the intensity of the stresses and with stiffening ribs at frequent intervals.

COULAROU.

M. Coularou, 6 rue Beaurepaire, Paris.

In this method of beam reinforcement, the lower round rods extend throughout the whole length, while those along the top remain parallel to the upper surface till approaching the centre of the span, when they are bent down at an angle of 45 degrees and are hooked round the lower reinforcing rods; the stirrups inclined at an angle of 45 degrees are round rods hooked over both the upper and lower reinforcing rods. Other arrangements of rods are used for floors, walls, columns, stairs, and roofs.

CRACOANU.

Hollow concrete floor without beams and consisting of simple prismatic hollow forms without grooves, and with a network of round iron embedded in the upper spaces or seams between the bricks.

CRUCIFORM.

The Cruciform Reinforced Concrete Co., 12 Savage Gardens, London, E. C.

Telegraph poles and piles with reinforcement consisting of a cruciform construction made up of large and small angles, either rivetted together or bound with wire.

CUSTODIS.

Actiengesellschaft Alphons Custodis, Düsseldorf (Germany).

Round bars supported by secondary reinforcements when required.

CZARNIKOW.

A system of floors consisting of slabs moulded on the spot, and reinforced with horizontal flat iron strips, bent in snake-like form.

DAWNAY.

Archibald D. Dawnay & Sons, Ltd., Steelworks Road, Battersea, S. W.

A system of floors, one type using small steel joists, another square steel bars, in each case laid between the larger main joists.

DEGON.

This system is based on the belief that the various elements should be completely tied into a skeleton, and the stirrups not left loose. The reinforcement employed in beams is therefore double, composed of two or more sets of round rounds; the bottom and heavy rods are bent up at the ends so that those at the top may be hooked around them. The vertical reinforcements are round rods bent in several forms, the most simple being a rectangle with a wavy bottom member, the lower reinforcements resting in the depressions. The floors are reinforced with rods running across the beams, with snake like transverse rods. Wrapping wires also pass in a longitudinal direction along the web of the beam.

DEMAY.

Demay Freres, 30 rue Payen, Reims (France).

66 Bd. de Strasbourg, Paris.

This system is peculiar in the employment of flat bars for the main reinforcements, and in the very thorough manner in which all the reinforcements are secured together. A double reinforcement is used in the case of beams. For floors a network of round rods is used, tied to the upper beam reinforcements; the two series of rods are fastened together with wire ties at every other intersection in both directions.

DEUMLING.

A system of suspension and latticed floors covered by German Patent No. 82,931.

DIETRICHKEIT.

Herr Dietrichkeit, Archt., Cöln a. Rh. (Germany).

This is a system of flat floors in which the reinforcement consists of twisted strips spaced from 10 to 20 cm. apart according to the length of span and the load, and fastened to rods anchored in the walls. For long spans the reinforcement is further strengthened by diagonals.

DONATH.

A modification of the Monier System, for slab reinforcement, using flats placed on edges and sometimes single or double T-shapes for the carrying bars. Pieces of sheet iron bent in the form of an S are sometimes used.

DOUCAS.

Königin Marienhütte, Cainsdorf (Germany).

This is a special shaped reinforcing bar of round, or in larger sizes, a diamond shaped section, with two opposite webs or wings attached, which are waved in the operation of rolling.

German Patent 157,837.

DUMAS.

A system much resembling that of Monier.

EBERT.

Herr Ebert (Baumeister), Leipzig-Platzwitz (Germany).

This is a system of flat flooring in which the reinforcement consists of steel strips set on edge and bent up at the ends where they rest on the lower flanges of the supporting I-beams. The upper part of the floor is moulded around wooden blocks, which are subsequently removed.

German Patent 139,339, June 15, 1901.

EGGERT.

Diss & Co., Düsseldorf (Germany).

This system, which is applicable to flat and also arched floors, renders the use of supporting beams unnecessary. There are two special features, one, that the round bars are inclined up at each end and the ends hooked over, and the other that both rods are in the same plane, the bottom rod being the longer. When specially strong anchorage is necessary, small plates are wedged on the bent up parts of each rod.

ELLIS.

John Ellis & Sons, Ltd., Leicester (England).

A system of circular and elliptical pipes, reinforced with ribs formed of round steel rods welded and worked into the concrete.

FICHTNER.

This system of reinforcement is used for high pressure pipes, especially when laid at great depths. The main reinforcement consists of two hoops of thick wire bent into ovals and laid on each other so that they cross at four points, and leave four central crescent shaped spaces, through each of which at least two wires run longitudinally.

FRANKE.

Eisenbeton Franke G.m.b.H., Friedenau b/Berlin

and

L. Mannstaedt et Cie, A. G., Kalk b/Cöln (Germany).

In this system of flooring, the supporting beams are of inverted T-section with the top piece rolled into conical waves. They are laid 1 meter apart. The arched concrete slabs, 1 x 0.25 meters, are made in advance and contain no reinforcement, but have a series of small semicircular holes along their edges. After placing the slabs in position, the end spaces over the T-beams are first filled with concrete and finally the small binding holes in the edges of the slabs are filled with cement mortar.

German Patent 182,970, Sept. 18, 1904.

FRAULOB.

Walther Fraulob, Archt., Gera-Reuss (Germany).

GABELLINI.

Societa del Cemento armato Gabellini.

GASTERSTÄDT.

R. Gasterstädt, Archt., Steinstrasse 75, Düsseldorf (Germany).

A patented system of flat floors constructed without falsework for semicircular hollow concrete forms, made in advance. The reinforcement consists of T-sections and round rods. It is claimed that this floor is sound proof, resists heavy loads and is of cheap construction.

GUILLEMENT.

Guillement-Lathieze, 5 rue General-Margueritte, Nantes (France).

Round rods used for reinforcement.

HABRICH OR THOMAS & STEINHOFF.

Thomas & Steinhoff, Mülheim a/d. Ruhr (Germany).

Hot twisted flat bars with special rolled T-bars.

HAREL DE LE NOE.

Paris.

A system of pile reinforcement, similar to that of Pavin de Lafarge, and consisting of round rods held in position by a wire framework. Around this reinforcement, a cement pipe is placed which is filled with concrete.

HELM.

E. Helm, Berlin.

A system of floors, resembling Czarnikow's, and consisting of a central falsework, with small boards above and below to which round vertical rods are fastened.

German Patent 156,871, May 7, 1903.

HENNEBIQUE.

Beton Armé Hennebique, 1 rue Danton, Paris.

U. S. A. R. Baffrey, 1123 Broadway, New York, N. Y.

M. Hennebique constructed reinforced concrete floors in 1879, and brought out his patented system in 1892. A vast number of all types of construction have been erected by the numerous licensed constructors of this system. Round bars are used in all forms of construction. A typical beam consists of two round rods with split ends, the lower rod is straight while the upper is bent upwards at a point about one-third of the span from the supports to resist the shearing stresses at the ends. Vertical U-bars or stirrups of flat iron pass around the straight bar and reach nearly to the top of the beam, where their ends are partly bent over.

Walls are reinforced with vertical round rods, placed alternately near each face and tied to the opposite face by means of open U-shaped stirrups.

Several arrangements of round rods are used for arches, usually there are three series of longitudinal rods, one set being straight and placed near the top surface, another being curved to follow the intrados through the central portion of the span, but is bent up near the supports, and passes over these in the neighborhood of the upper surface. All the longitudinal reinforcements are well tied together and to the opposite face by crossties. A series of transverse rods is also employed, being placed just above the lower reinforcement. In column reinforcement the four or more vertical rods are now tied by wires instead of flat punched plates. For piles the wire crossties are placed nearer together than for columns.

German Patent 126,312, Sept. 2, 1897.

HERBST.

W. Herbst, Breitestr. 14 Steglitz b/Berlin (Germany).

Special corrugated rolled steel ribs, embedded in concrete webs, and used for floors with concrete tubes fitting therein.

HODKIN-JONES.

Hodkin-Jones, Queen's Road, Sheffield.

A system of floors with a reinforcement of special bars having three corrugations in their width. These bars are placed on edge.

HOLZER.

Wayss & Freitag, München (Germany).

Small sections in the form of I-beams or sometimes L's or T's, resting on their under flange of the main I-beams. Transverse rounds are held up against the I-, L- or T-beams by binding wires.

HOMAN.

Homan & Rogers, 17 Gracechurch Street, London, E. C.

A system of floors in which the reinforcement consists of a waved T-bar or sometimes round, either of which pass through holes in the web of ordinary I-bars.

HUGNET.

A system of walls consisting of cement slabs containing a metal webbing and which are made in advance. The slabs are held together by a framework of U-section.

IMPROVED CONSTRUCTION.

The Improved Construction Co., Ltd., 47 Victoria Street, London, S. W.

A system of beams and floors with double reinforcements of round steel bars, with tie bars so arranged as to constitute a kind of polygonal truss. This company uses a special machine for agitating the concrete before it sets.

JOHNSON'S WIRE LATTICE.

Richard Johnson, Clapham & Morris, Ltd., 24 & 26 Lever Street, Manchester.

Percy Tomey, C. E., General Agent & Consulting Engineer, Queen Anne's Chambers, London, S. W.

A system of floors, beams, etc., in which the reinforcement consists of cold drawn .20 Carbon O.H. Steel, woven into square or oblong meshed netting.

KEMNITZ.

This system, chiefly applicable to floors, consists of wires twisted by means of short round bars, which latter are hooked or otherwise anchored either to the supporting I-beams or into the walls; both the wires and the short rods are embedded in the concrete.

KIEFER.

Kiefer & Borchmann G.m.b.H., Heidelberg (Germany).

A system of floors consisting of hollow slabs, 1,000 x 500 x 120,180 mm., moulded on the spot and containing in the lower part a wire net reinforcement which projects at each end. These slabs are made of 1 part cement, 2 sand, and 5 of slag. The ends of the slabs, which are chamfered, rest on wooden supporting beams and in the space between a reinforcing round rod is placed, and the projecting wire net is also bent up into a hook before the space is filled with cement mortar (made of 1 part cement, and 3 parts of gravel).

KISSE.

Johannes Kisse, Berlin (Germany).

A system of rectangular piles, made up of sections of concrete moulded in advance and each of which contains four oval holes; four round rods, the length of the pile, pass through these holes and the space is then filled up with thin cement mortar.

German Patent 173,035, March 11, 1905.

KLEIN.

Paul Zöllner & Co., Lützowstrasse 13, Berlin W. 35 (Germany).

KLEINE.

The Kleine Patent Fire-Resisting Flooring Syndicate, Ltd., 133 to 136 High Holborn, London, W. C.

A system of floors in which the reinforcement consists of flat rolled bars used in connection with hollow bricks and ballast concrete.

KLETT.

Vereinigte Maschinenfabrik, Augsburg (Germany).

Rolled I-beams, over the top of which are bent strips or flats, curved and laid flatwise, and on which at intervals are riveted small angle irons for transverse reinforcement.

KNAUER.

Boswan & Knauer, Berlin (Germany).

A system of floors, in which the reinforced concrete slabs are laid between the supporting I-beams. These slabs are thicker at the supports than in the middle; the middle portion is reinforced with rounds laid horizontally, flattened at ends, and bent over the bearers, the thicker ends of the slabs are also reinforced with rounds laid parallel to the supporting beams.

KOENEN.

Aktiengesellschaft für Beton und Monierbau, Potsdamerstr. 129, Berlin (Germany).

Floor slabs haunched near supports, reinforced with round bars. The slabs rest on steel joists.

German Patent 124,879, Aug. 13, 1899.

KOHLMETZ.

In this system of floors, the supporting member is made up of an upper and lower light steel angle, diagonally trussed by light strips riveted thereto. Around this light frame work is placed hollow clay pyramidal bricks; on these the floor slab rests, which latter may be or may not be reinforced depending upon the span.

KOSSALKA.

Dr. Johann Kossalka, Budapest (Hungary).

A beam with I-shaped reinforcement.

KOSTEN.

O. Wachtel, Zwingerplatz 1, Breslau (Germany).

KOVACS & RESZÖ.

Aladar Kovacs of Sebesteny (Hungary)

and

Polka Reszö, Budapest (Hungary).

In this system of walls, a rectangular net work with large meshes is hung on small reinforced concrete supports like rafters, which are of square section, and are made in advance; the whole is then embedded in concrete.

German Patent 176,885, Dec. 25, 1904.

KRAUSS.

Max Krauss, München (Germany).

In this system of floors, the pieces of falsework remain, forming the under part of the floor slab; one of the ends rests on the lower flange of the supporting I-beam, and the free ends cross each other and are held apart by a short wedge under the free end. The concrete is placed on top of the falsework.

German Patent 172,046, Feb. 26, 1905.

KUHLMEYER.

In this system of stairways the main supports are either I- or L- sections. The parts forming the staircase are so connected with the wall, that they form a continuous hollow construction. For the reinforcement of the treads, iron rods crossed, or wire webbing or perforated sheets are used.

LANG.

Lang & Fils, Ave. de la Bourdonnais 17, Paris.

Round bars are used for reinforcement.

LANZONI.

Lanzoni, Galli & Co.

A system of doors, windows, etc., in which small rods are used for reinforcement.

LEFORT.

In this floor system, the concrete slab is reinforced with two groups of wires spaced in pairs, one over the other. The concrete beam is reinforced with an upper and lower round rod, the former passing between the above pair of wires; also a third rod midway between the two, to care for the shearing stress.

LESCHINSKY.

Paul Leschinsky, Berlin (Germany).

In this floor system, the main reinforcing bar, of I or other convenient section, and anchored at the ends in each wall, is placed as low in the depth of the floor as possible, the bar is strong enough to ultimately withstand the load, but until the concrete is added, it is supported below by a framed falsework.

German Patent 173,953, Feb. 12, 1905.

LILIENTHAL.

G. Lilienthal, Gr. Lichterfelde b/Berlin (Germany).

This floor system is only applicable to light loads or short spans. Over the upper flanges of the row of supporting I-beams is laid a netting of galvanized wire, which is allowed to sag down for a distance equal to one tenth the length of the span. On this netting, paper is laid, and on which the concrete is deposited. A thin top finishing layer is added after setting, and this sometimes contains a light reinforcement of lightly drawn wire netting.

German Patent 100,194, Sept. 3, 1897.

LINDSAY.

W. Lindsay & Co., 23 Queen Anne's Gate, London, S. W.

A system of floors in which the slabs are reinforced by round steel bars in pairs, the bars passing alternately over and under the joists and crossing at the middle of each panel, thereby forming a trussed construction.

LOCHER.

Locher & Co., Zürich (Switzerland).

The beams of this system are entirely different from any other, in that the reinforcements are placed so as to follow the direction of the lines taken by the combined tensile stresses in a beam freely supported at the ends. The reinforcements consist of flat bars laid on the widest side. They are placed in layers, each bar being horizontal through the centre of the span, and are bent up at a different distance from the supports.

LOLAT.

Gustav Lolat, Kaiserallee 65, Berlin-Friedenau (Germany).

In the walls is placed an anchorage of flat or angle iron forming a framework. Over this framework are laid hooked pieces of wire with eyes projecting from the walls into which the bent ends of the carrying rods are inserted.

German Patents 151,093, June 1, 1901, 183,341, Nov. 22, 1905.

LUIPOLD.

Luipold and Schneider, Stuttgart (Germany).

In this system of beams, round reinforcing rods are put in both the upper and lower parts, so as to take up the negative moments in the centre of the beam; usually there are two upper and five lower rods. The connecting stirrup consists of a long round rod, so bent as to pass around each of the upper and lower rods.

LUND.

Norway.

A system devised by Ing. Lund in which round rods are used.

MACIACHINI.

Ing. A. Maciachini, Milan (Italy).

The object of this system is to obtain for beams the advantage gained in the Considere method of hooping columns. The efficient hooping of a beam is difficult because the moulding must be done horizontally if formed *in situ,* and the fabrication of a beam in advance, causes the loss of many advantages. Maciachini uses hooping wires of suitable diameter and as long as possible; these are bent up and down before being placed in position, the height being that of the width or depth of the beam less about 1.6 inches to allow for a covering of 0.8 inch of concrete on all sides. The bottom and side transverse hoopings are looped together, and four corner rounds constitute the longitudinal reinforcement.

de MAN.

This consists of a special twisted or crimped flat bar, the usual size being from ¼ to 1½ inches wide, by 1/10 to ¼ inch thick. It is intended for use in floor slabs made of cinder concrete.

MANKE.

M. Manke, Spandau (Germany).

An arrangement of reinforcement adapted to massive floors and consisting chiefly in rigidly holding the round reinforcing bars which extend from one supporting beam to the other, by driving into the beam, iron wedges, one on each side of the bar.

German Patent 153,430, May 19, 1901.

MANNSTAEDT.

L. Mannstaedt & Cie, A. G., Kalk, bei Köln (Germany).

This company rolls 12 special shapes used in reinforced concrete construction.

MATRAI.

Matrai, Gfreret & Grossman, Budapest (Hungary).

Steel suspension wires, sometimes twisted into cables, anchored at the ends and given the curve which they would naturally take under the load. The arrangement of the wires is varied according to the application and often is of a spider like form.

German Patent 83,939, Feb. 3, 1895.

MELAN.

Pittel & Brausewetter, Frankenberggasse 13, Vienna (Austria).

I-beams, T's, four angles latticed, or other forms of light built-up girders, wedged tightly against the webs of the supporting beams and embedded in the concrete of the arch.

METAL LADDER TAPE

The Metal Ladder Tape Co., Ltd., 84 Newhall St., Birmingham (England).

A system of thin partitions and walls in which the reinforcement consists of thin steel strips split at intervals into a ladder-like form and furnished in long coils.

MELANKOVITCH.

Ed. Ast & Co., Lichtensteinstrasse 41, Vienna (Austria).

MÖLLER.

Drehhahn & Sidhop, Braunschweig (Germany).

This floor slab is reinforced with rolled I-beams and is supported by fish-bellied beams usually spaced 4 feet apart. These latter consist of flat bars firmly anchored into the walls by pieces of angle iron riveted thereto. Short pieces of angle iron of the same length as the width of the flat iron, are riveted thereto at equal distances, to resist the longitudinal shear of the flat bars.

MOLLARET ET CUYNAT.

Mollaret et Cuynat, 17 rue Augerau, Lyon (Rhône) (France).

Round rods are used for reinforcement.

MONIER.

This inventor was the first to employ reinforced concrete in a large way. His first Patent is dated July 16, 1867. He died on March 13, 1906, at the age of 83, almost unknown, almost forgotten and in unfortunate circumstances. His German Patents which have lapsed were purchased in 1884 by Freytag & Heidschuch, (now Weyss & Freytag), and also Martenstein & Josseaux, who later requested Ing. G. A. Weyss to develop the patent into a System of general application. This was done with the assistance of Prof. Bauschinger of Munich, and the Monier System was introduced in Germany in 1887 by the publication of Weyss' Book on the Monier System.

The Monier trellis consists of two series of parallel round rods, crossing each other at right angles. The lower rods, called the carrying rods or resisting rods, are placed in the direction of the span of the slab and form the resisting elements. The upper rods, called distribution rods, perform the two-fold function of holding the resistance rods at proper intervals apart and of distributing the load to them. The rods are tied together by wrapping the intersections with annealed wire.

Many modifications of the Monier trellis have been introduced, as well as many devices of securing a rigid connection at the intersections.

MÜLLER.

Müller, Marx & Co., Greifwalterstrasse 212-213, Berlin.

I-beams with zigzag reinforcements made of flat bars, placed on edge, and tied together with thin clips.

de MURALT.

Ing. de Muralt, Engineer of the Corps des Ponts et Chaussees, Zierikzee (Holland).

A system particularly applicable for dykes and sea defences, and in which expanded metal, and to some extent round rods are used.

NEVILLE.

This system, applicable to large floor slabs consists in a double netting reinforcement, the top and bottom main longitudinal netting being jointed by transverse pieces of netting so fastened that when all is coated with concrete, triangular hollow spaces are left in the slab.

NIVET.

Ingenieur á Marans, pres La Rochelle (Charante Inferieure) (France).

Use round rods for reinforcement.

ODORICO.

Societa Odorico et Cie., Milan (Italy).

OPELT & HENNERSDORF.

This is a construction for shallow floors, but it can be used also for walls. Shallow slabs with annular holes, tongue and grooved edges, and a ribbed surface on the lower side, are used; they are made in advance. They rest on the lower flanges of the supporting I-beams, grooved side down, and which grooves insure the layer of plaster sticking firmly to the slab. Along the edges is a reinforcement of band iron.

PARMLEY.

Bars with bent edges, to place in the sides of a conduit or the haunches of an arch to resist tension.

PAVIN de LAFARGE.

Société Pavin de Lafarge, Joseph Colomb, 49 rue de Provence, Paris (France).

In its application to beams, this system is similar to that of Coignet. The double reinforcements are tied together by transverse reinforcements, consisting of wires wrapped around each rod or of strips bent zigzag, and fastened by tight loops to the upper and lower rods. In the other applications of this system, round rods, wires and sometimes flats are used.

PERFECTOR.

The Perfector Bar Co., Queen Anne's Chambers, London, S. W.

A system of beams, partitions and walls in which the reinforcement consists of a rolled round bar with flat flange below, which is slotted horizontally or at an angle of 45 degrees for the rigid insertion of stirrups at any angle or spacing desired.

PERRAND.

A system much resembling that of Monier.

H. PICQ.

A construction of reinforced beams, similar to Matrai, in which the rolled sections or the latticed supports are fortified with square tension rods.

PIKETTY.

Paul Piketty, Quai de la Rapee 88, Paris (France).

This constructor claims to adapt his reinforcements to suit the exigencies of the case, and beyond adhering to certain general principles he cannot be said to work by any special "system." He prefers round rods to flat bars or hooped iron, as the flats separate the concrete for a greater width. He uses a double reinforcement tied with round stirrups, set at varying angles from vertical at the centre to the greatest inclination near the supports.

PINKEMEYER.

(Germany).

German Patent 113,744.

PÖTSCH, also called "Massivdecke Germania."

This system of flooring known as Massive German Floors

(Massivdecke Germania) is much used in Westphalia. It consists of wedge-shaped slabs containing three annular holes which are made in advance from cement and ashes; they are 300 mm. long and vary in height according to the load which the floor must resist. The reinforcement consists either of solid triangular cast iron blocks, or hollow triangularly shaped sheets not quite meeting in the base, and which latter are filled with cement-mortar before use. The wedge-shaped slabs are placed between the triangular blocks and the top and the intervening spaces filled with concrete.

POHLMANN.

F. Pohlmann, Schoneberg, b/Berlin (Germany).

Consists of rolled bulb iron, like that used for ship ribs, in the web of which are cut octagonal holes at frequent intervals and in which are fitted hooped stirrups set at any angle or spacing desired.

German Patent 170,117, June 14, 1902.

POTTER.

Potter & Co., Ltd., 66 Victoria Street, London, S. W.

A long established system of general application in which the reinforcement consists of corrugated tension rods with rolled steel joists when required.

PRATT.

A beam similar to the Visintini beam. Round rods are used for main reinforcement, and sometimes flats are used for reinforcing the diagonals. Applicable for deep girders spanning between columns.

PRÜSS.

Prüss'sche Patentwände aus Stein, Zement & Eisen, G.m.b. H., Schonebergerstrasse 18, Berlin, S. W. (Germany).

In this system of walls the reinforcement consists of vertical and horizontal strips, 1¼x26 mm., stretched tightly and formed into a mesh 530 mm. square. Any kind of bricks or else concrete can be used to embed the reinforcement, and skilled labor is not required.

RABBITZ.

Herr Rabbitz, Berlin (Germany).

Galvanized wire network having either diamond or hexagonally shaped meshes.

RAMISCH.

Prof. Ramisch, Breslau (Germany).

This is a floor system in which the supports may be I-beams, reinforced beams or brick walls. The spans can be as long as 6 meters, with a thickness of floor from 100 to 130 mm. The novelty consists in the arrangement of the upper and lower reinforcing round rods; the upper are hooked over the top flanges of the I-beams, but extend only about one-third of the length of the span, the lower rods are placed in the central two-thirds of the span, and are supported by hangers on the upper rod; the ends of both rods are bent up at right angles to avoid shear. It is claimed that thus the expansion of the cement due to variation in temperature is equalized and cracking prevented.

RIBERA.

J. Eugen Ribera, Spanish Engineer (Spain).

This system which is similar to Melan, is only applicable for arched bridges. The reinforcement, which can of itself bear the load, consists of longitudinal angles running near the edges of the arches, and which are connected by braces as required.

RIDLEY-CAMMELL.

M. Noel Ridley, 2 Esmond Road, Bedford Park, London, W.

A system of general application in which the reinforcement usually consists of rounds, but also flats and angles with dovetailed corrugated sheeting.

ROSSI.

In this system of floor slabs, light wires are used, placed near together, and in the opposite direction, light T-sections connected together so as to maintain equal spacing.

SACHSE.

Oskar Sachse, Schoneberg b/Berlin (Germany).

This invention consists simply of a ring and a metal piece of special wedge-shape which together hold firmly in position, two or more reinforcing rods.

German Patent 173,257, Nov. 11, 1904.

SANDERS.

Amsterdamische Fabriek von Cementijerwerken, 108 Wittenbergerstratt, Amsterdam (Holland).

The main reinforcement consists of top and bottom round rods, with smaller transverse round rods extending in a sinuous form across the whole width of beam or floor slab.

SCHLÜTER.

Firma Schlüter, Dortmund (Germany).

A modification of the Monier System, in which the rods are placed diagonally. They are tied occasionally and varied in size and sometimes woven into a metal webbing.

SCHNELL.

Janesch & Schnell, Wieder Hauptstrasse 45, Vienna (Austria).

SCHWEITZER.

Eisenbeton Schweitzer, Augustenstrasse 37, Munich (Germany).

SIEGWART.

International Siegwart Beam Co., Lucerne (Switzerland).

Hollow concrete floor beams, moulded in advance and reinforced with round rods; the corrugated open spaces between the beams are filled with cement grout.

SKELETON.

William Heuman, The Sideolith Co., 72 Victoria Street, London, S. W.

A system of partitions, lintels, beams and floors in which the reinforcement consists of a special skeleton, split and expanded from bars or bands into girder-like forms.

SOHNIUS.

Heinrich Sohnius, Saarbrucken (Germany).

SOMERVILLE.

D. G. Somerville & Co., 72 Victoria Street, London, S. W.

A system of floors and roofs in which the reinforcement consists of rolled steel joists or frames constructed of round or square rods.

STAPF.

This is a form of reinforcing bar consisting of flats, usually placed on edge, and along the length of which at equal and frequent spacings small circular depressions are produced during rolling, first on one side, and then on the other, the object being to somewhat "deform" the bar so as to increase the mechanical bond.

STRAUSS & RUFF,

called "Drahtziegel" bauweise; said to be first introduced in Germany.

This is a special form of reinforced wire netting, known as "Drahtziegel," made in advance, by pressing a cruciform clay brick over each cross section, so that the wires are completely embedded. It is used for dome-shaped ceilings, where it rests on a lattice work of heavy wires, or light round rods, to which it is fastened by binding wires. It is also used for short span floors in which case it is covered with a plain wire netting before depositing the concrete. Where resistance to sounds are desired, two layers of the drahtziegel are used.

STOLTE.

Deut. Cementbau Gesellschaft Paul Stolte, Berlin (Germany).

Reinforced hollow concrete blocks, moulded in advance and laid across between I-beams, which form the beams for the floor. The reinforcement consists of flat bars laid upright.

German Patent 150,320, Dec. 1, 1901.

THURL.

(Said to be so far only used in Vienna.)

Herr. Thurl, Stadtbaumeister, Vienna (Austria).

This system of beams is like Visintini's. In spans over 6 meters, the beam consists of an arched part and also a flat part member. Each are reinforced with four round rods or else wires of 2 to 3 mm. in diameter. The beams are usually 20 cm. wide.

U. K.

United Kingdom Fireproofing Co., Ltd., 47 Victoria Street, London, S. W.

A system of floors consisting of elliptically-shaped hollow tubes with flat bottoms, with chamfered edges which rest on concrete inverted T's, which latter are reinforced with three round rods. Both the tubes and the T's rest on the main I-beams.

de VALLIERE.

de Valliere & Simon, 1 Place de la Cathedrale, Lausianne (Switzerland).

Floor slabs and beams of T-sections with one or more round rods, forming the bottom main reinforcement and which pass through the transverse reinforcement, which latter consists of heavy wire bent up and down and pulled out forming a zigzag arrangement of any spacing desired.

VIENNOT.

L. Viennot, 9 Bd. de Demain, Paris (France).

Uses round rods for reinforcement.

VISINTINI.

Franz Visintini, Dohlinger Hauptstrasse 33, Vienna (Austria).

Shallow cored beams moulded in advance, the embedded reinforcement consisting of light latticed girders.

German Patents 163,838, Sept. 9, 1902, 179,366, May 4, 1905.

WALSER-GERARD.

The beams are T-shaped, and have upper and lower round bars for main reinforcements, the number of top rods being always one in excess of the number of bottom rods; the transverse wire reinforcement is bent around both series of rods. For floor slabs the arrangement is somewhat different, but is also such as to give excellent mutual support.

WAYSS.

Wayss & Freytag, A. G. Sendlingerstrasse, Munich (Germany).

G. A. Wayss & Co., Mollwaldplatz 4, Vienna (Austria).

For floors, Wayss has improved on the Monier System, in his arrangement and bending of the round reinforcing rods. He has developed a flexible floor in which the reinforcement is hinged at the negative points of the moments. For piles, the system includes many variations of the principle of vertical reinforcing rods, near each edge held in position by looped light rods, placed at frequent intervals.

WELLS.

E. P. Wells, Civil Engineer & Surveyor, 94 Larkspur Rise, Clapham, London, S. W.

A system of general application in which the reinforcement consists of two rods held together by a thin diaphragm, so that when one-half is cranked, it does not form a loose member. The arrangement facilitates the fixing of the stirrups on hangers in the correct position.

WEYHE.

also called "Victoria Decke."

Hansa, G.m.b.H. (Wilckens & Ruhl) Bremen (Germany).

A system of floors in which the reinforcing rods passing from one supporting I-beam to the other are first bent in a convex and then in a concave form.

German Patents 81,135, March 14, 1894, 82,941, March 14, 1894.

WILKINSON.

W. B. Wilkinson & Co., Ltd., Townsmead and Imperial Roads, Fulham, London, S. W.

A long established system of floors and general application, in which the reinforcement consists of longitudinal rolled rounds bent up towards supports with similarly shaped transverse bars laid at intervals between supports.

WILLIAMS.

Samuel Williams & Sons, Ltd., Dagenham Dock, Essex (England).

A system applicable to beams, piles, quays, jetties, and Piers in which the reinforcement consists of small rolled I-sections or standard joists with vertical round bars having split ends to withstand the shear.

WISSEL.

Wilh. Wissel, Hannover (Germany).

This invention consists of using a light latticed frame to temporarily connect the upper and lower members of a beam containing reinforcing rods.

German Patent 175,655, Nov. 1, 1904.

WOLLE.

Cementgeschäft Rud. Wolle, Leipzig (Germany).

This system of floors is similar to that of Weyhe. Upper and lower reinforcing round rods are used which are hooked over the top flanges of the supporting I-beams, or firmly anchored in the walls. Vertical stirrups connect the rods at each end of the span, where the concrete is arched, but not in the thinner middle part. Spans up to 6 meters can be built; falsework is always necessary.

WÜNSCH.

Robert Wünsch, Budapest (Hungary).

T-sections, embedded in the floor and ceiling concrete slabs, which latter rests upon the upper or lower flanges of the supporting I-beams. The T-sections are sometimes riveted to the I-beams.

ZIEGLER.

Herr. Ziegler, Bauinspector (Germany).

In this system of reinforced pipes, a provision is also made which secures tight joints, so that the pipes are applicable for fluids, gases and steam under high pressure. The wall of the pipe consists of an inner layer of concrete, around which is a sheet mantle: over this is a second concrete mantle, reinforced with round longitudinal rods.

A rubber washer is used at the overlapping of the joints, which, with the sheet mantle, gives a gas tight pipe.

ZIMMER.

Winklemann & Braums, G.m.b.H., Albrechtstrasse 1, Wissbaden (Germany).

ZÖLLNER.

P. Zöllner & Co., Berlin (Germany).

Wayss & Freytag, A. G. and

Windschild & Langelott, G.m.b.H.

Two systems for the reinforcement of flat floors are used. One in which wires are strung between the walls, being tightly anchored at each end. In the middle of the span these wires are either wound round a rod or clamped on to a small I-beam, and which rod or I-beam is moved so that the wires assume an oblique direction and are thereby more tightly stretched.

In the other system, hollow blocks are used, laid with space for a concrete joint. Above and below these blocks are longitudinal reinforcing rods, hooked at the free ends and connected near the walls with diagonal stirrups.

German Patent 119,651, Aug. 12, 1897.

APPENDIX NO. 2.

COMPARISON OF THE REQUIREMENTS OF FOURTEEN FOREIGN CEMENT SPECIFICATIONS, UNDER THE FOLLOWING HEADINGS:—

1. Fineness.
2. Chemical Composition.
3. Specific Gravity.
4. Weight.
5. Soundness or Constancy of Volume.
6. Distortion in Cold and Hot Water.
7. Setting Time.
8. Mode of Gauging.
9. Neat Test (Tensile Strength).
10. Sand Test (Tensile Strength).
11. Compressive Strength.
12. Blowing Test.
13. Coolness.

CEMENT USED IN REINFORCED CONCRETE. THE CHIEF REQUIREMENTS OF FOREIGN CEMENT SPECIFICATIONS COMPARED.

INTRODUCTION.

The chief requirements of 14 Specifications for Artificial Portland Cement, representing *current* practice in England, France, Germany, Austria, Switzerland, and Russia and also the International Standard Recommendations, are classified under 13 Headings.

For brevity, references were omitted to instructions relating to the manufacture, the sampling, and the preparation of the sample for testing and analysis; also references to packing, branding, storage and the conditions governing the acceptance of the consignments which the sample represents.

ENGLAND.

Seven (7) Specifications as follows:—

(a) British Standard or "Engineering Standards" Committee's Specification of June, 1907, (still in force).
(b) Bertram Blount's suggested modifications of July, 1908.
(c) David B. Butler's suggested modifications of July, 1908.
(d) J. S. de Visian's Specification of Nov., 1907, (Agent of the Hennebique Co.).
(e) Canadian Soc. of Civil Engineers' Specification of May, 1903.
(f) D. G. Somerville & Co.'s Specification of 1907.
(g) Marsh and Dunn's Specification of Feb., 1908.
Note on the importation into England and its Colonies of bogus Portland or "Natural" Cement.

FRANCE.

Government Specification of June, 1902 (still in force).

GERMANY.

Government Specification of Feb. 19, 1902, (still in force).
Association of German Portland Cement Mfgrs., Specification of Feb., 1908.

AUSTRIA.

Austrian Engineering and Arch. Asso. Rules. April 27, 1907 (now in general use).

SWITZERLAND.

Federal Testing Station Standard Specification of 1901, (still in force).

RUSSIA.

Ministry of Public Highways' Specification of April 15, 1905 (still in force).

INTER. ASSO. FOR TESTING MATERIALS.

Recommendations of Brussel's Congress of Sept., 1906.

COMPARISON OF THE CEMENT SPECIFICATIONS.

The requirements of the fourteen (14) Cement Specifications are classified under the following 13 Headings:—

1. Fineness.
2. Chemical Composition.
3. Specific Gravity.

4. Weight.
5. Soundness or Constancy of Volume.
6. Distortion in Cold and Hot Water.
7. Setting Time.
8. Mode of Gauging.
9. Neat Test (Tensile Strength).
10. Sand Test (Tensile Strength).
11. Compressive Strength.
12. Blowing Test.
13. Coolness.

1. FINENESS.

In each of the following quotations, it is assumed that thoroughly dried sieves are used.

BRITISH STANDARD, JUNE, 1907.

Residue on a sieve 76 × 76 = 5,776 meshes per sq. inch shall not exceed *3.00 per cent.*

Residue on a sieve 180 × 180 = 32,400 meshes per sq. inch shall not exceed *18.00 per cent.*

BERTRAM BLOUNT, JULY, 1908.

Residue on a sieve 76 × 76 = 5,776 meshes per sq. inch shall not exceed *1.00 per cent.*

Residue on a sieve 180 × 180 = 32,400 meshes per sq. inch shall not exceed *10.00 per cent.*

J. S. E. DE VESIAN, NOVEMBER, 1907.

Residue on a sieve 180 × 180 shall not exceed *20.00 per cent.*

CANADIAN SOCIETY OF CIVIL ENGINEERS, MAY, 1903.

Residue on a sieve of 10,000 meshes per sq. inch shall not exceed *10.00 per cent.*

The whole of the Cement shall pass through a sieve of 2,500 meshes per sq. inch.

D. G. SOMERVILLE & CO., 1907.

Residue on a sieve 180 × 180 (No. 47½ B. S. Wire Gauge) must not be, after gently shaking, more than 15 per cent.

The whole of the cement must pass through a 76 × 76 sieve.

FRENCH GOVERNMENT, JUNE, 1902.

The fineness test shall be made on 100 grams.

Three sieves shall be used as follows:—

Sieve of 324 meshes per sq. cm., wires 2/10 mm. thick.
Sieve of 900 meshes per sq. cm., wires 15/100 mm. thick.
Sieve of 4900 meshes per sq. cm., wires 5/100 mm. thick.

Residue left on sieve of	Cement for sea water work	Cement for other uses
324 mesh	not over 2%	
900 mesh		not over 10%
4900 mesh	not under 40%	not over 30%

GERMAN GOVERNMENT, FEBRUARY, 1902.

Portland cement must be ground so fine that not more than 10 per cent. of residue is left after a sample of the same has been passed through a wire sieve of 900 meshes to the square centimeter (5806 per square inch). The thickness of the wire of the sieve should be equal to one-half of the width of the opening of the mesh.

ASSOC. OF GERMAN PORTLAND CEMENT MFGRS., FEBRUARY, 1908.

Portland cement must be ground so fine that not more than 5 per cent. of residue is left on a sieve of 900 meshes per square centimeter. The width of the mesh being 22 mm. 100 grams of cement should be used for each determination.

AUSTRIAN ENG. & ARCH. SOC., 1907.

Portland cement shall be ground as fine as possible.

The residue on a sieve with 4900 meshes per 1 $cm.^2$ and made of 0.05 mm. wire shall not be more than 30 per cent.

The residue on a sieve with 900 meshes per 1 $cm.^2$ and made of 0.10 mm. wire shall not be more than 5 per cent.

SWISS FEDERAL TESTING STATION STANDARD, 1901,

Portland cement must be ground fine enough, so that the residue on a sieve with 900 meshes per cm. square and made of 0.1 mm. wire, shall not be over 5 per cent.

RUSSIAN MINISTERIAL REGULATIONS, 1905.

Portland cement shall be ground as fine as possible.

The residue on a sieve with 4900 meshes per 1 cm.^{2} and made of 0.05 mm. wire shall not be more than 50 per cent.

The residue on a sieve with 900 meshes per 1 cm., made of 0.10 mm. wire shall not be more than 15 per cent.

INTER. ASSOC. TEST. MAT. BRUSSELS, 1906.

(a) The fineness of grinding is measured with the aid of the following set of sieves having rectangular meshes.*

No. of meshes per sq. cm.	No. of wires per cm.	Thickness of wires in mm.	Width of meshes in mm.
900	30	0.10	0.23
2500	50	0.07	0.13
4900	70	0.05	0.09

The fineness of grinding should preferably be determined mechanically as it is very difficult to obtain thoroughly concordant results by hand-sieving. A machine for the purpose should be as simply and strongly built as possible and should shake the sieves a definite number of times in a given interval of time.

(b) The substances to be tested should be separated into three portions by means of two sieves as follows:

Portland cement on sieves with ..... { 900 meshes, 4900 meshes

Other cements and hydraulic lime .. { 900 meshes, 2500 meshes

(c) Amounts of 100 grams should be taken for each experiment.

(d) The result of passing the material through each sieve is expressed in terms of the proportion of the total material which is retained on that sieve.

2. CHEMICAL COMPOSITION.

BRITISH STANDARD, JUNE, 1907.

The cement shall comply with the following conditions as

* Sieves having wires and apertures uniform in size are difficult to procure; but the dimensions specified above should be adhered to as closely as possible, until such time as sieves constructed of wires or perforated sheet metal are better made than at present.

to its chemical composition. There shall be no excess of lime, that is to say, the proportion of lime shall not be greater than is necessarv to saturate the silica and alumina present.* The percentage of insoluble residue shall not exceed 1.50 per cent.; that of magnesia (MgO) shall not exceed 3.00 per cent.; and that of sulphuric anhydride (SO_3) shall not exceed 2.75 per cent.

BERTRAM BLOUNT, JULY, 1908.

Same as British Standard except that the percentage of insoluble residue shall not exceed 1.0 per cent.

CANADIAN SOCIETY OF CIVIL ENGINEERS, MAY, 1903.

The manufacturer shall, if required, supply chemical analyses of the cement.

D. G. SOMERVILLE & CO., 1907.

This is a most important point, and should be carefully embodied in every specification for reinforced concrete work.

Lime	58 to 62%
Silica	21 to 23%
Alumina	6 to 8%
Ferric oxide	3 to 4%
Magnesia	not more than 1.26%
Sulphuric anhydride	not more than 1.6 %
Insoluble residue	not more than 1.1 %
Alkalies	not more than 1.6 %

FRENCH GOVERNMENT, JUNE, 1902.

Quality. The cement shall be of uniform quality and composition. It shall contain no unburnt or foreign matter.

The maximum allowable percentages of certain ingredients are as follows:

	Cement for sea water work	Cement for other uses
Sulphuric anhydride	1.50%	3.00%
Magnesia	2.00%	5.00%
Alumina	8.00%	10.00%
Sulphides	Only traces permitted in both cases.	

* NOTE.—The proportion of lime to silica and alumina shall not be greater than the ratio (calculated in chemical equivalents) represented by $\frac{CaO}{SiO_2 + Al_2O_3} = 2.85$.

Molecular weight of lime (CaO) = —56; silica (SiO_2) = 60; and alumina (Al_2O_3) = 102.

For cement for Sea Water Work the index of hydraulicity, that is to say, the proportion between the weight of the combined silica and alumina on the one part, and the weight of lime and magnesia on the other part, shall be at least 0.47 for a percentage of 8 per cent. of alumina with a diminution of 0.02 for each 1 per cent. of alumina below 8 per cent.

RUSSIAN MINISTERIAL REGULATIONS, 1905.

The sum of percentages of Lime, Soda and Potash (CaO Na_2O K_2O) divided by the sum of the percentages of Silica, Alumina and Ferric Oxide (SiO_2 Al_2O_3 Fe_2O_3) must fall between 1.7—2.2 per cent.

The quantity of Sulphuric Acid and of Magnesia in the finished Portland Cement (*i. e.* after the addition of any foreign substances to the burned product) must not be more than 1.75 and 3.00 per cent. respectively.

3. SPECIFIC GRAVITY.

The specific gravity determination can not in itself be considered an indication of the adulteration of Portland Cement, until placed in comparison with other tests indicating quality.

BRITISH STANDARD, JUNE, 1907.

Not less than 3.15 when fresh burnt and ground, or not less than 3.10 after 28 days from grinding.

BERTRAM BLOUNT, JULY, 1908.

Not less than 3.15 when fresh burnt and ground, or not less than 3.10 after 28 days from grinding.

CANADIAN SOCIETY OF CIVIL ENGINEERS, MAY, 1903.

Not less than 3.09 nor over 3.25 for fresh cement; the term "fresh" being understood to apply to such cements as are not more than two months old.

D. G. SOMERVILLE & CO., 1907.

Not less than 3.16 nor more than 3.27 with new cement, or not less than 3.09 after 24 hours exposure to air in a 3/8 inch layer.

RUSSIAN MINISTERIAL REGULATIONS, 1905.

Shall not be less than 3.05.

INTER. ASSOC. TEST. MAT. BRUSSELS, 1906.

Apparent Density.

(a) The apparent density is determined by filling a cylindrical measure (with or without shaking) which holds 1 litre and has a height equal to its diameter.*

(b) The measure is preferably filled with the aid of the apparatus illustrated, the various dimensions of the latter being shown in the drawing.

Half way up, the funnel is fitted with a sheet of perforated metal, having holes, roughly, 2 mm. in diameter. The cylindrical measure is placed 50 mm. below the lower edge of the funnel. Cement is then introduced into the funnel in small quantities of 300 to 400 grams, and made to pass the sieve by stirring it with a spatula.

The filling of the measure is stopped as soon as the base of the cone of cement powder, which is formed in the vessel, reaches its upper edge. The excess of cement is then struck off, and the weight of material remaining in the measure is determined.

(c) For determining the weight of the powder when shaken down in the measure, an equable percussion movement should be imparted to it. The application of a machine for this purpose is desirable.

4. WEIGHT.

FRENCH GOVERNMENT, 1902.

Instead of specifying Specific Gravity, these Specifications state that for Sea Water Work, Portland Cement must weigh at least 1200 grams per litre and for other uses, at least 1100 grams per litre.

The weight shall be determined by gently pouring the cement, without shaking, into a metal measure, cylindrical in form, having a capacity of 1 litre and a height of 10 cm. The cement contained in the measure shall be weighed;

* A vessel of this sort is not in accordance with the German weights and measures law.

the average results of three successive operations shall be taken as the weight of the sample.

In case of dispute, the filling of the measure shall be effected by means of a funnel containing a sieve of perforated plate having holes of 2 mm.; this funnel shall be placed in such a manner that the bottom of the tube shall be 5 cm. above the measure. The cement shall be poured in without shaking or jarring of any kind. When the measure overflows, the material in excess shall be removed by scraping it off with a straight-edge held vertically.

5. SOUNDNESS OR CONSTANCY OF VOLUME.

BRITISH STANDARD, JUNE, 1907.

As tested by the Le Chatelier method and apparatus (described in detail in the Specification) the cement shall in no case show a greater expansion than

10 mm. after 24 hours aeration, and
5 mm. after 7 days aeration.

BERTRAM BLOUNT, JULY, 1908.

By above method, cement for reinforced concrete should not show over

6 mm. after 24 hours aeration, and
3 mm. after 7 days aeration.

J. S. E. DE VESIAN, NOVEMBER, 1907.

Same as the recommendation of Bertram Blount.

D. G. SOMERVILLE & CO., 1907.

The Constancy of Volume is also most important, and the following test should be applied:

After air-slaking cement for 24 hours in a layer ½ inch thick, a pat of 3 inches diameter, ¼ inch thick at centre and reduced to fine edges, mixed for between 3 and 6 minutes on a non-absorbent surface, with 22½ per cent. of water, shall be placed on a glass plate, and allowed to set under a damp cloth for 24 hours; it shall then be placed in cold water, which shall be raised to boiling point and kept boiling for 3 hours. There should be no signs of warping or cracking.

GERMAN GOVERNMENT, FEBRUARY, 1902.

Portland cement should be constant in its volume. The decisive test of this property shall be, that a pat of neat cement, made on a glass plate and kept in a damp atmosphere for twenty-four hours, and afterwards immersed in water, shall not show any signs of warping or cracking at the edges, even after the lapse of a considerable period.

In carrying out this test, the pat prepared for determining the time of set should be placed under water at the end of twenty-four hours, in the case of slow-setting cements, but in any case only after it has become set. This may be done much sooner in the case of quick-setting cements. The pats especially in the case of slow-setting cements, must be well protected from draughts, and the direct rays of the sun, until after they have become set. The best method is to place them in a closed box, or cover them with damp cloths. Hair cracks which are caused by shrinkage, due to rapid drying, will thus be avoided. These generally appear in the centre of the pat, and are often mistaken by the uninitiated for cracks caused by blowing. If the cement shows any crumbling, or cracks are visible during the process of hardening while under water, this is a certain indication of the blowing of the cement; that is to say, the cement becomes cracked in consequence of an increase of volume, and a gradual disruption of the particles previously connected takes place, which may ultimately lead to the total destruction of the mass. These symptoms of expansion usually appear within three days, but an observation extending over twenty-eight days is always sufficient.

ASSOC. OF GERMAN PORTLAND CEMENT MFGRS., FEBRUARY, 1908.

The Rules state that "Portland Cement must be constant in its volume. The decisive test of this property shall be, that a pat of neat cement, prepared on a glass plate and kept in a damp atmosphere for 24 hours, and afterwards immersed in water for 24 hours shall show no signs of curvature or cracking on the edges, even after the lapse of a considerable period."

AUSTRIAN ENG. & ARCH. SOC., 1907.

Portland cement shall have the same constancy of volume in air as under water.

The volume of Portland Cement is often constant under water but not in air, or *vice versa.* Hence it must be tested under both conditions. It is not safe to use Portland Cement which has not the same Constancy of Volume in air as under water.

SWISS FEDERAL TESTING STATION STANDARD, 1901.

Hydraulic binding materials shall have the same constancy of volume in air as under water.

RUSSIAN MINISTERIAL REGULATIONS, 1905.

Mortar made from neat Portland Cement must have the same Constancy of Volume in air as under water.

Briquettes of such mortar must not show any crimping or any radical cracks on the edges after being exposed in the air, to a temperature of 120°C. for one hour, nor after having laid in water for 27 days.

These tests shall be made on at least two briquettes.

6. DISTORTION IN COLD AND HOT WATER.

FRENCH GOVERNMENT, JUNE, 1902.

Pats of neat cement, after being kept 24 hours in a damp atmosphere, are immersed in either sea-water or fresh water, depending upon the use to which the cement is to be put.

In each case a temperature of 100°C. is maintained for 3 hours.

In the sea-water test, the distance between the points of the needle shall not exceed 5 mm.; in the fresh water not over 10 mm.

The tests for distortion in the cold shall be made with pats of cement gauged with fresh water into a stiff paste. The pats, being about 10 cm. diameter and 2 cm. thick, shall be thinned out on the edges and placed on glass plates; the pats shall be immersed under the conditions stipulated by the specification adopted and kept in water until the cement has been definitely accepted.

None of the pats shall show the least trace of blowing, buckling or bursting; the edges of the pats shall remain firmly fixed to the glass and shall not show any signs of lifting.

The tests for distortion in the hot shall be determined with cylindrical test pieces, of a diameter and depth of 30 mm. moulded in a brass tube, ½ mm. in thickness, split vertically and carrying, soldered to each end of the slit, a needle of 150 mm. in length.

Twenty-four hours after being set, these test pieces shall be immersed in water which shall be gradually raised to the temperature fixed by the specification, and maintained at that temperature during the time, likewise fixed by the specification; then cooled to the initial temperature. The increase of distance between the points of the needles shall not exceed the figure indicated by the specification adopted.

None of the pats and test pieces shall show the least trace of blowing or distortion, such as cracks, buckling or bursting. The edges of the pats shall remain firmly fixed to the glass without any sign of lifting.

The water in which the pats and test pieces are kept shall be maintained at temperatures of between 12 and 18°C.

INTER. ASSOC. TEST. MAT. BRUSSELS, 1906.

Cold Deformation Tests.

(a) The cold tests for permanency of form are conducted with the standard paste.

(b) The paste is spread out on glass plates. On these it forms cakes, run out thin at the edges, of about 10-15 cm. in diameter and 1½-2 cm. thick.

(c) The cakes, after hardening for 24 hours in moist air, are placed in water of 15-18°C.

(d) The tests consist in noting the condition of the pats at the dates when the tensile and compression tests are being carried out.

7. SETTING TIME.

The requirements quoted cover the time within which "initial" set shall take place and the limits of time within which "final" or "hard" set must occur.

BRITISH STANDARD, JUNE, 1907.

For this test the "pats" shall be mixed as described under "Mode of Gauging." The cement shall be considered as finally "set" when a "needle" of the prescribed form, having a flat end 1/16 inch square, weighing in all 2½ lbs., fails to make an impression when its point is applied gently to the surface.

There shall be three distinct graduations of setting time. which shall be designated as "Quick," "Medium" and "Slow."*

Quick: The final setting time shall not be less than 10 minutes, nor more than 30 minutes.

Medium: The final setting time shall not be less than 30 minutes, nor more than 2 hours.

Slow: The final setting time shall not be less than 2 hours, nor more than 7 hours.

BERTRAM BLOUNT, JULY, 1908.

He recommends the adoption of the above requirements.

MARSH & DUNN'S MANUAL, FEBRUARY, 1908.

Recommends that Portland Cement for reinforced concrete should be manufactured from proper materials and preferably calcined in rotary kilns; it must satisfy in every respect the conditions specified in the British Standard Specification (of 1907) and they recommend in addition, that the *initial set* shall not take place under 30 minutes, nor the *final set* under 3 hours or over 10 hours, when mixed with 22½ per cent. of water.

DAVID B. BUTLER, JULY, 1908.

Recommends the conditions specified in the British Standard Specification (of 1907) except as regards the "Setting Time." He considers that the *initial set* should not take place under 30 minutes, nor the *final set* under 5 hours.

D. G. SOMERVILLE & CO., 1907.

"This is a somewhat vexed question, as different makers and constructors vary in their estimates as to what gives the

* NOTE.—When a specially slow setting cement is required the minimum time of final setting shall be specified.

most satisfactory results. Our feeling is, however, that a slow setting cement is preferable as the work being usually constructed in layers has more chance of becoming incorporated."

"Test.—The initial set shall not take place under 15 minutes nor the final set under 4 or over 8 hours, the pat being covered with a damp cloth between testing."

FRENCH GOVERNMENT, JUNE, 1902.

Cement, for Sea Water Work, immersed in fresh water shall not commence to set in less than 20 minutes.

The set shall be completely finished within a period not less than 3 hours nor more than 12 hours.

Cement, for other Uses, immersed in fresh water shall not commence to set in less than 20 minutes.

The set shall be completed within a period of not less than 2 hours nor more than 12 hours.

The cement shall be gauged with potable water into a stiff paste, and shall be made in the form of a pat about 4 cm. thick, immediately immersed either in fresh water or in sea water according to the conditions of the particular specification adopted. The cement, water, and immersion tank shall be of a temperature of at least 15°C. when it is desired to determine the maximum rapidity of set, and at most 15°C. when it is desired to ascertain the minimum.

The commencement of set shall be when a Vicat needle having a section of 1 square mm. and weighing 300 grams. does not wholly penetrate the pat.

The final set shall be the time when the surface of the pat supports the same needle without appreciable penetration, such as a one-tenth mm.

In case of dispute, the term "stiff paste" shall be estimated as follows. When gauged in the proportion of five minutes per kilogram, this paste, in a box 4 cm. deep, shall be penetrated to within 6 mm. of the bottom of the box by a consistence plunger of 1 cm. diameter and 300 grams weight.

GERMAN GOVERNMENT, FEBRUARY, 1902.

Portland Cement can be furnished to set slowly or quickly according to the purpose for which it is required. Cements which take two hours or more to set, may be described as slow-setting cements.

In order to ascertain the time of set of slow-setting cements, take a sample of neat cement and mix for three minutes with water to a stiff paste; for quick-setting cements only one minute's mixing is required. The mixture is then spread on a glass plate, at a single operation, in the form of a pat 1½ cm. thick (about ⅝ inch), and tapering towards the edges.

The consistency of the gauged cement should be such that a few taps on the glass plate will cause the mass, which was placed thereon with a spatula, to flow towards the edges. From 27 to 30 per cent. of water is generally sufficient for this purpose. When the pat becomes hard enough to withstand a slight pressure with the finger nail, the cement may be considered as set.

To ascertain accurately the exact time of set, and to determine the commencement of setting, which is of the greatest importance with quick-setting cement (as it must not be worked after it begins to set), a standard needle of 300 grams (10½ oz.) weight is used, with a diameter of 1 mm. (.039 inch) and a flat point. A metal ring 4 cm. (about 1½ inches) in height, and having 8 cm. (3 inches) clear diameter, is placed upon a glass plate and filled with gauged cement of the above-mentioned consistence, and tested at intervals with the needle. The exact moment when the needle fails to penetrate the entire depth of the mass, is considered as the commencement of setting. The time which elapses between the gauging and the moment at which the normal needle leaves no visible impression on the surface of the pat, is the time taken to set. In order to obtain uniform results in determining the setting of cement, it is of importance to carry out the tests at a mean temperature of both air and water of 15° to 18°C. (59° to 64°F.), as the setting is influenced by the temperature of the air and of the water used in gauging; a high temperature quickens the setting, a low temperature, on the other hand, retards it.

Slow-setting cements should not materially increase in temperature during setting, whereas with quick-setting cements a marked increase is permissible. Portland Cement is rendered slower settting by long storage, and its tensile strength is increased if kept in a dry place free from draughts. The opinion frequently prevailing, that Portland Cement deteriorates by long warehousing is therefore an erroneous one, and contract clauses which specify the use of fresh cement only, should be discarded.

ASSOC. OF GERMAN PORTLAND CEMENT MFGRS., FEBRUARY, 1908.

The initial set of normal Portland Cement shall not take place in less than one hour after gauging. For particular purposes a quicker setting Portland Cement can be prepared; such cement, however, shall be so marked on the package.

The initial set of normal Portland Cement should require at least one hour, because the beginning of the setting is important; on the contrary, if a definite interval of time is required for the hard set it is of less value in the use of Portland Cement, if the process of hardening is completed in a shorter or longer time. Possibly specifications concerning the setting time should, therefore, not be limited too closely.

AUSTRIAN ENG. & ARCH. SOC., 1907.

There shall be three grades of setting time for Portland Cement known as QUICK-, MEDIUM- and SLOW-setting.

Cements hardening within 10 minutes are QUICK-setting SLOW-setting cements are those which begin hardening after 30 minutes.

MEDIUM-setting cements are those which harden between 10 and 30 minutes.

Quick-setting cement is only to be used when specially ordered.

SWISS FEDERAL TESTING STATION STANDARD, 1901.

There shall be three grades of setting time for hydraulic binding materials known as QUICK-, MEDIUM- and SLOW-setting.

Those which begin setting promptly and in which final setting time is not over 30 minutes shall be called "QUICK"-setting.

Those which take over 3 hours to become finally set shall be termed "SLOW"-setting.

"MEDIUM"-setting materials are those in which the final setting is between 30 minutes and 3 hours.

RUSSIAN MINISTERIAL REGULATIONS, 1905.

Portland Cement must be slow-setting.

It must not begin to set before 15 minutes after the water has been added. The final setting time shall not be less than 1 hour nor more than 12 hours.

INTER. ASSOC. TEST. MAT. BRUSSELS, 1906.

Setting tests.

(a) The setting tests are to be undertaken with the normal paste described in 3. Whilst mixing, the water and air should have a temperature of between 15° and 18°C.

(b) The test consists in ascertaining the commencement and the end of the setting process.

(c) As soon as it is filled, the mould should be placed in a damp situation where the temperature is maintained between 15° and 18°C.

(d) For the test is employed a metal needle (Vicat's needle) that is cylindrical, smooth, clean, and dry, and at the lower end cut off sharp at right angles to its axis. It should be 1 sq. cm. in section, 1.13 cm. in diameter, and should weigh 300 grams.

(e) The commencement of setting is regarded as being the moment at which the needle, carefully placed upon the surface, no longer passes vertically through the paste to the bottom of the mould.

The end of the setting is the moment when the surface of the paste is hard enough to support the same needle, without allowing it to penetrate to an appreciable depth.

The times in question are calculated from the moment when the water is brought into contact with the cementitious material.

(f) In hot countries, the mechanism of the setting test must be specially studied, in order that due allowance may be made for the effect of a high temperature upon the time occupied in setting.

8. MODE OF GAUGING.

BRITISH STANDARD, JUNE, 1907.

The quantity of water used in gauging shall be appropriate to the quality of the cement, and shall be so proportioned that when the cement is gauged it shall form a smooth, easily worked paste, that will leave the trowel cleanly in a compact mass. Fresh water shall be used for gauging, and the temperature thereof, and that of the test room at the time the said operations are performed, shall be from 58° to 64°F.

BERTRAM BLOUNT, JULY, 1908.

He recommends the above mode of gauging but lays particular stress on the fact that the gauged cement *shall leave the trowel* cleanly and in a compact mass, and explains that this does not mean that the trowel shall be scraped off or otherwise handled to clean it from the gauged cement.

FRENCH GOVERNMENT, JUNE, 1902.

The following statements refer, in general, to both the Neat and Sand Test, of the French Government Specification.

The tests for tensile strength shall be made on a stiff paste of pure cement and on a plastic mortar of cement gauged with fresh water. They shall be carried out by means of test pieces in the form of a figure 8, having a section in the centre of 5 sq. cm.

The moulds in which the test pieces are to be made shall be filled in one operation: they shall be first shaken to expel air-bubbles, the paste or the mortar shall then be pressed with a trowel, but not rammed, then with the edge of the trowel, the excess material shall be scraped off and the surface of the test piece smoothed off.

The briquettes, after having been kept in damp air and sheltered from draughts and the direct rays of the sun, during the time fixed by the specification adopted, shall be removed from the moulds and immersed in fresh or sea water, according to the condition of the specification; in any case, the water shall be renewed every seven days.

In case of dispute, the stiff paste of neat cement shall be that designated by the previous clause, and the plastic cement mortar shall be a mortar composed of Leucate shore sand, furnished by the Administration, and gauged with a quantity of water equal to 1 kilogram of material to 70 grams plus 1/6 P,—P being the weight of water necessary to make 1 kilogram of cement into a stiff paste.

GERMAN GOVERNMENT, FEBRUARY, 1902.

In order to ensure the necessary uniformity in carrying out the tests, it is advisable to employ the apparatus and machines used at the Royal Testing Station at Charlottenburg, Berlin.

To arrive at consistent results, sand of the same size of grain and of the same kind should be used in all cases. The normal sand is obtained by washing pure quartz sand as clean as possible, drying it, and passing it through a sieve of 60 holes per sq. cm. (387 per sq. inch) in order to separate the coarser particles; the sand thus obtained is again passed through a sieve of 120 holes per sq. cm. (775 per sq. inch), to free it from the finer particles. The thickness of the wire of the sieves should be 0.38 and 0.32 mm. (.014 and .012 inches) respectively.

Since all quartz sands do not always give the same results when similarly treated, it should be ascertained whether the normal sand employed will give results consistent with the normal sand supplied for testing purposes under the direction of the Committee of the German Cement Manufacturers' Association, and which is also used by the Royal Testing Station of Charlottenburg, Berlin.

As in testing the same cement, a great deal depends on consistent results being obtained at different places, the subjoined rules should be strictly adhered to.

In order to secure accurate results, the average of at least ten tests should be made at each date.

The mixing of the mortar of one part by weight of cement to three parts by weight of standard sand, shall be carried out as follows, with a Steinbruck-Schmelzer mortar mixing machine. 500 grams of cement and 1500 grams of standard sand shall be mixed together dry for half a minute in a mortar with a light spoon. The amount of water previously determined is then to be added to the dry mixture. The moist mass is again mixed for half a minute, then eventually turned into the mortar mixing machine and worked for 20 revolutions.

The determination of the water is affected by the use of a cube mould in the following manner:—The dry mortar in the above specified quantities, is mixed in the mortar mixer as before described, with 160 grams of water as the first experiment (8 per cm.), and when necessary 200 grams (10 per cm.) as the second experiment.

860 grams of the ready mixed mortar are filled into the cube mould, the filling box of which is provided on the under edge with two holes as shown in the sketch, and struck 150 blows with a Böhme hammer apparatus fitted with a Marten's clamp.

According to the state of the mortar during the blows, an opinion can be formed as to which of the above extreme limits of percentage of the water is nearest the correct one, whereupon experiments shall be undertaken with different percentages of water.

The percentage of water is correct when, after between 90-110 blows, the liquid cement begins to flow out through both of the holes.

The mean of three test blocks, with the same proportion of water, determines the correct proportion, and this proportion is to be used as the proportion for both tensile and crushing test pieces.

The extrusion of the liquid takes longer when a dry filling box is used than when it has been once used, therefore, the result of the first use of the filling box is incorrect.

The estimation of the percentage of water by the extrusion of the liquid from the tensile test pieces is unreliable.

The preparation of test pieces from normal mortar, for tensile and crushing tests, shall be carried out as follows:—

Of the mortar mixed as previously described, 180 grams shall be filled into the standard briquette moulds, and 860 grams into the standard cube moulds, the moulds placed under the Böhme hammer apparatus, fitted, with the Marten's clamp, and subjected to 150 blows with the hammer.

The mortar produced from 500 grams of cement and 1500 grams of standard sand is sufficient for the preparation of two briquettes and two cubes.

The test pieces, with their moulds resting on a non-porous bed, shall be covered with a box lined with damp cloth; the briquettes shall be removed from the moulds in about half an hour and the cubes in about twenty hours; twenty-four hours after moulding, the test pieces shall be taken out of the box, and placed in water of 15° to 18°C., where they shall remain until due for testing, and shall be tested immediately on being taken out of the water.

INTER. ASSOC. TEST. MAT. BRUSSELS, 1906.

Standard Paste:[1]

(a) The standard paste used for testing should answer the following requirements:

(b) A weight of 0.40 kilo of cement or lime is placed in the shape of a ring on a non-absorbent slab, and the quantity of water necessary[2]), to satisfy clause (e) below, is poured into the centre without stopping. The whole is then thoroughly mixed together with a trowel for three minutes (or for one minute if the cement is quick-setting), counting from the moment when the water is poured on.

(c) A conical metal vessel with a flat bottom, 8 cm. in diameter at the base, 9 cm. at the top, and 4 cm. deep, is immediately filled with the paste, and the excess is

[1] By the term paste is understood a cement or lime gauged with water, no sand being present.

[2] This quantity should be ascertained by repeated tests.

struck off with the trowel, pressure on the paste and agitation being avoided.

(d) In the centre of this mass and normal to its surface, a parallel needle is caused to descend slowly into the paste, until it comes to rest. The needle should weigh 300 grams, be 1 cm. in diameter and be constructed of clean, polished, and dry metal. Its end should be cut off sharply at right angles to its length. The apparatus is known as a consistence probe, and is so designed as to show exactly the thickness of the paste remaining between the bottom of the vessel and the lower end of the needle.

(e) The thickness of the paste should be such that, at the moment at which the needle stops sinking in, the thickness between the bottom of the vessel and the end of the needle is 5 to 6 mm.

9. NEAT TEST. (TENSILE STRENGTH.)

BRITISH STANDARD, JUNE, 1907.

For the following minimum requirements, the average tensile strength of six briquettes, of the standard shape recommended, and of a minimum section of 1 inch square, shall be taken as the accepted tensile strength for each period.

7 days (1 day in moist air, 6 days in water of 58°-64°F.) 400 lbs.

28 days (1 day in moist air, 27 days in water of 58°-64°F.) 500 lbs.

The increase from 7 to 28 days shall not be less than:—

25% when the 7 day test falls between 400-450 lbs.
20% when the 7 day test falls between 450-500 lbs.
15% when the 7 day test falls between 500-550 lbs.
10% when the 7 day test falls between 550-600 lbs.
5% when the 7 day test is 600 lbs. or upwards.

BERTRAM BLOUNT, JULY, 1908.

He considers the "Neat Test" an unimportant and, therefore, unnecessary requirement, in a specification governing the acceptance of Portland Cement for reinforced concrete work.

CANADIAN SOCIETY OF CIVIL ENGINEERS, MAY, 1903.

For the following minimum requirements, the average tensile strength of five briquettes, made of neat cement mixed with about 20 per cent. of water, by weight, shall be taken.

3 days (1 day in moist air, 2 days in water) 250 lbs.

7 days (1 day in moist air, 6 days in water) 400 lbs.

28 days (1 day in moist air, 27 days in water) 500 lbs.

Any cement showing a decrease in tensile strength, on or before the twenty-eight day shall be rejected.

D. G. SOMERVILLE & CO., 1907.

Briquettes of neat cement mixed with 22½ per cent. water, after being in moulds for 24 hours, must have the following maximum tensile strengths:

2 days after gauging, at least 230 lbs. per square inch.

4 days after gauging, at least 350 lbs. per square inch.

7 days after gauging, at least 450 lbs. per square inch.

28 days after gauging, at least 570 lbs. per square inch.

FRENCH GOVERNMENT, JUNE, 1902.

Briquettes of neat cement, immersed in *sea-water* after 24 hours shall withstand:—

After 7 days at least 15 kilos per sq. cm. (213 lbs. per sq. inch).

After 28 days at least 30 kilos per sq. cm. (427 lbs. per sq. inch).

The strength developed shall also increase at least 3 kilos per sq. cm. (43 lbs. per sq. inch), from 7 to 28 days.

Briquettes of neat cement, immersed in *fresh water* after 24 hours shall withstand:—

After 7 days at least 25 kilos per sq. cm. (356 lbs. per sq. inch).

After 28 days at least 35 kilos. per sq. cm. (498 lbs. per sq. inch).

The strength developed shall also increase at least 3 kilos (43 lbs. per sq. inch) from 7 to 28 days.

In both cases the Engineer can increase the above required tests of neat cement after 7 days and after 28 days, after he has satisfied himself that the manufacturers are able to supply what he specifies.

In both cases six briquettes must be tested and the tensile strength shall be the mean of the four best results.

GERMAN GOVERNMENT, FEBRUARY, 1902.

The tensile test at 28 days serves as a controlling test of cement delivered. If, however, a decision is to be arrived at after 7 days, it may be made with a given sample, after the ratio of tensile strength between the 7 days and the 28 days has been determined. This preliminary test may also be carried out with *neat* cement, after having ascertained the relation between the strength of the neat cement at 28 days and that mixed with three parts of sand.

Briquettes of neat cement should be made by rubbing the insides of the moulds with a little oil, placing them on a metallic or glass plate (without blotting paper); then weigh off 1000 grams (35.3 oz.) cement, add 200 grams = 200 cc. (7.06 oz.) water, and work the mass for five minutes (this is best done with a pestle), fill the moulds heaping full, and proceed as in making hand briquettes of cement and sand. The moulds, however, must not be removed till the cement is sufficiently hardened. As in beating in neat cement, briquettes are required, a very fine or very quick-setting cement will require a correspondingly larger quantity of water. The amount of water used should always be mentioned in giving the results of such tests.

In order to ensure the necessary uniformity in carrying out the tests, it is advisable to employ the apparatus and machines used at the Royal Testing Station at Charlottenburg, Berlin.

RUSSIAN MINISTERIAL REGULATIONS, 1905.

For the following minimum requirements, the average of the 4 best results, out of 6 briquettes tested, shall be the accepted tensile strength for each period.

After 7 days (1 day in moist air, 6 days in water), 20 kilos per cm.^{2} (284 lbs. per sq. inch).

After 28 days (1 day in moist air, 27 days in water), 25 kilos per cm.² (356 lbs. per sq. inch).

INTER. ASSOC. TEST. MAT. BRUSSELS, 1906.

(a) The tensile strength tests of cements should be carried out on the standard paste (neat), and on 1:3 standard cement mortar; tests of hydraulic limes upon 1:3 and 1:5 standard mortars.

(b) The test pieces for the tests should have the shape of the figure 8. These pieces are termed standard briquettes, they have a cross section in the middle, of 5 sq. cm. The general appearance is shown by the accompanying sketch.

(c) The 1:3 briquettes should be prepared with the aid of a machine giving the same number of blows, and exerting the same pressure on all samples.

(d) The iron or bronze moulds in which the briquettes of neat cement are allowed to set, should be placed on a table of marble or polished metal. Both moulds and slab should be well cleaned, and rubbed over with a greasy cloth.

Enough of the gauged cement is placed in each mould without stopping to cause it to overflow.

Pressure is applied with the fingers so as to ensure that no part is left unfilled, and the mould is struck several times with the trowel on each side in order to let the material settle well in, and to facilitate the escape of air bubbles.

When the cement has set a little, it is scraped off nearly horizontal to the edges of the mould with a straight knife blade, so that all the superfluous material is removed without putting any pressure upon it. Finally the surface is smoothed off by means of a knife resting on the edges of the mould.

(e) Another method consists in making a mixture of cement with a small quantity of water till the whole attains the consistency of moist earth; this is pressed into the mould with a spatula. The two processes give different results.

(f) For a period of twenty-four hours, counted from the commencement of gauging, the briquettes are kept on their supporting slabs in an atmosphere saturated with moisture, in a place protected from draughts and the direct rays of the sun, and at a temperature of between 15° and 18°C.

The briquettes are then slid on to glass plates covered with bibulous paper, and the moulds are removed from them. Briquettes made with standard sand are removed from their moulds about half an hour after being gauged. Briquettes of hydraulic lime mortars should remain in the moulds for 2, 4, or 7 days.

(g) At the expiration of the above mentioned periods of time, the briquettes are plunged into potable water; but the depth of liquid in the vessel should not exceed 1 m.

The water must be renewed each week and kept at a temperature of 15°-18°C.

(h) The breaking apparatus should work in such a way that the increase in load takes place regularly and equally at the rate of 5 kg. per second.

The form and method of securing the test pieces in position by means of grappling claws, is shown in the previous illustration.

(i) Breaking tests are carried out on batches of 10 briquettes at the end of 7 and 28 days, etc., counting from the date of gauging.

The average of the figures given by 10 briquettes is to be taken as the result of the test; but if any individual figures differ from the mean of all the 10 samples by more than 20 per cent., those figures are to be rejected as erroneous.

10. SAND TEST. (TENSILE STRENGTH.)

BRITISH STANDARD, JUNE, 1907.

For the following minimum requirements, the *average* tensile strength of six briquettes, of the standard shape recommended, and of a minimum section of 1 inch square, shall be taken as the accepted tensile strength for each period.

The briquette shall be prepared from a mixture of one part of cement to three parts of weight of dry standard sand; the proportion of water used shall be such that the mixture is thoroughly wetted, and there shall be no superfluous water when the briquettes are formed.

7 days (1 day in moist air, 6 days in water, 58°-64°F.) 150 lbs.

28 days (1 day in moist air, 27 days in water, 58°-64°F.) 250 lbs.

The increase from 7 to 28 days shall not be less than 20 per cent.

BERTRAM BLOUNT, JULY, 1908.

7 days (1 day in moist air, 6 days in water, 58°-64°F.) 200 lbs.

28 days (1 day in moist air, 27 days in water, 58°-64°F.) 300 lbs.

CANADIAN SOCIETY OF CIVIL ENGINEERS, MAY, 1903.

The briquettes are to be formed in suitable moulds. The sand and cement shall be thoroughly mixed dry, in the proportion of one of cement to three of sand, and then about 10 per cent. of their weight of water shall be added.

The sand for standard tests shall be clean quartz, crushed so that it passes through a 400 mesh sieve and is retained on a sieve of 900 meshes per sq. inch.

7 days (1 day in moist air, 6 days in water) 125 lbs.

29 days (1 day in moist air, 28 days in water) 200 lbs.

Sand and cement briquettes shall not show a decrease in tensile strength at the end of 28 days, or subsequently.

D. G. SOMERVILLE & CO., 1907.

Briquettes of cement and clean sharp sand, in proportions of 1 of cement to 3 of sand with 10 per cent. of water after 48 hours, must have the following maximum tensile strengths:—

7 days after gauging, at least 180 lbs. per sq. inch.

26 days after gauging, at least 260 lbs. per sq. inch.

FRENCH GOVERNMENT, JUNE, 1902.

Briquettes made of 1 part of cement to 3 of dry sand, by weight, gauged with fresh water shall show the following minimum strength, the mean of the best four out of six briquettes, being the accepted figure.

The sand used shall be composed of equal parts of grains of three sizes, separated by four sieves of perforated iron having holes of ½, 1, 1½ and 2 mm. in diameter.

Briquettes immersed in *sea-water* after 24 hours shall withstand:—

After 7 days, at least 6 kilos per sq. cm. (85 lbs. per sq. inch).

After 28 days, at least 12 kilos per sq. cm. (171 lbs. per sq. inch).

The strength developed shall also increase 20 kilos. per sq. cm. (28 lbs. per sq. inch) from the 7th to the 28th day.

Briquettes immersed in *fresh water,* after 24 hours shall withstand:—

After 7 days, at least 8 kilos per sq. cm. (114 lbs. per sq. inch).

After 28 days, at least 15 kilos per sq. cm. (213 lbs. per sq. inch).

The strength developed shall also increase 2 kilos per sq. cm. (28 lbs. per sq. inch) from the 7th to 28th day.

In both cases the Engineer can increase the above required tests of sand and cement mortar briquettes after 7 and after 28 days, after he has satisfied himself that the manufacturers are able to supply what he specifies.

GERMAN GOVERNMENT, FEBRUARY, 1902.

Slow-setting cement, when tested with 3 parts by weight of standard sand to 1 part of cement, must attain after 28 days (1 day in air and 27 days in water) a tensile strength of at least 16 kilograms per sq. cm. (227.5 lbs. per sq. inch). With quick-setting cements, the tensile strength at 28 days is generally less than that above mentioned. The time of set should, therefore, be stated when specifying the tensile strength required.

All test pieces must be tested immediately after being taken out of water. Since the speed at which the strain is applied has an influence on the result, in testing for tensile strength the increase of weight shall be at the rate of 100 grams (3.53 oz.) per second. The average of the ten best results shall be taken as the tensile strength developed.

ASSOC. OF GERMAN PORTLAND CEMENT MFGRS., FEBRUARY, 1908.

Slow-setting Portland Cement shall show at least 160 kilos per cm.^{2} (2275 lbs. per sq. inch) compressive strength when tested with 3 parts by weight of standard sand to 1 part of cement, after 28 days hardening (1 day in air and 27 days in water). The tensile strength shall be at least 16 kilos per cm.^{2} (227.5 lbs. per sq. inch).

With quick-setting cement, the tensile strength, after 28 days, is generally less than that above mentioned. The setting time should, therefore, be stated when specifying the tensile strength required.

To arrive at consistent results, sand of the same size of grain and of the same kind should be used in all cases. This normal sand is obtained by washing pure quartz sand as clean as possible, drying it, and passing it through a sieve of 60 holes per sq. cm. (387 per sq. inch) in order to separate the coarser particles; the sand thus obtained is again passed through a sieve of 120 holes per sq. cm. (775 per sq. inch), to free it from the finer particles. The thickness of the wire of the sieves should be 0.38 and 0.32 mm. (.015 and .013 inch) respectively.

Since all quartz sands do not always give the same results when similarly treated, it should be ascertained whether the normal sand employed will give results consistent with the normal sand supplied for testing purposes under the direction of the Committee of the German Cement Mfgrs. Association, and which is also used by the Royal Testing Station of Charlottenburg, Berlin.

AUSTRIAN ENG. & ARCH. SOC., 1907.

For the following minimum requirements the average of the 4 best results out of 6 briquettes tested, shall be the accepted tensile strength for each period.

In all cases the briquettes shall be prepared of a mixture of 1 part of cement and 3 of standard sand.

Slow- and medium-setting Cement:—

After 7 days (1 day in moist air, 6 days in water), 12 kilos cm.² (171 lbs. per sq. inch).

After 28 days (1 day in moist air, 27 days in water), 18 kilos cm.² (256 lbs. per sq. inch).

Quick-setting Cement:—

After 7 days (1 day in moist air, 6 days in water), 8 kilos per cm.² (114 lbs. per sq. inch).

After 28 days (1 day in moist air, 27 days in water), 18 kilos per cm.² (171 lbs. per sq. inch.)

SWISS FEDERAL TESTING STATION STANDARD, 1901.

For the following minimum requirements the average of the 4 best results, out of 6 briquettes tested, shall be the accepted tensile strength for each period.

The briquettes shall be prepared from a mixture of 1 part of cement and 3 of standard sand.

After 7 days (1 day in moist air, 6 days in *warm* water), 22 kilos per cm.² (313 lbs. per sq. inch).

After 28 days (1 day in moist air, 27 days in *cold* water), 22 kilos per cm.² (313 lbs. per sq. inch).

RUSSIAN MINISTERIAL REGULATIONS, 1905.

For the following minimum requirements, the average of the 4 best results, out of 6 briquettes tested, shall be the accepted tensile strength for each period.

In all cases the briquettes shall be prepared of a mixture of 1 part of cement and 4 of standard sand.

After 7 days (1 day in moist air, 6 days in water), 7 kilos per cm.² (100 lbs. per sq. inch).

After 28 days (1 day in moist air, 27 days in water), 10 kilos per cm.² (143 lbs. per sq. inch).

INTER. ASSOC. TEST. MAT. BRUSSELS, 1906.

Standard Sand.

(a) Standard cement mortars should be made with standard sand.

It has been ascertained by numerous experiments that quartz sands procured from different localities give very different results when used in tension tests, even when their particles are of known size, and even if their particles have almost the same appearance and possess practically the same composition.

It is therefore desirable that some sand should be agreed upon for international purposes, and that it should be screened with sieves constructed of perforated metal having holes of specified diameter.

Standard Cement and Lime Mortars.

(a) Standard hydraulic mortars used for testing purposes should be composed as follows: (1) 1:3 cement and hydraulic lime, 250 g. cement or lime mortars, 750 g. sand. (2) 1:5 hydraulic lime mortar only, 167 g. of lime, 835 g. of sand.

The mixtures should be gauged in a smooth vessel with a spatula having a rounded end.

It is desirable that experiments should be carried out in order to ascertain whether standard samples of cement mortar cannot be produced, suitable for submission to bending and to compression tests; the samples being either prepared mechanically with a consistency equal to that of natural soil, or gauged in a plastic state, and finally moulded into prisms.

11. COMPRESSIVE STRENGTH.

J. S. E. DE VESIAN, NOVEMBER, 1907.

Test blocks of 4 inch cube are required to stand the compressive strength of 600 lbs. per square inch at the age of 28 days.

GERMAN GOVERNMENT, FEBRUARY, 1902.

The crushing strength must be at least 160 kilograms per sq. cm. (2275 lbs. per sq. inch). The standard test of strength is the crushing test at 28 days, it being impossible to accurately determine the cementing power, when comparing different kinds of cement, in a shorter period of time. Thus, for instance, the strength of various samples of cement may be alike after 28 days, whereas there may be a material difference in the strength of the samples after only 7 days.

In testing for crushing strain, in order to get a uniform result, the pressure should always be exerted on the side surfaces of the cube, and not on the bottom and upper troweled surface. The average of the ten best results shall be taken as the crushing strength of the sample.

In order to insure the necessary uniformity in carrying out the tests, it is advisable to employ the apparatus and machines used at the Royal Testing Station at Charlottenburg, Berlin.

ASSOC. OF GERMAN PORTLAND CEMENT MFGRS., FEBRUARY, 1908.

The compression strength must be at least 200 kg. per sq. cm. (2,844 lbs. per sq. inch) by testing after 1 day in moist air, 6 days in water and 21 days in air of a temperature of from 15° to 30°C. (59° to 86°F.), the tensile strength shall be at least 20 kg. per sq. cm. (284 lbs. per sq. inch).

Compression tests may be made at an earlier time than after 1 day in moist air and 6 days in water when compressive strength shall be at least 120 kg. per sq. cm. (1,760 lbs. per sq. inch).

AUSTRIAN ENG. & ARCH. SOC., 1907.

For the following minimum requirements, the average of the 4 best results, out of 6 briquettes tested, shall be the accepted tensile strength for each period.

In all cases the briquettes shall be prepared of a mixture of 1 part of cement and 3 of standard sand.

Slow- and medium-setting cement, after 28 days (1 day in moist air and 27 days under water) shall have a compressive strength of 180 kilos per cm.^{2} (2560 lbs. per sq. inch).

Quick-setting cement, after 28 days (1 day in moist air and 27 days under water) shall have a compressive strength of 120 kilos per cm.^{2} (1707 lbs. per sq. inch).

SWISS FEDERAL TESTING STATION STANDARD, 1901.

For the following minimum requirements, the average of the 4 best results out of 6 briquettes tested, shall be the accepted tensile strength for each period.

The briquettes shall be prepared from a mixture of 1 part of cement and 3 of standard sand:—

After 7 days, (1 day in moist air, 6 days in *warm water*), 220 kilos cm.[2] (3130 lbs. per sq. inch).

After 28 days, (1 day in moist air, 27 days in *cold water*), 220 kilos cm.[2] (3130 lbs. per sq. inch).

INTER. ASSOC. TEST. MAT. BRUSSELS, 1906.

(a) The pressure tests are carried out with cube-shaped test pieces, each surface of which is 50 sq. cm.

(b) The test pieces should be made by machinery.

(c) The cubes should remain for at least 24 hours in the moulds. Five cubes should be crushed; but in case of disputes, ten must be tested.

(d) Compression tests are to be carried out at the same period of time after gauging as the tensile tests (Section 7, i), and should be performed on 5 cubes.

12. BLOWING TEST.

CANADIAN SOCIETY OF CIVIL ENGINEERS, MAY, 1903.

Mortar pats of neat cement thoroughly worked, shall be troweled upon carefully cleaned 5-inch by 2½-inch ground-glass plates. The pats shall be about ½ inch thick in the centre and worked off to sharp edges at the four sides. They shall be covered with a damp cloth and allowed to remain in the air until set, after which they shall be placed in vapor in a tank in which the water is heated to a temperature of 130°F. After remaining in the vapor 6 hours, including the time of setting in air, they shall be immersed in the hot water and allowed to remain there for 18 hours. After removal from the water the sample shall not be curled up, shall not have fine hair cracks, nor large expansion cracks, nor shall they be distorted. If separated from the glass, the sample shall break with a sharp, crisp ring.

13. **COOLNESS.**

D. G. SOMERVILLE & CO., 1907.

Cement should on no account be used when fresh, and should be spread out on delivery in thin layers and turned over at least once a week. It should then be subjected to the following test:—After mixing for 3 to 4 minutes with 22 per cent. of water there must not be more than 6°F. rise in temperature in one hour.

It is certainly more costly to air-slake the cement, but you thereby obtain almost complete immunity from after-expansion in the work.

APPENDIX NO. 3.

LISTS AND DESCRIPTION OF FOREIGN GOVERNMENT AND PRIVATE TESTING STATIONS, CONGRESSES, TECHNICAL INSTITUTIONS, ASSOCIATIONS, AND COMMITTEES, WHO HAVE ENDORSED REINFORCED CONCRETE AS A MATERIAL OF CONSTRUCTION OR WHO HAVE ADOPTED RESOLUTIONS, SPECIFICATIONS, OR RULES RELATING THERETO.

NOTE:—All references are here omitted to the Text of the adopted Specifications for Cement, Concrete, and the Metal used and the Rules for Reinforced Concrete Construction, because four subjects are discussed elsewhere and separately in this Report.

INTERNATIONAL.

List.

CONGRES INTERNATIONAL DES METHODES D'ESSAI DES MATERIAUX DE CONSTRUCTION. PARIS, 1900.

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

Methods for the Testing of Hydraulic Cements recommended by the IVth Congress held at Brussels, September 3-6, 1906.

INTERNATIONAL COMMISSION ON CEMENT.

Appointed by the International Association for Testing Materials.

INTERNATIONAL COMMISSION ON REINFORCED CONCRETE.

Appointed by the International Association for Testing Materials. Prof. F. Schüle, Chairman, Federal Polytechnic, Zurich, Switzerland.

INTERNATIONAL RAILWAY CONGRESS OF 1905.

INTERNATIONAL CONGRESSES OF ARCHITECTS OF 1906 and 1908.

INTERNATIONAL FIRE SERVICE CONGRESS OF 1906.

INTERNATIONAL.

Description.

CONGRES INTERNATIONAL DES METHODES D'ESSAI DES MATERIAUX DE CONSTRUCTION. PARIS, 1900.

The work accomplished at the Sessions of this Congress, which were held during the Paris Exposition of 1900, has been published in three volumes as follows: the subjects of Reinforced Concrete, Concrete and Cement occupied considerable time during the sessions.

TOME I.—Etudes générales.

I. — Etudes sur la constitution moléculaire des corps et leurs lois de déformation sous l'application des efforts.

II. — Historique des méthodes d'essai. Laboratoires et appareils d'essai.

TOME II.—Première partie (métaux).

I. — Essais mécaniques.

II. — Etudes des essais de divers métaux et de certaines pièces assemblées.

TOME III.—Deuxième partie (matériaux autres queles métaux).

Liste des membres du Congrès. Procès-verbaux des séances.

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

Methods for the Testing of Hydraulic Cements recommended by the IVth Congress held at Brussels, September 3-6, 1906.

At the IVth Congress of this Association, held at Brussels on September 3-6, 1906, Methods for testing Hydraulic Cements, proposed by the sub-committee were accepted in principle by the main Committee and examined and sanctioned by the Congress itself.

The features of these recommended Methods are quoted in this Report under Cement Specifications.

INTERNATIONAL COMMISSION ON HYDRAULIC CEMENTS. APPOINTED BY THE INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

At the 5th Congress of the International Association for Testing Materials to be held at Copenhagen, Denmark, in September, 1909, the following so called "Principal Questions" in reference to Hydraulic cements will take precedence in the discussions.

HYDRAULIC CEMENTS.

(g) Reinforced Concrete.
(h) Progress in the Methods of Testing (Cements).
(i) Cement in Sea Water.
(j) Constancy of Volume (of Cements).
(k) Tests (of Cement) by means of prisms and standard sand.
(l) Weathering Resistance of Building Stones.

In addition, the following "Technical Problems" relating to Cement, have been placed in the hands of Committees or Referees, with a request from the Council for Reports at the 5th Congress.

PROBLEM NO. 9.

On rapid methods for determining the strength of hydraulic cements. (Proposed at the Zürich Congress, 1895.)

PROBLEM NO. 10.

To digest and evaluate the resolutions of the conferences of 1884-1893, concerning the adhesive qualities of hydraulic cements. (Proposed at the Zürich Congress, 1895.)

PROBLEM NO. 11.

To establish methods for testing puzzolanas with the object of determining their value for mortars. (Proposed at the Zürich Congress, 1895.)

PROBLEM NO. 12.

Investigation on the behavior of cements as to time of setting. and on the best method for determining the beginning and the duration of the process of setting. (Proposed at the Zürich Congress, 1895, enlarged in conformity with the resolution of the Budapest Congress, 1901.)

PROBLEM NO. 30.

Determination of the simplest method for the separation of the finest particles in Portland cement by liquid and air process. (Proposed at the Budapest Congress, 1901.)

PROBLEM NO. 31.

On the behavior of cements in sea-water. (Proposed at the Budapest Congress.)

PROBLEM NO. 32.

On accelerated tests of the constancy of volume of cements. (Decision of the Zürich Congress, 1895.)

PROBLEM NO. 33.

On the influence of the proportion of water and sand on the strength of Roman and other cements. (Proposed at the Budapest Congress, 1901.)

PROBLEM NO. 42.

Uniform tests of hydraulic cements by prisms, and determination of a standard sand. (Proposed at the Brussels Congress, 1906.)

INTERNATIONAL COMMISSION ON REINFORCED CONCRETE APPOINTED BY THE INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

At the XVIth Meeting of the Council of the International Association for Testing Materials, held in Munich, February 11th and 12th, 1907, an "International Commission of Inquiry on Reinforced Concrete" was appointed.

The Chairman of this Commission, Prof. F. Schüle, of the Federal Polytechnic at Zürich, Switzerland, at a meeting in October, 1908, explained that the object of the Commission is to assemble and summarize the world's experience on Reinforced Concrete, and at least a Report of Progress will be made at the next (the fifth) Congress of the Association to be held in Copenhagen, Denmark, in September, 1909.

The Problem, assigned to this Commission, and known as "Problem No. 41" was proposed at the Brussels Congress of 1906 and the Programme of work announces the four following subjects:

A. Summary of Tests completed in different countries.
B. Summary of the Facts definitely established by these tests.
C. Summary of the Chief Causes of difference of opinion on questions relating to reinforced concrete.
D. Set of Standards for future tests.

At the Meeting in Bâle in November, 1908, the following memorandum was presented by the Chairman, Prof. Schüle:—

"The Application of reinforced concrete to all kinds of work in connection with engineering and architecture has caused quite a number of technical questions to be raised—some of them of a very complex character—as to the safety and life of structures of this material.

In its early days, reinforced concrete—comprising materials of such an utterly different character as iron and concrete—cannot be said to have been very favorably received by those who occupied themselves with the scientific aspects of building construction, and thus at the International Congress on the Testing of Materials, held at Budapest in 1901, reinforced concrete was but very casually mentioned in a short note by Monsieur Considère. Since that time, however, numerous buildings in reinforced concrete have been erected, and much experience has been gained in the different countries, and the scientific aspects of reinforced concrete have become matters of moment to all concerned.

It was in France that the initiative was taken of investigating reinforced concrete systematically. A French Commission of Inquiry was formed by a Ministerial Order of December, 1900, which undertook a series of experiments, and this investigation resulted in the Report of October 20, 1906, which contained instructions regarding the use of reinforced concrete pending further experience being gained. (See "Concrete," Vol. I., Nos. 5 and 6.)

Other countries also realized the importance of having some rules or recommendations upon which to base the calculation and execution of works in reinforced concrete, and the following method was generally adopted by the different nations concerned—namely: (1) Provisional Rules were set up by the most competent and experienced public officials or professional men conversant with the work; (2) National Commissions were created to pursue the studies and elucidate technical points. The expenses incurred by these technical commissions are either borne by the State or by funds subscribed by the industries concerned, or by both.

In Germany and in the United States the research work is being carried out on a vast scale, and large sums of money are expended on it. In fact, a majority of the testing laboratories all over the world, but especially in the United States and Germany, have occupied themselves for some years so actively with experiments in reinforced concrete, that one can say with truth that at no period has there been such a number of engineers working to progress a branch of civil engineering as is the case at present with reinforced concrete.

The International Congress of Testing Materials, held at Brussels in 1907, recognized the great international importance of reinforced concrete, and thus arose the constitution of the International Commission on Reinforced Concrete, the study of reinforced concrete on international lines.

Monsieur Considère, who, prior to his retiring from the official position he held in France, occupied the chair in this Commission, issued a memorandum to the members in which he proposed a number of questions to be dealt with, embracing all points relating to the constitution of reinforced concrete as distinct from its application. He proposed as a preliminary the preparation and consideration of:—

A. A summary of tests completed in different countries.

B. A summary of the facts definitely established by these tests.

C. A summary of the chief causes of difference of opinion on questions relating to reinforced concrete.

D. A set of standards for future tests.

There can be no doubt that this programme, if put into execution, would make a considerable difference in the science of reinforced concrete; but, as I mentioned in my memorandum when appointed to the chair, upon Monsieur Considère's resignation, the research work at present in train is not sufficiently advanced to permit of data being collated in time for the next International Congress on Testing Materials, to be held at Copenhagen next year, and we must limit our work to some preliminary matters for the present until we meet again at Copenhagen next year."

INTERNATIONAL RAILWAY CONGRESS OF 1905.

At the seventh session of the Railway Congress, under Subject IV "On the Question of Concrete and Embedded Metal," a Report was presented by W. Ast covering all Countries except Russia and America. J. F. Wallace submitted a Report on the experience in America.

These two Reports will be found in Vol. XIX for 1905, of the English Edition of the Bulletin of this Congress, pages 363-450 and pages 451-455 respectively.

INTERNATIONAL CONGRESSES OF ARCHITECTS, 1906 AND 1908.

At the SEVENTH International Congress of Architects, held in London in July, 1906, the following nine papers were presented dealing with Reinforced Concrete:

(1) **REINFORCED CONCRETE.**

"Communication from the Joint Reinforced Concrete Committee."

(2) **E. P. GOODRICH, Mem. Amer. Soc. C. E.**

"Reinforced Concrete and its Relation to Fire Protection."

(3) **PROF. LOUIS CLOGUET, Central Society of Architecture of Belgium.**
"The Employment of Reinforced Concrete in Architecture."

(4) **GASTON TRELAT, Paris.**
"Constructions in Steel and in Reinforced Concrete."

(5) **HENRY ADAMS, M. Inst. C. E.**
"Ferro-Concrete Construction."

(6) **A. von WIELEMANS, Vienna.**
"Reinforced Concrete Construction in Monumental Architecture."

(7) **A. AUGUSTIN REY, Paris.**
"Construction in Steel and in Reinforced Concrete."

(8) **PETER B. WIGHT, Chicago.**
"The use of Burned Clay Products in the Fire-Proofing of Buildings in the United States of America."

(9) **JOAQUIN BASSEGODA, Barcelona.**
"Constructions in Steel and in Reinforced Concrete."

After the discussion of these Papers, the following RESOLUTIONS were adopted:

"That this Congress considers it desirable that an inquiry should be made as to what failures have taken place in reinforced concrete buildings, and as to the causes of the failures."

"That this Congress is of the opinion that, where reinforced concrete is intended to be fire-resisting, the greatest possible care should be taken as to the nature of the aggregate and its size, and also as to the protection of the steel."

At the EIGHTH CONGRESS held at Vienna in May, 1908, a number of papers on Reinforced Concrete were read, chief among which was one by Prof. F. von Emberger, entitled "A Review of the Present Position of Reinforced Concrete Generally" and another by Launer of the Prussian Ministry of Public Works, Berlin, entitled "Accidents on Reinforced Concrete Work and Proposals for their Prevention."

The following Resolutions were adopted by the Congress.

"That public and municipal authorities should publish official impartial reports on building accidents, so that the true facts of such accidents, classified as far as possible according to the nature of the material, should be at the disposal of those technically interested."

Besides the papers there were many informal discussions and personal interchange of opinion and experience in reference to reinforced concrete, which showed an enthusiasm as to its practicability and economy.

INTERNATIONAL FIRE SERVICE CONGRESS, HELD AT MILAN IN 1906.

The subject of the Fire Resistance of Reinforced Concrete was discussed by the International Fire Service Congress held at Milan in 1906.

The following RESOLUTIONS were adopted on the subject of necessary safeguards to be observed in the use of Reinforced Concrete in buildings intended to be fire-resisting.

The resolutions have carried considerable weight as the Congress consisted of over 500 representatives of men interested in the protection of life and property from fire. There were representatives present from nearly every country, including the fire chiefs from the capital cities of France, Germany, Austria, and Italy. The text of the RESOLUTIONS is as follows:

"That the Congress considers that no reinforced concrete construction should be permissible in buildings intended to be fire-resisting, unless the aggregate be most carefully selected and applied in such a manner as to give substantial protection to all metal parts."

"That it is advisable where reinforced concrete is intended to be fire-resisting, that every portion of the metal rods or bars contained therein be covered by not less than 2 in. of concrete, the aggregate of which must be able to pass through a sieve having a mesh of no more than 1 in. diameter, and that Portland cement of great fineness only be used."

"That where feasible all external angles should be rounded."

"That any angle iron needed for mechanical protection should be held in position independently of the concrete."

GREAT BRITAIN.

List of Committees, Associations, Etc.

JOINT COMMITTEE ON REINFORCED CONCRETE.

Formed under the auspices of the Royal Institute of British Architects.

9 Conduit St., London, W.

SPECIAL COMMISSION ON CONCRETE AGGREGATES.

Formed by the Executive Board of the British Fire Prevention Committee.

THE CONCRETE INSTITUTE OF GREAT BRITAIN.

1 Waterloo Place, London, S. W.

INSTITUTION OF CIVIL ENGINEERS.

Committee on Reinforced Concrete appointed by the Council in January, 1909.

BRITISH GOVERNMENT DEPARTMENTS OFFICIAL ENDORSEMENT OF REINFORCED CONCRETE.

THE BRITISH FIRE PREVENTION COMMITTEE'S TESTS ON REINFORCED CONCRETE CONSTRUCTION.

1 Waterloo Place, London, S. W.

FIRE OFFICES COMMITTEE OF LONDON.

Rules of 1905.

"LOCAL GOVERNMENT BOARDS." RULES AT PRESENT MILITATE AGAINST THE USE OF REINFORCED CONCRETE FOR THE CONSTRUCTION OF BUILDINGS IN GREAT BRITAIN.

MOST BRITISH MUNICIPAL BUILDING LAWS AT PRESENT MILITATE AGAINST THE USE OF REINFORCED CONCRETE.

BRITISH ENGINEERING STANDARDS COMMITTEE ON CEMENT SPECIFICATIONS.

28 Victoria St., London, S. W.

BRITISH ENGINEERING STANDARDS COMMITTEE ON STRUCTURAL STEEL.

28 Victoria St., London, S. W.

LIST OF TESTING LABORATORIES.

CEMENT USER'S TESTING ASSOCIATION.

2 Victoria St., Westminster, London, S. W.

BERTRAM BLOUNT F. I. C.

76-78 York St., Westminster, London, S. W.

KIRKALDY TESTING AND EXPERIMENTING WORKS.

99 Southwark Street, London, S. E.

HENRY FAIJA & CO.

Portland Cement Testing Works and Chemical Laboratories, 41 Old Queen St., Westminster, London, S. W.

BURSTALL & MONKHOUSE.

14 Old Queen St., Westminster, London, S. W.

ASSOCIATION OF PORTLAND CEMENT MFGRS., LTD.

Chemical and Mechanical Laboratory at their Works. Office at Park House, Gravesend.

G. AND T. EARLE, LTD.

Wilmington Hull.

WM. CUBITT & CO.

Gray's Inn Road.

HARRY STANGER.

2 Broadway, Westminster, London, S. W.

NOTE :—There is no Official Laboratory in Great Britain devoted to the testing of or experimenting with Reinforced Concrete, Concrete or Cement nor even of any one Laboratory which enjoys Official support.

GREAT BRITAIN.

Description of Committees, Associations, Etc.

JOINT COMMITTEE ON REINFORCED CONCRETE FORMED UNDER THE AUSPICES OF THE ROYAL INSTITUTE OF BRITISH ARCHITECTS.

Early in 1906, the Royal Institute of British Architects of 9 Conduit St., Hanover Square, London, W., invited the co-operation of other English bodies in the formation of a Committee "to consider and report on reinforced concrete and to draw up regulations embodying the essential requirements for permanence and stability." This was the first independent inquiry on reinforced concrete inaugurated in Great Britain.

On the Committee finally appointed, were representatives, besides the Royal Institute of British Architects, of His Majesty's Admiralty, the War Office, the Institute of Builders, the District Surveyor's Association, and the Association of Municipal and County Engineers.

After many meetings and discussions, the Committee drew up a unanimous Report setting forth the conditions under which reinforced concrete should be used, and they found that under these conditions the work would be trustworthy, and that decay of the metal is not to be feared.

The Report was adopted at a General Meeting of the Royal Institute of British Architects, held on May 27, 1907.

The Report is regarded as provisional, and although it does not carry the official power to insist on the adoption of its recommendations, in British reinforced concrete construction, such as is the case with the Official Rules of Germany, France, and some other Continental Countries, it still, however, has exerted a strong favorable influence towards reinforced concrete in prominent British circles.

The chief features of the Report are quoted in the Discussion of the Specifications for Reinforced Concrete.

While the deliberations of the Committee were not made public, the following quotations embodying the views of the Council of their Science Standing Committee, and embodied in a letter dated Dec. 9, 1907, from the Secretary, W. J. Locke, to the first Commissioners of His Majesty's Office of Works, show that the Royal Institute of British Architects now strongly endorses Reinforced Concrete Construction.

"The Development of this type of construction from simple uses for parts of buildings to its employment to-day for complete structures of all sorts, road and railway bridges, sewers, water mains, reservoirs, jetties, piles, dock walls, coast protection, warehouses, and other buildings etc., by Governments, municipalities, railway and dock companies, and private owners, has been slowly built up step by step by practice and experience aided in later years by scientific research, which research in foreign countries has been largely undertaken by the initiative and at the expense of the State."

"It is sometimes thought that the metal may perish, but all experience shows that concrete is the best preservative for iron and steel known to us. A bar of iron or steel slightly rusty embedded in properly made concrete may be taken out after some months or after hundreds of years, brighter than when it was put in. Perhaps I may quote an instance—the experience of Mr. Somers Clarke, late Surveyor to St. Paul's Cathedral, who being anxious as to the condition of the great chain tie which binds the dome at its base, caused an opening to be made in the concrete in which it has been embedded for over two hundred years, and found the iron bright and perfect, notwithstanding the fears which had naturally been felt because of the percolation of water from the gallery over it. This is but one of many examples, showing not only that metal reinforcements and concrete have been used by architects for many years back, but that their confidence in the durability of concrete and metal in combination is justified.

"The many instances of the anchor chains of suspension bridges being embedded in concrete as a provision against their deterioration through the action of moisture, may also be cited as showing the reliance placed on concrete by engineers for the protection of steel from corrosion.

"There appears to us to be no more reason to doubt the durability of reinforced concrete in the walls, columns, floors, and roofs of buildings, and basement walls in damp situations, than in retaining walls, piled jetties, bridges, and other engineering structures.

"There is also every reason to believe that it is as durable as brickwork or masonry for tanks, reservoirs, and similar structures, resisting the pressure of water under moderate heads, even if there be a slight sweating of water through the concrete, providing the metal is carefully embedded and thoroughly surrounded with a concrete of a moderately wet consistency, and especially if the embedded metal has been washed over with a cement grout before being placed in it.

"A still more severe test is afforded by works in sea water or works in tidal waters, and by bridges, the piers and abutments of which are exposed to abrasion by running waters. Constructions such as these are more in the province of the engineer, but their behavior and the opinions practically shown by engineers in ever increasing the use of reinforced concrete are evidences of which we take account.

"The accidents and failures which have occurred in reinforced concrete works have not arisen from a want of durability, but have almost invariably taken place when the centres are struck, as, contrary to experience in other materials, the strength of concrete increases with age. Improper materials and imperfect design which produce failure after completion would equally produce failures in other materials.

"My council is of the opinion that works in reinforced concrete which comply with the requirements laid down in the report of the Committee appointed by this Institute are at least as durable as brick or stone buildings."

BRITISH SPECIAL COMMISSION ON CONCRETE AGGREGATES.

Formed by the Executive Board of the British Fire Prevention Committee.

Late in 1906, the Executive Board of the British Fire Prevention Committee, (of No. 1 Waterloo Place, Pall Mall, London, S. W.) formed, from among its leading members and the representatives of the public bodies who are subscribers to the Committee, a "Special Commission on Concrete Aggregates."

The object of this Commission is to investigate the subject of Concrete Aggregates, both as regards their resistance to fire, and their capability to withstand stresses, and also to elaborate specifications which will enable architects and engineers to obtain what they want to carry out their designs, with more uniformity than at present. They will not include the cement to be used, as the standardization of cement specifications is in charge of the "Engineering Standards Committee."

The Commission's work has been divided into two sections, in charge of two sub-Committees, one dealing with Specifications, and the other with research Work and Tests.

An abstract of the "Interim Report" of this Commission, presented in December, 1908, is as follows:—

SPECIFICATION OF MATERIALS FOR AGGREGATES.

"The divergency of views as to the correct description of the actual materials in use as aggregates has, however, led the Commission to the decision of publishing at this stage, with this Interim Report the Schedule A attached, comprising a series of Specifications for Artificial and Natural Materials for Aggregates frequently used in this Country for Concrete."

"The Specifications issued are for the following—namely:—

Artificial materials for aggregates.

(1). Coke breeze.
(2). Clinker.
(3). Blast furnace slag.
(4). Broken brick.
(5). (a). Gault clay burnt.
(b). Ordinary burnt clay ballast.
(c). Broken terra-cotta:—
(1). Porous.
(2). Dense.
(6). Natural ballast (gravel).

Natural materials for aggregates.

(7). Volcanic Rocks.
(a.) Basalts, traps, dense, lavas etc.
(b). Lavas and rocks of similar character.
(c). Pumice, etc.
(8). Crushed granite.
(9). Sandstones, limestones, quartzites, and rocks of a similar character.

"The Specifications may be deemed complete with the exception of (a) the percentage of sulphur allowable in certain of the artificial aggregates, (b) the weight limits for certain volcanic rocks, and (2) the porosity of certain clay products, which points can alone be decided after considerable further inquiry and test."

"The tests necessary prior to framing recommendations should be with concretes in which aggregates complying with the Specifications as now drafted alone will be used."

"The Specifications as they stand, even without any recommendations, should be found useful, and may lead to standardization in the description of aggregates."

"As to size to which aggregates should be used to fulfill different purposes, etc., these are also matters for which further research is still necessary prior to the recommendations being framed."

The following comprises the Schedule to the Report:—

ARTIFICIAL MATERIALS FOR AGGREGATES.

1. **Coke Breeze.**—Coke breeze for use as a concrete aggregate shall be entirely coke taken from the gas retort, coke oven, or special furnace. It shall be absolutely free from clinker, coal and all substances that will not float in water, and from any admixture of material taken from the retort furnace or water-pan below it, and from cinder, ash, or other admixture. The proportion of sulphur in coke breeze shall not be more than ...... per cent.

NOTE:—It was decided that the determination of the allowable amount of sulphur should be the subject of future consideration.

2. **Clinker.**—Clinker for use as a concrete aggregate shall be the thoroughly burnt and hard waste product of furnaces, free from dust, shale, or free lime, and not having more than .... per cent. of sulphur.

NOTE:—Pan breeze is included in this definition.

NOTE:—In this case, as in that of coke breeze, it was decided that the determination of the allowable amount of sulphur should be the subject of further consideration.

3. **Blast Furnace Slag.**—Blast furnace slag for use as a concrete aggregate to be obtained and selected from pig iron smelting furnaces (to the exclusion of basic slag), to be of porous quality, to be washed to remove dust and sulphur, to be without free lime, and not to contain more than .... per cent. of sulphur.

NOTE:—In this case also, it was decided that the allowable amount of sulphur should be the subject of further consideration.

4. **Broken Brick.**—Broken brick for use as a concrete aggregate shall be from well-burnt and perfectly sound and hard

clay bricks, such as London stock bricks, or bricks of equal quality, and shall be of the size specified and be free from old mortar, and from dust or particles that will pass through a sieve of ⅛ in. mesh.

5. (a) **Gault Clay Burnt.**—Burnt gault clay for use as a concrete aggregate shall be free from free lime and sulphur and from unburnt particles, and shall be thoroughly hard, so that pieces soaked in water for ...... hours shall not disintegrate.

NOTE:—It was decided that the Tests Sub-Committee should be asked to determine the length of time to be inserted in the clause.

5. (b) **Ordinary Burnt Clay Ballast.**—Ordinary burnt clay ballast for use as a concrete aggregate shall be free from free lime and sulphur and from unburnt particles, and shall be thoroughly hard, so that pieces soaked in water for .... hours shall not distintegrate.

NOTE:—It was decided that the Tests Sub-Committee should be asked determine the length of time to be inserted in the clause.

5. (c) **Broken Terra-Cotta.**—(1) Porous: Broken, porous terra-cotta for use as a concrete aggregate shall be (a) from clean and well-burnt earthenware, unglazed, which has been mixed before firing with some combustible material such as sawdust, so that after firing it is of a porous or cellular texture, or (b) from clean and well-burnt unglazed earthenware which is capable of absorbing at least ...... per cent. of its own weight of water. (2) Dense: Broken, dense terra-cotta for use as a concrete aggregate shall be from clean and well-burnt earthen or stone ware, unglazed, and shall be incapable of absorbing more than ...... per cent. of its own weight of water.

NOTE:—It was decided that the Tests Sub-Committee should be asked to determine the percentages to be inserted in these clauses.

NATURAL MATERIALS FOR AGGREGATES.

6. **Natural Ballast (Gravel).**—Natural ballast for use as a concrete aggregate shall be gravel from river beds, sea coasts or glacial deposits, washed, if necessary, to remove dirt, loam, earthy or saline matter, clay, and other foreign substances.

7. **Volcanic Rocks.**—All rock of volcanic origin for use as a concrete aggregate shall be entirely free from decomposed parts and must show no signs of expansion, disintegration, or dissolution after having been immersed in water for 72 hours.

Rocks of this nature may be divided into the following classes:

(a) Basalts, traps, dense lavas, etc., weighing not less than ......lbs. per cubic foot. These shall be dense, thoroughly vitrified, not scoriaceous, show a clean fracture when broken, be homogeneous and free from marked cellular structure.

(b) Lavas and rocks of similar character weighing not less than ......lbs. per cubic foot. These shall be hard and free from all soft or organic matter, but they will not be so hard, and will be more cellular than those of section (a).

(c) Pumice weighing not more than ...... lbs. per cubic foot. It shall be hard, free from all organic matter, soft dust or impurity, and show a bright silky structure when broken.

NOTE:—It was decided that the Tests Sub-Committee should be asked to determine the weights to be inserted in these clauses.

8. **Granite.**—Granite for use as a concrete aggregate shall be obtained from ...... (here insert name of quarry), and shall be reduced to the specified dimensions by crushing or breaking, and shall be close, hard, and of even texture; free from large crystals of feldspar, dirt, argillaceous or organic materials, all decomposed particles, and from dust that will pass through a 1/16 inch mesh.

9. **Sandstones, Limestones, Quartzites and Rocks of Similar Character.**—Rocks of these characters for use as concrete aggregates shall be dense, uniform, and homogeneous in structure and composition. They shall have small even grains and crystalline texture.* Fractures shall be clean and free from large flaws. The weight of the material shall not be less than 130 lbs. per cubic foot, nor its crushing strength less than 200 tons per square foot, and it shall not absorb more water than 8 per cent. of its weight after immersion for 24 hours. The aggregate after preparation shall be free from all dirt, decomposed rock, argillaceous and organic material.

* This is not intended to exclude Oolites otherwise suitable.

THE CONCRETE INSTITUTE.

As an evidence of the recent rapid advance in the introduction of Reinforced Concrete in Great Britain, the following quotation is made from the Constitution of "The Concrete Institute" formed early in 1908, by parties interested either professionally or industrially in Concrete or Reinforced Concrete.

The objects of the Institute are:—

(a) To advance the knowledge of concrete and reinforced concrete, and direct attention to the uses to which these materials can be best applied.

(b) To afford the means of communication between persons engaged in the designing, supervision, and execution of works in which concrete and reinforced concrete are employed (excluding all questions connected with wages and trade regulation).

(c). To arrange periodical meetings for the purpose of discussing practical and scientific subjects bearing upon the application of concrete and reinforced concrete, and to conduct such investigations and to issue such publications as may be deemed desirable.

The Institute consists of Members who have one or the other of the following qualifications:—

(a) Persons professionally or practically engaged in the application of concrete or reinforced concrete and the production of their constituents.

(b) Persons of scientific, technical or literary attainments specially connected with the application of concrete, reinforced concrete and their constituents.

There is also a roll of "Special Subscribers," comprising Public Authorities, Corporations, Public Companies and Firms, etc., desirous of assisting in the work of the Institute.

The Council of the Institute comprises a President, four Vice-Presidents, a Chairman of the Executive, a General Secretary, a Treasurer and twenty Members of Council. A proportion of the Council retires annually and the vacancies are filled by postal ballot.

Arrangements for meetings, the selection and publication of papers, and all technical matters, investigations, tests, questions of management, etc., are in the hands of the Council.

Papers dealing with the subjects engaging the attention of the Institute will be published under its auspices, and Members, "Honorary Members," and "Special Subscribers" are entitled to copies of these publications.

Arrangements will eventually be made for a reading room in connection with the offices, and a reference library will be formed there.

The first 100 Members and the first 25 "Special Subscribers" will be known as the Founders of the Institute.

The membership in February, 1909, had exceeded 500.

Up to March, 1909, three meetings of the Concrete Institute have been held at which important papers have been read and discussed.

INSTITUTION OF CIVIL ENGINEERS.

The Appointment, in January, 1909, of a Committee on Reinforced Concrete by the Council of the Institution of Civil Engineers, is a somewhat delayed, but nevertheless, an important evidence of the recognition in Great Britain of the importance of Reinforced Concrete Construction.

The Personnel of this Committee is not yet completed (March, 1909,) and hence no recommendations have yet been made by the Committee.

BRITISH GOVERNMENT DEPARTMENTS' OFFICIAL ENDORSEMENT OF REINFORCED CONCRETE.

Several of the Departments of the British Government have, in preference, adopted Reinforced Concrete Construction and have furthermore officially admitted its economy and value.

Parties in Great Britain interested in Reinforced Concrete, both professionally and industrially, look upon as a great endorsement the fact that early in 1907, it was decided to execute the extension of the General Post Office in London, in Reinforced Concrete.

During 1907, the representatives of three of the Government Departments have, in response to official inquiries, announced to the House of Commons, that they are satisfied with the results of the employment of Reinforced Concrete in the works under their direction, both as regards economy and efficiency.

His Majesty's Office of Works has officially admitted that the saving, by the use of Reinforced Concrete is 20 per cent.

Both the War Office and the Admiralty, have adopted Reinforced Concrete, in preference, in many important constructions, and they furthermore consented to act through representatives, on the important British Committees having the standardization of Specifications relating to Reinforced Concrete under consideration.

THE BRITISH FIRE PREVENTION COMMITTEE'S TESTS ON REINFORCED CONCRETE CONSTRUCTION.

This Committee was founded in 1897 and incorporated in 1899.

Its independent investigations have done more to establish standards of fire resistance, than that of similar bodies in other countries. In fact its Standards of Fire Resistance were adopted as "Universal Standards" by the International Fire Prevention Congress, London, 1903.

All its tests are carried out entirely independent of any financial interest, and its conclusions are received with confidence. The members of its Committee serve gratuitously; the expenses of the Committee are born by Subscribing members and by a scale of fees charged for the different kinds of tests.

The purpose of the tests undertaken by the Committee is to obtain reliable data, as to the exact fire resistance of the various materials and systems of construction used in building practice, and to give precise particulars regarding fire alarm, fire preventive or fire extinguishing Appliances.

The publications of the Committee to April, 1908, include eleven Fire Tests on Reinforced Concrete Foors and Partitions. A list of these, with prices, follows together with the "Red Books" giving the Standards of Fire Resistance and the Testing Arrangements, including many interesting illustrations of the Committee's Testing Station.

THE BRITISH FIRE PREVENTION COMMITTEE'S PUBLICATIONS RELATING TO:

(a) Methods and Standards for Fire Tests.

(b). Fire or Load Tests on Reinforced Concrete Construction.

The reference Numbers and Prices are quoted from a list of their "Red Books" issued in April, 1908, from the office of the Committee, No. 1, Waterloo Place, Pall Mall, London, S. W., England.

	Price
GENERAL.	
65. The Testing Arrangements of the British Fire Prevention Committee, London, 1902..	2/6
REPORTS.	
82. The Standards of Fire Resistance of the British Fire Prevention Committee, London, 1904..	2/6
JOURNAL.	
3. The Official Fire Tests of the British Fire Prevention Committee as conducted at the Committee's Testing Station, London, 1905	5/--
FIRE TESTS ON REINFORCED CONCRETE FLOORS.	
14. A Floor by the Expanded Metal Co., Ltd., London	1/--
78. A Floor of Concrete Beams, reinforced with iron rods, by Messrs. Visintini & Weingartner, Head Office, Döhlinger Hauptstr. 33, Vienna	2/6
106. A Floor of Reinforced Concrete, by E. Coignet, Paris and London................	2/6
109. A Floor by the New Expanded Metal Co., Ltd., London	2/6
112. A Floor of Reinforced Concrete, by Messrs. E. Coignet, Paris and London.............	2/6
114. A Floor of Reinforced Concrete, by the Patent Indented Steel Bar Co., Ltd., London	2/6
118. A Floor of Reinforced Brick & Concrete, on the "Eggert Girderless System" by Messrs. C. Simeons & Co., Ltd., London	2/6
119. A Floor of Reinforced Concrete, on the	

	Price
"Herbst Armocrete Tubular System" by W. Herbst (Berlin),—The Armoured Tubular Flooring Co., Ltd., London	2/6

LOAD TESTS ON REINFORCED CONCRETE FLOORS.

125. Three Floor Slabs of Reinforced Concrete on the "Herbst Armocrete Tubular System" by W. Herbst (Berlin),—The Armoured Tubular Flooring Co., Ltd., London........	2/6

PARTITIONS.

53. A Partition known as the "Cunnah-Wright Partition" by the Fireproof Partition Syndicate, Ltd., London—(now out of business)..	2/6
92. A Partition erected by the Adamant Co., Ltd., London & Birmingham..............	2/6
Total £.......	1.16/0

FIRE OFFICES COMMITTEE OF LONDON. RULES OF 1905.

The following quotation from their Rules of 1905, refers to Reinforced Concrete:

"Concrete may be composed of sand and gravel that will pass through a 3/4 in. mesh, or of the other materials mentioned in the Rule, but in any case the cement used must be Portland (equal to the British Standard Specification of December, 1904),* in the proportion of 6 cwt. of cement to each cubic yard of concrete.

All structural metal work must be embedded in solid concrete so that no part of any rod or bar shall be nearer the face of the concrete than double its diameter, such thickness of concrete must be in no case less than 1 in., but need not be more than 2 in."

"LOCAL GOVERNMENT BOARD" RULES AT PRESENT MILITATE AGAINST THE USE OF REINFORCED CONCRETE FOR THE CONSTRUCTION OF BUILDINGS IN GREAT BRITAIN.

This branch of the British Government Bureaus, controls the rate of interest, at which money shall be advanced, for the construction of Buildings.

The present rulings, retard the adoption of reinforced concrete

* Since superceded by Specification of 1907.

in Great Britain, because they base their rates on the arbitrary assumption that the life of reinforced concrete is only 50 per cent. of that of ordinary building materials, that is, they allow a loan period of 30 years on timber roof trusses and timber floors in one building, and only 15 years on a building with reinforced roof trusses or floors.

Numerous protests have been made during the past three years, and the continuance of the Board's attitude has created finally marked dissatisfaction from local authorities and their technical officials, such as County, District, City, Borough and Parish Councils, who, as they are dependent upon the funds raised by rates, are restricted by regulations which are supposed to safeguard the public interests.

It is explained that the Local Government Board particularly fear accident during construction, and prominent interests have suggested as a possible compromise, that the Board grant the loan on the 15 year basis, and settle upon the additional loan period after the completion of the structure.

It is stated that such has been the demand for the adoption of reinforced concrete on the part of Councils, who are desirous to carry out their works with due regard to economy, that, in spite of the restrictions above referred to, many buildings and works have recently been constructed in Great Britain out of reinforced concrete, out of the revenue, or even under the disadvantageous loan conditions above cited, and it is stated that the tendency to use reinforced concrete would certainly be increased if these Councils had a free hand.

As an example of the best recent independent protest against the present adverse rulings of the Local Government Board of Great Britain, the following is submitted:—

The Royal Institute of British Architects, in a letter to the first Commissioner of Works, dated Dec. 9, 1907, writes through their Secretary:

"Though innumerable buildings in England have parts, such as floors, roofs, and lintels, in reinforced concrete, comparatively few have been executed entirely in it, one reason being the difficulty of securing a good artistic result, and another reason that our building by-laws, which fix the thicknesses of walls in nearly all cities, towns, and urban districts, prescribe certain minimum thicknesses for concrete walls, and no reduction is allowed even if strengthened by steel reinforcements. Accordingly, there is no advantage gained by the use of reinforced concrete for walls, except in the case of railway and dock companies and Government departments not under control of local authorities. Such bodies have built and are building largely in reinforced concrete."

"My Council would call attention to this strange anomaly of public authorities, which employ an economical method of construction, and yet practically debar the private citizen from also using it under powers which are conferred for the protection of the public interest."

"My council are of the opinion that works in reinforced concrete which comply with the requirements laid down in the Report of the Committee, appointed by this Institute, are at least as durable as brick or stone buildings. They think that any rearrangement of the rates, as suggested in the proposal of the Local Government Board, which would limit the period of loans for reinforced concrete work to less than the period for brickwork would be a mistake, resulting in this country being largely debarred from the advantages of modern and more economic methods of construction employed, not only by foreign countries, but by bodies not requiring the consent of the Board or free from the control of building by-laws."

This was in response to a letter addressed to the Royal Institute on July 31, 1907, announcing that His Majesty's Office of Works had been informed that in the opinion of the "Local Government Board," buildings constructed in "ferro-concrete" are likely to prove less durable than those of bricks and mortar, and that that Board was rearranging accordingly the rates at which money is to be advanced for the erection of the "ferro-concrete" buildings.

Another protest was addressed in July, 1908, to the President of the Local Government Board by the Association of Municipal and County Engineers.

Owing to some question of bias among the personnel of the Local Government Board, this dignified protest was of no avail, so that the unjust discrimination against the loan period for reinforced Concrete Buildings in England still exists. A recent reference to this Subject states:—

"Plainly stated the position still is that a timber roof can be accorded a thirty years' loan period but a reinforced concrete roof only a period of fifteen years. Groins of red deal are similarly accorded double the loan period allowed to reinforced concrete groins. Further a local authority putting up the simplest reinforced concrete structure costing £1,000 is practically told by the Government that it must not expect it to last longer than fifteen years, whilst hundreds of thousands of pounds are being spent in reinforced concrete construction by the self-same Government where works of permanent value are intended."

MOST BRITISH MUNICIPAL BUILDING LAWS AT PRESENT MILITATE AGAINST THE USE OF REINFORCED CONCRETE.

In addition to the restriction placed upon the application of reinforced concrete to the construction of buildings, brought about by the "Local Government Board" and elsewhere referred to, it is also a fact that most of the Municipal British Building Laws, as at present framed, are a serious hindrance to the adaption of reinforced concrete construction in Great Britain.

Although the feeling in Great Britain to-day is becoming general, that State interference with the construction of Buildings should be limited to matters of health or Public safety, still at present, in all towns and cities in the British Islands, no buildings can be erected unless in conformance with certain local Rules, Codes or Acts, in most of which no account is taken of the fact that by the use of reinforced concrete the minimum thickness of external and party walls can be safely reduced. Furthermore there is at present, in general, no provision made for limiting the use or dimensions of reinforced concrete in any other parts of the buildings such as columns, floors, beams, roofs, etc.

This is an anomalous condition, because complete buildings have been erected in Great Britain for Railway and Dock companies and for Government Departments, which do not come under the control of the local building acts.

While in time this unjust discrimination will undoubtedly disappear, it is at present a serious hindrance in the adoption of reinforced concrete in Great Britain.

Two important municipalities have already Bills in Parliament which will probably lead to modifications in the present antiquated rules, and the London City Council will present a Bill in November, 1909, amending the existing Rules.

BRITISH ENGINEERING STANDARDS COMMITTEE ON CEMENT SPECIFICATIONS.

The formation of the Engineering Standards Committee dates from January, 1901. It now has the support of several bureaus of the British Government, as well as that of the following British Institutions who are also represented on the Main and Sub-Committees.

The Institution of Civil Engineers.
The Institution of Mechanical Engineers.
The Institution of Naval Architects.
The Iron and Steel Institute.
The Institution of Electrical Engineers.

The third Report on Work Accomplished,[1] issued by the Secretary, Mr. Leslie S. Robertson, M. Inst. C. E., shows the large number of subjects which have been, or are now under consideration, with a view of recommending standard requirements.

The Committee on *Cement* was appointed at a meeting of the Main Committee on March 27, 1903. Their first meeting was held on June 12, 1903, and after 12 meetings a "British Standard Specification for Portland Cement" was adopted on November 23, 1904, and approved by the Main Committee on December 8, 1904.

Since then the Cement Committee has been considering the question of making some stipulation as to Initial Setting Time, and experiments have been and are being carried out with a view to the inclusion of a Clause dealing with this point. The Committee are also making certain other investigations, the desirability of which has been brought to their notice, but pending the completion of these experiments they issued a Revised Specification which was approved by the Main Committee on June 6, 1907.[2]

The chief requirements of this Specification, published by permission of the Committee, will be found under the Discussion of Cement Specifications.

Although important Bureaus of the Government are represented on the Committee, the requirements of this Specification cannot be insisted upon in Concrete and Reinforced Concrete Constructions in Great Britain, such as is the case with the Official

[1] "Third Report on Work Accomplished, August, 1906, to July, 1907," London, September, 1907. Offices of the Engineering Standards Committee, No. 28 Victoria Street, London, S. W.

[2] British Standard Specification for Portland Cement, No. 12, Revised June, 1907. Offices of the Engineering Standards Committee, No. 28 Victoria Street, London, S. W. Price, postpaid, 2/8.

Specifications for Portland Cement issued in Germany, Austria, Hungary, Switzerland, Italy and France.

However, although not carrying the weight of official sanction, this Specification is now recognized as a Standard and very generally adopted, and was recommended, as is elsewhere stated, by the Joint Committee on Reinforced Concrete formed under the auspices of the Royal Institute of British Architects.

BRITISH ENGINEERING STANDARDS COMMITTEE ON STRUCTURAL STEEL.

The Sectional Committee on Bridges and General Building Construction was appointed by the Main Committee on July 19, 1901.

This Committee prepared a Standard Specification for Structural Steel for Bridges and General Building Construction. The draft of this Specification was submitted to the Science Standard Committee of the Royal Institute of British Architects and certain suggested modifications were incorporated. The Specification was then adopted by the Sectional Committee on May 23, 1906 and approved by the Main Committee at their meeting held on June 19, 1906.

The principal requirements of this Standard Specification are quoted, by permission of the Secretary, under the discussion of the Metal used for Reinforcement.

FRANCE.

List of Commissions, Etc.

COMMISSION DU CIMENT ARME.

Appointed in 1901 by the French Minister of Public Works.

COMMISSION DES METHODS D'ESSAI DES MATERIAUX DE CONSTRUCTION.

1895 and 1900.

MINISTERE DES TRAVAUX PUBLICS, Direction de la Navigation.

Paris.

List of Testing Laboratories.

LABORATOIRE DE L'ECOLE DES PONTS ET CHAUSSEES.

28 rue des Saints Péres, Paris.

LABORATOIRE DU CONSERVATOIRE NATIONAL DES ARTS ET METIERS.

292 rue Saint-Martin, Paris.

LABORATOIRE MUNICIPALE D'ESSAIS DES MATERIAUX.

rue Brezin, Paris.

LABORATOIRE DES PONTS ET CHAUSSEES.

President R. Feret.
Boulogne sur Mer.

LABORATOIRE DE LECAMPREDON.

(Analyses et essais des Ciments, etc.)
5 rue Drouot, Paris IX.

FRANCE.

Description of Commissions, Etc.

COMMISSION DU CIMENT ARME.

The French Government, through its minister of Public Works, appointed in 1901 a "Commission du Ciment Armé" to investigate the properties of Reinforced Concrete and prepare Regulations to govern its use in Government Contracts.

The personnel of the Commission was as follows:

Lorieux, Inspecteur-Général (Chairman).

Rèsal, Rabut, Bechmann, Considère, Harel de la Noe, Mesnager, } Ingenieures-en-chef Professeurs à l'Ecole des Ponts et Chaussées.

Boitel, State Engineer Officer.
Hartman, Artillery Officer.
Gautier, Architect.
Hermant, Architect.

Candlot, Coignet, Hennebique, } Specialists or Contractors.

After carrying out a comprehensive programme of research work and holding numerous meetings, the conclusions of the Commission were finally submitted to the Ministry in March, 1906, and referred by them for approval by the Conseil Général des Ponts at Chaussées who selected three of their members to examine the proposed rules.

This committee thoroughly inquired into every point, calling upon the leading members of the "Commission du Ciment Armé" to argue their cases personally, and hearing with deference the arguments of the minority of the Commission who had so strongly advocated the separation of the Instructions into two parts, Rules and an explanatory "Circular."

The actual reason why the Rules are officially termed "Instructions" is due to their being considered provisional.

The Rules were signed by the Ministry of Public Works on Oct. 20, 1906.

The full work of the Commission was published in 1907 as a Broché, entitled "Experiences, rapports et propositions. Instructions ministérielles relatives à l'emploi du beton armé (Ministére des Travaux Publics des Postes et Télégraphes)."

It forms a volume of 481 pages with figures, and 8 plates and is sold by Dunod & Pinat, 49 quai des Grands Augustins, Paris, at 27 francs 50.

The printed record of the work of the Commission is divisible under three heads.

1. The "Instructions" (Rules) for the Design of Structures in Reinforced Concrete.
2. Circular explaining the Instructions or Rules.
3. Report of the Commission appointed by the Conseil Général des Ponts et Chaussées.

A translation of the chief features of these Rules is embodied in this Report when discussing Specifications for Reinforced Concrete.

COMMISSION DES METHODS D'ESSAI DES MATERIAUX DE CONSTRUCTION 1895 AND 1900.

This Commission held two Sessions, one in 1895 and the second in 1900. The results of their deliberations form seven large volumes, in each of which the subject of Reinforced Concrete, Concrete or Cement is treated.

PREMIÈRE SESSION—1895.

TOME I.—Documents généraux.

TOME II.—Rapports particuliers de la Section A—Première série-métaux.

TOME III.—Rapports de la Section A. deuxieme série-métaux.

TOME IV.—Rapports particuliers de la Section B—matériaux d'agrégation des maconneries.

Le rapport général contient les rapports des deux sections ainsi que les conclusions qui ont été adoptées par la commission après discussion et lecture des rapports particuliers qui lui ont été communiqués.

Pour chaque nature de matériaux il est donné des conclusions qui sont en somme l'enoncé des meilleures méthodes à suivre pour les essais, les analyses, etc.

DEUXIÈME SESSION—1900.

TOME I.—Documents généraux.

TOME II.—Section A. Rapports particuliers.

TOME III.—Section B et A et B réunies. Rapports particuliers.

MINISTERE DES TRAVAUX PUBLICS.

This Department of the French Government, a branch of the "Direction de la Navigation," issued official Specifications for artificial Portland Cement in June, 1902.

The chief requirements of this Specification are given in the Discussion of Cement Specifications.

GERMANY.

List of the Scientific and Commercial Associations Devoted Entirely or Prominently to Reinforced Concrete, Concrete and Cement.

DEUTSCHER VEREIN FÜR TON-, ZEMENT- UND KALKINDUSTRIE, E. V.

Office: Tonindustrie Zeitung G.m.b.H., Dreysestrasse 4, Berlin, N. W. 21.

President: A. March, Charlottenburg bei Berlin.

German Society for the Clay, Cement and Lime Industries (incorporated).

VEREIN DEUTSCHER PORTLAND ZEMENT FABRIKANTEN, E. V.

Director: P. Siber, Secretary, Bredow bei Stettin.
President: Kommerzienrat F. Schott, Heidelberg.
The Association of German Portland Cement Manufacturers (incorporated).
Their Laboratory under direction of Dr. Fromm is located at Karlshorst.

DEUTSCHER BETON VEREIN (e. V.).

Office: Biebrich am Rhein.
President: Kommerzienrat Eugene Dyckerhoff.
The German Concrete Association (incorporated).
Publish an annual Bericht über die Jahresversammlung.

VEREIN DEUTSCHER EISENHÜTTENLEUTE.

Jacobistrasse 3-4, Düsseldorf.
Secretary: Herr Dr. Emil Schrödter.
German Society of Iron Manufacturers and Engineers.
Official Organ: Stahl und Eisen. A weekly Journal, edited by Dr. E. Schrödter, 5 Jacobistrasse, Düsseldorf. Volume for 1908 is No. 28. Price 30 marks per annum postpaid.

DEUTSCHER ARCHITEKTEN UND INGENIEUR VEREIN.

Hannover.
German Society of Architects and Engineers. (The President edits a bimonthly Journal.)

VEREIN DEUTSCHER INGENIEURE.

43 Charlottenstrasse, Berlin, N. W.
German Society of Engineers. (Publish a weekly Journal.)

ARCHITEKTEN VEREIN, BERLIN.

C. Heymanns Verlag, Berlin, W. 8.
Architectural Society of Berlin. (Publish a weekly Journal.)

DEUTSCHER BETON VEREIN IN VERBINDUNG MIT DEM DEUTSCHEN ARCHITEKTEN UND INGENIEUR VEREIN.

President: Prof. Dr. C. von Bach, K. Tech. Hochschule, Stuttgart.

The Joint Committee of the German Concrete Association (incorporated) and the Union of the German Architectural and Engineering Societies.

VERBAND DER MASSIVBAU- UND DECKENINDUSTRIE.

President: Kgl. Baurat Jaffe, Berlin, W.

(This Society has made special efforts to promote and popularize reinforced concrete construction.)

GERMANY.

List of the Government Testing Stations for Reinforced Concrete, Concrete and Cement Mostly in Connection with High Schools.

KÖNIGLICHES MATERIAL-PRÜFUNGSAMT DER KÖNIGLICH TECHNISCHEN HOCHSCHULE.

Gross-Lichterfelde-West bei Berlin.

Direktor Geh. Reg.-Rat Prof. Dr. Ing. h. c. A. Martens. (Also Prof. M. Gary.)

Station for testing materials at the Royal Technical High School at Gross-Lichterfelde-West near Berlin. (Issue a Journal in 6 to 8 parts annually.)

KÖNIGLICH SÄCHSISCHE TECHNISCHE HOCHSCHULE.

Abteilung: Mechanische technische Versuchsanstalt, Dresden.

Direktor Reg. Rat Prof H. v. Scheit.

The Mechanical Engineering Testing Station of the Royal Saxon Technical High School at Dresden. (Issue no separate Journal.)

KÖNIGLICH TECHNISCHE HOCHSCHULE.

Abteilung: Mechanisch technisches Laboratorium, München.

President: Prof. Dr. A. Föppl.

The Mechanical Engineering Laboratory of the Royal Technical High School at Munich. (Issue no separate Journal.)

MATERIALPRÜFUNGSANSTALT DER KÖNIGLICH TECHNISCHEN HOCHSCHULE.

Stuttgart.

Director: Königl. Baudirektor Prof. C. von Bach.

Station for testing Materials at the Royal Technical High School at Stuttgart.

The Reports of their Investigations are published in the "Zeitschrift des Vereins Deutscher Ingenieure."

PRÜFUNGSANSTALT FÜR BAUMATERIALIEN AN DEN TECHNISCHEN STAATSLEHRANSTALTEN.

Chemnitz, Schillerplatz.

President: Baurat Prof. A. Gottschaldt.

Testing Station for Building Materials of the Technical Government School. (Issue no separate Journal.)

GROSSHERZOGLICHE CHEMISCH-TECHNISCHE PRÜFUNGSANSTALT ABTEILUNG FUR BAUMATERIALPRÜFUNG.

Karlsruhe.

President: Geh. Hofrat Prof. Dr. Bunte.

Vice President: Prof. R. Maars.

Second Laboratory President: Dr. P. Eitner.

The Department for Testing Building Materials of the Grand Ducal Chemical Technical Testing Station. (Issue no separate Journal.)

PRÜFUNGSANSTALT FÜR BAUMATERIALIEN AN DER KÖNIGL. BAUGEWERKSCHULE.

Privatstr. 2, Dresden, N.

President: Prof. P. Kayser.

Testing Station for Building Materials of the Royal Architectural School.

The Reports of their Investigations are published in the "Zeitschrift Zivilingenieur."

HERZOGLICHE TECHNISCHE HOCHSCHULE.

Braunschweig.

Prof. M. Möller.

Ducal Technical High School.

Deliver a course of Lectures on Reinforced Concrete and have a Testing Laboratory. (Issue no separate Journal.)

GERMAN COMMISSION ON REINFORCED CONCRETE APPOINTED BY THE PRUSSIAN MINISTRY OF PUBLIC WORKS.

This important Commission was appointed in response to a memorial addressed to the Chancellor on April 24, 1905, by the Union of the German Architectural and Engineering Associations.

This Commission includes representatives of the German State Departments, the larger German States, the Material Testing Stations, the German Concrete Association, the Association of German Portland Cement Manufacturers, the Union of German Architectural and Engineering Associations, the Association of German Engineers and the Association of German Iron Masters.

GERMANY.

List of the Private Testing Stations for Reinforced Concrete, Concrete and Cement.

CHEMISCHES LABORATORIUM FÜR "TONINDUSTRIE VEREIN" UND LABORATORIUM DES VEREINS DEUTSCHER FABRIKEN FEUERFESTER PRODUKTE.

Dreysestrasse 4, Berlin, N. W. 21.

Prof. Dr. H. Seger, E. Cramer.

Chemical Laboratory for Companies connected with the Clay Industry and the Laboratory of the Society of the German Manufacturers of Refractory Materials.

LABORATORIUM FÜR ALLE CHEMISCHEN UND TECHNISCHEN UNTERSUCHUNGEN VON HYDRAULISCHEN BINDEMITTELN.

Ferdinand M. Meyer, Malstatt-Burbach, bei Saarbrucken.

CHEMISCH-TECHNISCHE PRÜFUNGSANSTALT.

Dr. C. Schoch, Courbierstr. 6, Berlin, W. 62.

CHEMISCH-TECHNISCHE VERSUCHSSTATION.

Dr. Hermann Passow, Blankenese, a.d. Elbe.

LABORATORIUM DES VEREINS DEUTSCHER PORTLAND-ZEMENT-FABRIKANTEN.

President, Dr. Fromm, Karlshorst.

CHEMISCH-TECHNISCHES LABORATORIUM FÜR HYDRAULISCHE BINDEMITTEL NEBST PRÜFUNGSANSTALT FÜR BAUMATERIALIEN.

Dr. Michaelis, Friedenstr. 19, Berlin, N. O.

Founded in 1872.

CHEMISCH-TECHNISCHE VERSUCHSTATION.

(Laboratorium des Vereins Eisenportlandzementwerke.)
Dr. Hermann Passow, Blankenese, a.d. Elbe.

GERMANY.

Description of the Committees, Associations, Etc.

The three long lists just preceding, giving the Scientific and Commercial Associations, etc., and the Government and the Private Testing Laboratories, are evidences of the characteristic thoroughness of the study which Germany has devoted and is still giving to all matters in relation to Reinforced Concrete.

Lack of space prevents including a detailed Description of the personnel and the special objects of each of these Associations, Committees, etc., but a general reference to those of most importance will be made.

The greater majority of the German Manufacturers of Portland Cement are now members of the "Association of German Portland Cement Manufacturers." This Association holds Annual Meetings at which Papers are read and discussed and prizes are offered to stimulate original research. It conducts its own testing Laboratory and its members are required to periodically submit samples of their Cement for test. The standing of the Association is evidenced by the following Declaration issued to the Trade.

A. The members of the Union of German Portland Cement Manufacturers undertake to bring into the market, under the denomination of "Portland Cement," only a product formed from a mixture of calcareous and argillaceous substances forming the principal ingredients, calcined to incipient vitrification, and reduced to a fine powder.

Any material produced by any other method than that stated above, or to which foreign bodies are added, either during or before calcination, will not be acknowledged by them as "Portland Cement," but rather, the sale of such products under the term "Portland Cement" will be considered as an imposition on the buyer.

This declaration has no reference to trifling additions made for regulating the setting of Portland Cement, which are allowed to the extent of 2 per cent.

B. Any member acting contrary to the obligation thus undertaken shall be excluded from the Association, and his expulsion made public.

C. The members, in giving this declaration, acknowledge the duty of the Committee of the Union to see that the obligations thus entered into, are strictly adhered to.

This Association has issued Standard Specifications for artificial Portland Cement, which compare favorably with those of the Prussian Government Specification as revised February 19, 1902, and still in force.

Through the co-operation of the Technical, Commercial and Official interests the chief requirements of the principal Specifications covering the Steel used in Germany for reinforcement, are uniform.

As far back as 1881, the Association of German Iron Masters adopted a Classification, and Requirements for Iron and Steel. They joined the Society of German Architects and Engineers in 1886 and adopted a Specification. In 1889 they elaborated and revised their own Classification of 1881.

In 1892 they joined the Society of German Architects and Engineers and the Society of German Engineers, in framing a revision of the Specification of 1886, which is still in force. The Iron Masters Association met independently immediately after, and revised their own Rules of 1889, printing them in Feb., 1893. These they again revised in March, 1901, and which edition, known as the "Rules for the Delivery of Iron and Steel," is still in force (Sept., 1908).

The current official Specification containing the requirements for Steel, was issued by the Prussian Government on November 25, 1891.

Thus by a co-operation of interests, the Portland Cement and the Metal used in Germany in reinforced concrete construction, is to-day governed by uniform specifications.

The Aggregates with which the Cement is mixed in making up the Concrete have also received the attention they deserve.

The German Concrete Association, founded on Dec. 5, 1898, has by its annual meetings and its co-operation with other interests done much to establish uniformity in requirements.

Through a Union of the German Architectural and Engineering Associations and their co-operation with the German Concrete Association, the Prussian Ministry was induced to appoint a "Commission on Reinforced Concrete," the results of whose deliberation will be of the utmost importance.

The "Union" and the Concrete Association first drafted and adopted in August, 1904, "Preliminary Rules for the Preparation, Erection and Testing of Reinforced Concrete Buildings. The Prussian Ministry had also issued on April 16, 1904, Official Regulations for the Employment of Reinforced Concrete Construction in Buildings."

The "Union" and the Concrete Association next presented a Memorial on April 24, 1905, to the Chancellor, which owing to the great interest which was being taken by the Prussian Government in Reinforced Concrete Constructions, led to the establishment by the Prussian Ministry of Public Works, of the above mentioned Commission on Reinforced Concrete and which is made up of representatives of the German State Departments, the larger German States, the Material Testing Stations, the German Concrete Association, the Association of German Portland Cement Manufacturers, the Union of German Architectural and Engineering Associations, the Association of German Engineers, and the Association of German Iron-Masters.

The principal task of this Commission is to prepare, on the basis of extensive scientific experiments, regulations for reinforced concrete work over all Germany, in order to prevent the recurrence of the numerous accidents which have occurred in the construction of reinforced concrete works, especially floors, by unskillful persons. For such experiments the sum of £22,500 has been provided for the years 1907-1911 by the German and Prussian Governments, and the Concrete, Cement, Engineers' and Ironmasters' Associations. The first series of experiments comprise the adhesion of concrete and steel, taking into account the influence of the amount of water used in mixing, the nature of the surface of the steel, the best mode of provision against shear, the protection of columns, the behavior of reinforced concrete in peat and sea-water, the action of electricity, the fireproof character of reinforced concrete, etc.

These experiments are being carried out in the German experimental stations, attention being given to the results gained from investigations in previous years. The completion of the work of the Commission will be a landmark in the history of concrete and reinforced concrete in Germany.

The work of this Commission has so far resulted in a Revision, under date of May 24, 1907, of the Official Prussian Regulations for Reinforced Concrete Construction.

AUSTRIA.

MECHANISCHE VERSUCHSANSTALT DER KAISERLICH KÖNIGLICHEN TECHNISCHEN HOCHSCHULE.

Lemberg. (Galizien).
Prof. Fiedler.
Prof. Dr. von Thullie.
Mechanical Testing Station of the Imperial Royal Technical High School.

OESTERREICHER INGENIEUR- UND ARCHITEKTEN-VEREIN.

Wien.
Austrian Society of Engineers and Architects, Vienna. (Publish a weekly Journal.)

ALLGEMEINER INGENIEUR VEREIN.

Wien.
Universal Engineering Society, Vienna. (Issue a bimonthly Journal.)

PRÜFUNGSANSTALT FÜR BAUMATERIALIEN AN DER I STADT-GEWERBESCHULE.

Wien, I.
Schellinggasse 13.
President: Baurat Prof. A. Hanisch.
Testing Station for Building Materials of the First City Architectural School of Vienna.

STÄDTISCHE MATERIAL PRÜFUNGSSTATION.

Wien, I.
Rathous.
President: Bauinspector A. Greil.
City Testing Station for Materials of Vienna.

VERSUCHSANSTALT FÜR BAU- UND MASCHINENMATERIAL DES K. K. TECHNISCHEN GEWERBE-MUSEUMS.

Wien, IX.
Währingerstrasse 59.
Testing Station for Building Materials and Machinery of the Imperial Royal Technical Industrial Museum.

OESTERREICHISCHER BETON HANDELS-VEREIN.

Vienna.
The Austrian Concrete Trade Association, formed about 1907.

SWITZERLAND.

SCHWEIZERISCHER INGENIEUR- UND ARCHITEKTEN VEREIN.

Zürich.
The Swiss Society of Engineers and Architects.

EIDGENOSSENSCHAFTLICHE MATERIALPRÜFUNGSANSTALT AM SCHWEIZERISCHEN POLYTECHNIKUM.

Zürich.
Prof. F. Schüle.
The Station for the Testing of Materials of the Federal Polytechnic at Zürich.

ANSTALT ZUR PRÜFUNG VON BAUMATERIALIEN AM SCHWEIZERISCHEN POLYTECHNIKUM.

Zürich.
The Station for the Testing of Building Materials of the Swiss Polytechnic, Zürich.
Their Reports are published yearly in the "Mitteilungen der Anstalt zur Prüfung usw," published by Meyer & Ziller, Zürich.

HUNGARY.

THE HUNGARIAN SOCIETY OF ENGINEERS AND ARCHITECTS.

Budapest.

ITALY.

ASSOCIATION ITALIENNE POUR L'ETUDE DES MATERIAUX DE CONSTRUCTION.

Laboratorio per experienze sui materiali da construzione.
Direktor Prof. C. Guidi. Torino. Castillo del Valentino.

SPAIN.

LABORATOIRE D'ETUDES ET D'ESSAIS DES MATÉRIAUX DE CONSTRUCTION.

Lisbon.

Direktor I. da P. Castanheira das Neves.

HOLLAND.

PROEFSTATION VOOR BOUWMATERIALLEN EN BUREAU VOOR CHEMISCH ONDERZOEK KONING & BIENFAIT.

Amsterdam, Da Costakade 104.

DENMARK.

PRÜFUNGSANTALT FÜR BAUMATERIALIEN DER KÖNIGL. TECHNISCHEN HOCHSCHULE.

Copenhagen.

President: Prof. H. J. Hannover.

F. L. SMIDTH & CO. TECHN. BUREAU.

Bau und Lieferung sämtlicher Maschinen für die Zementfabrikation, Kalkbrennereien und Mörtelfabriken.

APPENDIX NO. 4.

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Schweizerischer Ingenieur- und Architeken- Verein. Provisorische Normen für Projektierung, Ausführung und Kontrolle von Bauten in armiertem Beton, nebst einem erläuternden Berichte von Prof. Schüle. Zürich, August, 1903. (Gratis).

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Scriba, E. Moderne Decken und Gewölbe. Eine Sammlung mustergültiger Ausführungen. Mit 27 Tabellen und mit einem erläuterndem Bericht. 1906. M.8.00.

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Spitzer. Berechnung der Moniergewölbe. Mit 14 Abbildungen und 3 Tafeln. 1896. M.2.80.

Stampfbeton. Leitsätze für die Vorbereitung, Ausführung und Prüfung von Bauten aus. 1905. M.0.50.

Stern, O. Das Problem der Pfahlbelastung. 1908. M.7.00.

Thullie, Max R. von. Versuche mit exzentrisch belasteten betoneisernen Säulen. Berlin, 1909. M.6.00.

Tolkmitt, G. Leitfaden für das Entwerfen und die Berechnung gewölbter Brücken. Zweite Auflage von A. Laskus. Mit 37 Abbildungen. 1902. M.6.00.

Tormin, R. Kalk, Gips, Zement; Ihre Bedeutung und Anwendung zu baulichen, gewerblichen & landw. Zwecken. 4 Auflage. Leipzig, 1905. M.3.00.

Turley, Er. Beziehungen zwischen Spannungen und Abmessungen von Eisenbetonquerschnitten. Berlin, 1905. M.1.00.

Turley, Er. . Anleitung zur stat. Berechnung armierter Betonkonstruktionen unter Zugrundelegung des Systems Hennebique. Leipzig, 1902. M.1.00.

Turley, Er. Der Eisenbeton. Formeln, Tabellen & Grundsätze zum Gebrauch für die Berechnung von Eisenbeton-Bauausführungen berechnet und zusammengestellt. Berlin, 1906. M.2.50.

Unger. Entwickelung der Zementforschung. 1904. M.2.00.

Unna. Bestimmung rationeller Mörtelmischung, unter Zugrundelegung der Festigkeit, Dichtigkeit & Kosten des Mörtels. Köln, 1903. M.2.00.

Waldegg, v. Kalkbrennerei & Zementfabrikat. 5 Auflage. 1903. M.10.00.

Waldegg, v. Ziegel- und Röhrenbrennerei. 5 Auflage. 1901. M.20.00.

Wayss'schen Rohrzellen, Die. Die Wayss'schen Rohrzellen und ihre Fabrikation; die Wayss'schen Rohrzellendecken; Tabellen zur Bestimmung der Abmessungen. 1907. Beide Hefte, M.4.00.

Wayss & Freitag. Der Betonbau, seine Anwendung und Theorie. Mit 227 Abbildungen. 2 Auflage. 1906. M.6.50.

Weder, R. Leitfaden des Eisenbetonbaues. Für Baugewerk & Tiefbauschulen. Mit 213 Textabbildungen. 1906. M.5.00.

Weese, Rgbmstr. Zahlentafeln für Platten, Balken und Plattenbalken aus Eisenbeton, zusammengestellt in Uebereinstimmung mit den ministerialen Bestimmungen vom 24 Mai, 1907, aus den Leitsätzen des Deutschen Beton-Vereins. Teil I and II. 1908. M.14.00.

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Weiske, P. Dr. Ing. Die Berechnung von Betoneisenbauten. 1907. M.1.50.

Zement- & Beton- Adressbuch Deutschlands. Ausgabe, 1908. Berlin. M.8.00.

Zimmerman. Rechentafel nebst Sammlung häufig gebrauchter Zahlenwerte. 5 Auflage. 1907. M.5.00.

Zipkes, S. Kontinuierl. Balkenbrücken aus Eisenbeton in Theorie & Ausführung. Mit 80 Abbildungen & 2 Tafeln. Zürich, 1907. M.4.50.

Zipkes, S. Scher- & Schubfestigkeit des Eisenbetons. 1906. M.0.80.

Zschokke, B. and Moser, Dr. R. Resultate der technologischen Untersuchung der schweizerischen Tone. Mitt. der Edig. Materialpfgsanst. Zürich, II Heft. Zürich, 1907.

Zwick, H. Hydraulischer Kalk & Portland-zement. 2 Auflage. Mit 50 Abbildungen. Wien, 1892. M.5.30.

Journals or Periodicals Devoted Entirely or Prominently to Reinforced Concrete, Concrete and Cement.

INTERNATIONAL.

Proceedings of the International Association for Testing Materials. Edited by General Secretary, 50 Nordbahnstr., Vienna, Austria. Published at irregular intervals in an English, French and German edition. No. 1, May, 1908, price 12c; No. 2, May, 1908, price 12c; No. 3, Dec., 1908, 24c. Published by E. & F. N. Spon, 57 Haymarket, London, and 123 Liberty St., New York.

ENGLAND.

Concrete and Constructional Engineering. A bi-monthly journal for engineers, architects and surveyors, contractors and builders, and all workers in cement, concrete, reinforced concrete, and constructional steel. Vol. I., March, 1906 to Jan., 1907, inclusive. Vol. II., March, 1907, to Jan., 1908, inclusive. Vol. III., March, 1908, to Jan., 1909, inclusive. Offices, 57 Moorgate St., London, E. C. Subscription, £0.7/6 per annum, postpaid.

The Concrete Institute. As elsewhere referred to, more in detail, this Institute was formed early in 1908, by parties interested either professionally or industrially in concrete or reinforced concrete, and its list of officers and charter members is ample evidence of the present interest taken in England in reinforced concrete construction.

The Builders' Journal and Architectural Engineer. Published every Wednesday at Caxton House, Westminster, London, S. W. Subscription, 17/4 per annum, postpaid. They publish every three weeks supplements devoted to "Concrete and Steel" and to "Fire-Resisting Construction."

Specification, with which is incorporated the municipal engineers' specification for architects, surveyors and engineers when specifying, and for all interested in building. Issued annually (No. 11, 1908-9). Published by "The Builders' Journal and Architectural Engineer," Caxton House, Westminster, S. W. Price, 3/6d. Special chapter entitled "Concretor," No. 11, 1908, pp. 175-226.

Bulletin of the International Railway Congress of 1905. (English edition). Vol. XIX, 1905. "On the question of concrete and embedded metal (Subject IV. for discussion at the 7th session of the Railway Congress)." Report No. 2 (all countries except America and Russia) by W. Ast. pp. 363-450. Report No. 3 (America), J. F. Wallace. pp. 451-545.

The Following Journals Frequently Publish Important Articles on Reinforced Concrete:

Building News. Published weekly by the "Strand Newspaper Co., Ltd.," Clements House, Strand, London, W. C. Subscription, £1.6/- postpaid. Reinforced concrete occupies, regularly, a considerable space in their reading and advertising columns.

The Builder. A journal for the architect, engineer, operative and artist. (Established in 1842). Published every Friday at No. 4 Catherine St., London, W. C. Subscription 26/- per annum, postpaid. Reinforced concrete occupies, regularly, a considerable space in their reading and advertising columns.

The Engineer. Published weekly at No. 33, Norfolk St.. Strand. London, W. C. (Established in 1856). Subscription. £1.16/- per annum, postpaid. (During 1907 this leading engineering periodical contained 17 articles on reinforced concrete).

Engineering. Published weekly at No. 35-36 Bedford St., Strand. London, W. C. Subscription £1.16/- per annum, postpaid. (During 1907, this leading engineering periodical contained 14 articles on reinforced concrete).

Journals Devoted Entirely or Prominently to Cement, Concrete and Reinforced Concrete.

UNITED STATES.

Cement and Engineering News. Monthly. Volume for 1908 is 20. William Seafert, publisher, 22 Fifth Avenue, Chicago. Subscription, $2.00.

Cement Age. A magazine devoted to the uses of cement. Monthly. Volumes for 1908 are 6 and 7. Cement Age Company, 225 Fifth Ave., New York. Subscription, $1.50.

Cement. A journal of advancement, engineering, architecture, concrete-steel construction and fire-proofing. Monthly. Volume for 1908 is 5. Progress Publishing Company, 13 Park Row, New York. Subscription, $1.

Cement Era. Devoted to cement, concrete, and related machinery. Monthly. Volume for 1909 is 7. The Cement Era Pub. Co., 141 Fifth Ave., Chicago. Subscription, $1.00.

Concrete. Monthly. Volume for 1908 is 8. Newberry Bldg., Detroit, Mich. Subscription, $1.00.

Concrete Age. Monthly. Volume for 1909 is 8. Atlanta, Georgia. Subscription, $1.00.

Concrete Engineering. For engineers, architects and contractors. Monthly. Volume for 1909 is 4. Caxton Bldg., Cleveland, Ohio. Subscription, $1.00.

Concrete Review. A guide to the intelligent and proper use of concrete. Monthly. Volume for 1908 is 3. Association of American Portland Cement Mnfrs., Land Title Bldg., Phila., Pa. Subscription, $0.50.

Proceedings of National Association of Cement Users. Yearly. Volume for 1908 is 4. George C. Wright, Secy., Harrison Bldg., Phila., Pa. Subscription, $3.00.

Journals Frequently Publishing Articles on Cement, Concrete and Reinforced Concrete.

Engineering-Contracting. A weekly "Methods and Cost" journal for civil engineers and contractors. Volumes for 1908 are 29 and 30. Myron C. Clark Publishing Company, 355 Dearborn St., Chicago. Subscription, $2.00.

Engineering News. A weekly journal of civil, mechanical, mining and electrical engineering. Volumes for 1908 are 59 and 60. Engineering News Publishing Co., 220 Broadway, New York. Subscription, $5.00.

Engineering Record, Building Record and Sanitary Engineer. Weekly. Volumes for 1908 are 57 and 58. McGraw Publishing Company, 239 West 39th Street, New York. Subscription, $3.00.

Manufacturers' Record. A weekly Southern industrial railroad and financial newspaper. Volumes for 1908 are 53 and 54. Manufacturers' Record Publishing Company, Baltimore, Maryland. Subscription, $4.00.

Municipal Engineering. A monthly magazine devoted to the improvement of cities, concrete construction, paving, sewerage, water works, street lighting, parks, garbage disposal, bridges. Volumes for 1908 are 34 and 35. Municipal Engineering Company, 1 Broadway, New York. Subscription, $2.00.

Proceedings, American Society for Testing Materials, Affiliated with the International Association for Testing Materials. Yearly. Volume for 1908 is 8. Edgar Marburg, Secy., University of Pennsylvania, Philadelphia, Pa.

Rock Products. Devoted to concrete and manufactured building materials. Monthly. Volumes for 1908 are 7 and 8. The Francis Publishing Company, 355 Dearborn St., Chicago. Subscription, $1.00.

Insurance Engineering. Volumes for 1908 are 15 and 16. 120 Liberty Street, New York. Subscription, $3.00.

The Contractor. Semi-monthly. Volume for 1908 is 10. 188 E. Madison Street, Chicago. Subscription, $1.00.

Journals Occasionally Publishing Articles on Cement, Concrete and Reinforced Concrete.

Cassier's Magazine. An engineering monthly. Volumes for 1908 are 33 and 34. The Cassier Magazine Company, 12 West 31st Street, New York. Subscription, $3.00.

Electric Railway Journal. A consolidation of Street Railway Journal and Electric Railway Review. Weekly. Volumes for 1908 are 31 and 32. McGraw Publishing Company, 239 West 39th Street, New York. Subscription, $3.00.

Journal of the Association of Engineering Societies. Monthly. Volumes for 1908 are 40 and 41. Fred Brooks, Secy., 31 Milk Street, Boston, Mass. Subscription, $3.00.

Journal of the Western Society of Engineers. Papers, discussions, abstracts, proceedings. Bi-monthly. Volume for 1908 is 13. J. H. Warder, Secy., 1735 Monadnock Block, Chicago, Ill. Subscription, $3.00.

Proceedings of the Engineers' Club of Philadelphia. Quarterly. Volume for 1908 is 25. H. G. Perring, Secy., 1317 Spruce Street, Philadelphia, Pa. Subscription, $2.00.

Railroad Age Gazette. A consolidation of the Railroad Gazette and the Railway Age. Weekly. Volumes for 1908 are 44 and 45. 83 Fulton Street, New York. Subscription, $5.00.

Scientific American. Weekly. Volumes for 1908 are 98 and 99. Munn & Company, 361 Broadway, New York. Subscription, $3.00.

The Engineering Digest. Monthly. Volume for 1908 is 4. The Technical Literature Company, 220 Broadway, New York. Subscription, $2.00.

The Engineering Magazine. Specially devoted to the interests of engineers, superintendents, and managers. Monthly. Volumes for 1908 are 35 and 36. 140 Nassau Street, New York. Subscription, $3.00.

The Iron Age. Weekly. Volumes for 1908 are 81 and 82. David Williams Company, 14 Park Place, New York. Subscription, $5.00.

The Municipal Journal and Engineer. Weekly. Volume for 1908 is 25. Swetland Publishing Company, 231 West 39th Street, New York. Subscription, $3.00.

The Railway and Engineering Review. Weekly. Volume for 1908 is 48. 1305 Manhattan Bldg., Chicago, Ill. Subscription, $4.00.

Transactions, American Society of Civil Engineers. Semi-yearly. Volumes for 1908 are 60 and 61. Charles Warren Hunt, Secy., 220 West 57th Street, New York. Subscription, $10.00.

Transactions of the Canadian Society of Civil Engineers. Semi-yearly. Volume for 1908 is 22. Clement H. McLeod, Secy., 413 Dorchester Street, West, Montreal, Quebec, Canada.

University of Illinois Engineering Experiment Station Bulletin. Irregular. Bulletins for 1908, Nos. 21 to 26, inclusive. Urbana, Illinois.

FRANCE.

Le Ciment. Son emploi et ses applications nouvelles en France et à l'étranger. Organe officiel de la Chambre Syndicale des Fabricants de Ciment Portland. Rédacteur en Chef, Mr. N. de Tédesco, 20 rue Turgot, à

Paris. (Mensuel). Abonnements, France, 1 an, 15 fr. Union postale, 20 fr. Tomes I à XIII, 1896 à ce jour. Cette publication est consacrée spécialement aux questions se rapportant, tant à la fabrication du ciment qu'à son emploi dans les constructions. Un compte-rendu des périodiques français et étrangers. Un tableau des exportations et importations de chaux et ciments; une partie bibliographique; des renseignements commerciaux; avis d'adjudications, etc. peuvent être également consultés dans ce périodique.

Le Béton Armé. Publication spécialement destinée à renseigner sur les travaux exécutés par le système Hennebique. Renferme néanmoins quelques articles d'intérêt général se rapportant au ciment armé. Organe des agents et concessionnaires du système Hennebique, 1 rue Danton, Paris. Abonnements, France, 1 an, 20 francs, Union postale, 25 fr. (mensuel). Tomes I à XI, 1898 à ce jour.

The Following Journals Frequently Publish Important Articles on Reinforced Concrete.

L'Architecture. Journal hebdomadaire de la Société Central des Architectes Français, 51 rue des Écoles, Paris. Abonnements, France, 25 fr. Union postale, 30 francs. Tomes I à XXI, 1888 à ce jour. Renferme des descriptions de maisons et immeubles particuliers exécutés en France. Une partie spéciale mentionne les différents concours publics qui sont ouverts pour des questions se rapportant à l'architecture et un supplément donne, chaque semaine, le cours des matériaux de construction, tableaux des prix des divers matériaux, fers, aciers, tôles, bois, vitrerie, peinture, etc.

Compte-Rendu des Séances de l'Académie des Sciences. (Hebdomadaire). Gauthier-Villars, Éditeur, 55 quai des Grands Augustins, Paris. Abbonnements, France, 30 francs, Union postale, 44 francs. Tomes I à CXLVI, 1835 à ce jour. Compte-rendu hebdomadaire des séances rédigé par M. M. les Secrétaires perpétuels. Ce compte-rendu se compose des extraits des travaux des Membres de l'Académie et de l'analyse des mémoires ou notes présentés par des savants étrangers à l'Académie.

Memoires et Compte-rendu des Travaux de la Société des Ingénieurs Civils de France. 19 rue Blanche, Paris. (Mensuel). Abonnements, France, 36 fr., étranger, 40 francs. Tomes I à LXXXIX, 1848 à ce jour. Comprend les procès-verbaux des séances bi-mensuelles de la Société et les mémoirs in extenso des communications présentées en séance. Une chronique très savante est depuis 1880 jointe au Bulletin qui contient en outre une partie bibliographique.

Revue du Génie Militaire. (Mensuelle). Berger-Levraut, Editeur, 5 rue des Beaux-Arts, Paris. Abonnements, France, 25 francs, étranger, 27 francs. Tomes I à XXXV, 1887 à ce jour. Independamment des questions militaires qui sont plus spécialement traitées dans cette Revue, il est aussi publié des mémoires et articles se rapportant au Génie Civil en général. Les questions de constructions et de travaux publics y ont aussi leur places. On trouve en outre dans cette Revue une bibliographie et des documents officiels et administratifs de l'Administration de la Guerre.

Études Professionelles. (Bâtiment et travaux publics). (Mensuelles). 4bis rue Saint-Martin, Paris. Abonnements, 8 francs. Tomes I à III, 1906 à ce jour. Cette publication traite plus spécialement les questions économiques et sociales se rapportant au bâtiment et aux travaux publics en France at à l'étranger telles qu'adjudications, organisations du travail, syndicalisme, accidents du travail, retraites ouvrières, etc. Une chronique, rédigée dans le même ordre d'idées, existe dans ces études.

Nouvelles Annales de la Construction. 15 rue des Saints-Pères. (Mensuelles). Abonnements, France, 15 fr., étranger, 20 francs. Tomes I à LIV, 1855 à ce jour. Fondées en 1855 par Oppermann, Ingénieur des Ponts et Chaussées ; Gérant actuel, M. Ch. Béranger, Éditeur, ancien élèvé de l'École Polytechique. Renferme principalement des articles se rapportant aux constructions métalliques et à l'architecture ; publie assez fréquemment des articles sur le ciment armé. Une revue technologique existe dans cette publication ou se trouvent également traitées des questions, de jurisprudence. Un supplement public sous le titre "informations" donne des renseignements intéressant les industriels en général.

Revue Industrielle. 17 boulevard de la Madeleine, Paris. Abonnements, France, 25 francs, Union postale, 30 francs. Tomes I à XXXIX, 1870 à ce jour. Revue générale avec classement par nature des différentes questions intéressant le Genie Civil. Un bulletin commercial avec cours des différents métaux, une bibliographie et une liste des brevets délivrés sont joints à ce périodique.

Annales des Ponts et Chaussées. Chez Bernard, 1 rue de Médicis. Paris (partie technique, paraissant tous les deux mois). Abonnements, France 35 francs, étranger, 36 francs. 175 volumes, 1831 à ce jour. Recueil de memoires et documents relatifs à l'art des constructions et au service de l'ingénieur. Une partie bibliographique et un compte, rendu par nature des questions traitées dans les différents pèriodiques techniques français et rétangers sont annexés à ces annaes.

Annales des Travaux Publics de Belgique. Bruxelles, Goemaere Éditeur, 21 rue de la Limite. Dépôt pour la France chez Dunod et Pinat, 49 quai des Grands Augustins. (Paraissant tous les deux mois). Abonnements, étranger, 18 fr. 50. 66ème année, 1843 à ce jour. Organe official de l'Administration des Ponts et Chaussées de Belgique, de la Société Belge des Ingénieurs et des Industriels, de l'Association Internationale Permanente des Congrès de Navigation. Cette publication très importante renferme des mémoires techniques sur un grand nombre de questions principalement sur les travaux publics et les constructions civiles et publie en outre, en les classant par pays, les faits intéressants qui se produisent dans chacun d'eux. La plupart des articles de cette chronique sont de véritadles mémoires. Également dans cette publication une partie réservée à la bibliographie.

Revue des Matériaux de Construction et de Travaux Publics. 148 boulevard Magenta, Paris. (Mensuelle). Abonnements, 1 an, France, 20 fr., étranger, 25 francs. Tomes I à III, 1905 à ce jour. Cette revue qui e l'organe officiel du syndicat général des céramistes et des matériaux de construction traite plus spécialement de la fabrication et des applications diverses des différents matériaux employés dans les construction de toutes sortes.

Ciment, Chaux, Plâtre. 64 rue de la Chaussée d'Antin (bi-mensuel, illustré). Abonnements, France, 10 fr., Union postale, 12 francs. (Ce doit être la première année).

La Construction Moderne. 13 rue Bonaparte, Paris. (Hebdomadaire). Abonnements, France, 30 fr., étranger, 35 fr. Tomes I à XXIII, 1885 à ce jour. Art. Théorie appliquèe, pratique. Traite presque exclusivement des questions d'architecture avec planches détaillées et plans d'ensemble, l'emploi du ciment armé dans l'architecture est assez fréquemment traité dans cette publication.

Journal Technique et Industriel. 9 rue Laffitte, Paris (bi-mensuel, illustré). Abonnements, France, 20 fr., Union postale, 24 francs. Tomes I à IV, 1903 à ce jour. Rédigé par un comité ingenieurs et d'écrivians scientifiques, traite des questions se rapportant au Génie Civil. Parmi celles traitées il y a lieu de citer les travaux publics, les constructions civiles, métalliques, l'architecture, etc. Des informations diverses et une chronique scientifique sont insérées dans ce journal.

Le Génie Civil. 6 Chaussée d'Antin, Paris (hebdomadaire illustré). Abonnements, France, 36 francs, étranger, 45 francs. Tomes I à LIII, 1880 à ce jour. Revue générale des industries françaises et étrangéres. Les questions principales qui sont traitées sont les suivantes: travaux publics, agriculture, architecture, hygiène, économe, politique, sciences, arts, etc. Un compte-rendu sommaire des séances des sociétés savantes et industrielles, ainsi qu'une partie bibliographique sont annexés à ce périodique.

Bulletin de la Société d'Encouragement Pour l'Industrie Nationale. (Mensuel). 44 rue de Rennes, Paris. Abonnements, France et Union postale, 63 francs. Tomes I à CX, 1801 à ce jour. Organe de la Société d'Encouragement pour l'Industrie Nationale, publié sous la Direction des Secrétaires de la Société. Renferme les procès-verbaux des séances de la Société et les mémoires in-extenso publiés après le rapport des différentes sections auxquelles chacun d'eux se rapporte. Le nombre de ces comités est de 6.

GERMANY AND AUSTRIA-HUNGARY.

Beton und Eisen. An International Journal for Concrete and Reinforced Concrete construction. Edited by Dr. F. v. Emperger at Vienna and published monthly by Wilhelm Ernst & Sohn, 90 Wilhelmstrasse, Berlin, W. Subscription, 20 marks per annum. Vol. I-VII, 1902-1908.

Zement und Beton. An illustrated Journal for Cement and Concrete Construction. Published bi-monthly at No. 4 Dreysestrasse, Berlin, N. W. 21. Subscription, 12 marks per annum. Vol. I-VII, 1902-1908.

Tonindustrie Zeitung. Devoted to the interests of Cement, Concrete, etc. Published tri-weekly by the Seger & Cremer's Chemische Laboratorium für Tonindustrie und Tonindustrie Zeitung at 4 Dreysestrasse, Berlin, N. W. 21. Subscription, 20 marks per annum. Vol. of 1908 is No. 32.

Beton Zeitung. An Illustrated Journal for the Concrete, Decoration Stone and Cement Industries. The organ for the German Decorative Stone and Concrete Society inc. (Halle a. S.) Published bi-monthly at Halle an der Saale. Subscription, 14 marks per annum. Vol. for 1908 is No. 1.

The Following Journals Frequently Publish Important Articles on Reinforced Concrete:

Annalen für Gewerbe und Bauwesen. Edited by F. C. Glaser, civil engineer and patent attorney. Published bi-monthly at 80 Lindenstr., Berlin, S. W. Subscription, 24 marks per annum. Vol. for 1908 is No. 62.

Baugewerbe, Das. Organ für die wirtschaftlichen Interessen der Baugewerbe von Becher. Published weekly by "Das Baugewerbe" G. m. b. H., Berlin. Subscription, 6 marks per annum.

Baugewerkszeitung. Published at Berlin by v. Felisch. Vol. of 1908 is No. 104. Subscription, 12 marks per annum.

Bauhütte, Deutsche. Zeitschrift für alle Zweige der Baukunst. Published by C. R. Vincentz, Hannover. Volume for 1908 is No. 52.

Bauindustrie Zeitung, Wiener. Published by Volkswirtsch. Verlag, A. Dorn, Wien. Published weekly. Subscription, 28.60 marks per annum.

Bauingenieur Zeitung...Published bi-monthly by "Das Baugewerbe" G m. b. H., Berlin. Subscription, 8 marks per annum.

Baumaterialienmarkt. Published weekly by Richard Möckel, Leipzig. Subscription, 6 marks per annum.

Baumeister, Der. A monthly journal on architecture construction. Published by Die Schriftleitung (Der Baumeister). Steglitzerstr. 53, Berlin, W. 35. Subscription, 24 marks per annum. Volume for 1908 is No. 6.

Für Bauplatz und Werkstatt. Mitteilungen der Beratungsstelle für das Baugewerbe. 2 Hefte. Published by Carl Grüninger, Stuttgart. Subscription, 3.50 per annum.

Baupolizeiliche Mitteilungen. Prints the new rules or ordinances issued by the cities of Germany in reference to building construction. Published monthly by W. Ernst & Sohn, Berlin. Subscription, 8 marks per annum. Vol. 1-V, 1904-1908.

Bauzeitung, Deutsche. Journal of the Union of German Architectural Engineering Societies. Published bi-weekly at 105 Königgrätzerstrasse, Berlin, S. W. 11. Subscription, 24 marks per annum. Volume of 1908 is No. 42.

Bauzeitung, Süddeutsche. Journal for most of the principal architectural and engineering societies of South Germany. Published bi-weekly at Munich, 18 Paul Heysestrasse. Subscription, 20 marks per annum. Volume of 1908 is No. 18.

Bauzeitung für Württemberg, Baden, Hessen, Elsass-Lothringen. Wochenschrift f. Architektur, Baugewerbe and Ingenieurwesen. Published by Deutsche Verlagsanstalt, Stuttgart. Published weekly. Subscription, 8 marks per annum.

Berliner Architecturwelt. Illustrated journal on the building art. Published monthly, by Ernst Wasmuth A .G., 35 Markgrafenstr., Berlin, W. 8. Subscription, 24 marks per annum. Volume for 1908 is No. 11.

Stahl und Eisen. Zeitschrift für Verein deutscher Eisenhüttenleute, Düsseldorf.

Zeitschrift für Das Baugewerbe. Journal for building construction. Published bi-monthly by Carl Marhold, Halle a. d. Saale. Subscription, 10 marks per annum. Volume for 1908 is 52.

Zeitschrift, Bautechnische. Published weekly by G. D. W. Callwey, München. Edited by Dr. W. Bode. Subscription, 9.60 marks per annum.

Zeitschrift Zivilingenieur. Dresden.

Zentralblatt für das deutsche Baugewerbe. Published weekly at Berlin, S. W. 11. Subscription, 9 marks per annum.

Zentralblatt der Bauverwaltung. Herausgegeben im Ministerium der öffentlichen Arbeiten. Published bi-weekly by Wilhelm Ernst & Sohn, Berlin, W. 66 Wilhelmstr. Subscription, 17.20 marks per annum. Volume for 1908 is No. 43, XXVII Jahrgang.

Zeitschrift für Architectur & Ingenieurwesen. Published by the president of the Architectural & Engineers' Society of Hannover. Published in 6 parts yearly by the Society at Hannover. Subscription, 22.60 marks per annum. Volume for 1908 is 53.

Zeitschrift für Bauwesen. Published by Ministerium der Öffentlichen Arbeiten. Usually monthly by Wilhelm Ernst & Sohn at 90 Wilhemstr., Berlin. Subscription, 36 marks per annum. Volume of 1908 is No. 58.

Zeitschrift des Oesterreichischen Ingenieur- & Architecten- Vereins. Journal of the Austrian Society of Engineers & Architects. Published weekly at I. Eschenbachgasse, Wien. Subscription, krs. 34 per annum. Volume for 1908 is 60.

Zeitschrift des Vereins Deutscher Eisenbahnverwaltungen. Journal of the Society of German Railway Directors. Published bi-weekly at 28 Köthenerstrasse, Berlin, W. 9. Subscription, 22 marks per annum. Volume for 1908 is 48.

Zeitschrift des Vereins Deutscher Ingenieure. Transactions of the German Society of Engineers. Published weekly at 43 Charlottenstrasse, Berlin, N. W. Subscription, 40 marks per annum. Volume for 1908 is 52.

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