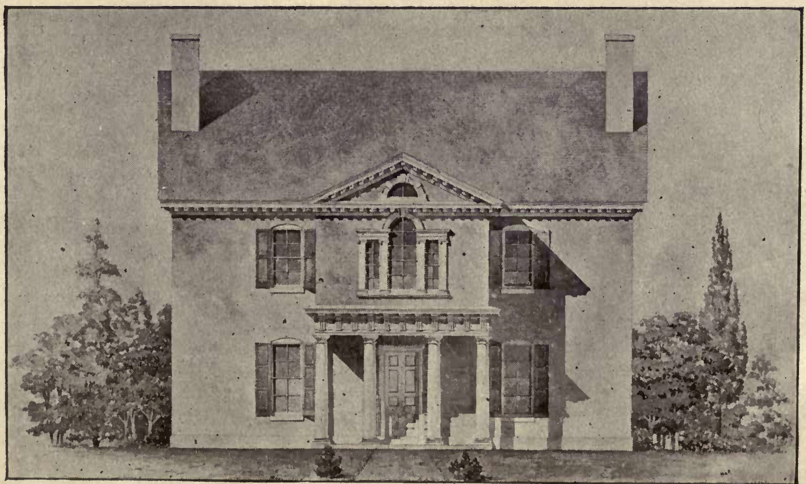

Measured Drawing by
Wm. W. Emmart.

OLD CARROLL HOUSE,
CARROLL PARK, BALTIMORE.

ARCHITECT'S

HAND-BOOK

ON

CEMENTS

BY

ADDISON H. CLARKE

PUBLISHED BY
WILLIAM WIRT CLARKE & SON
BALTIMORE
1899

PRICE ONE DOLLAR.

TO

MR. ROBERT D. ANDREWS,

Architect;

BOSTON, MASS.,

This little book is dedicated, with the earnest desire that his highest hopes may be realized, for the general advancement throughout our land of higher technical education in the mechanical arts.

THE AUTHOR.

PRESS OF
THE FRIEDENWALD CO.
BALTIMORE, MD.

FORE WORD.

Being frequently requested to give information regarding the proper use of cements, we determined to collect in convenient form some of the specifications and formulæ for mixing and using cements as recommended by the leading authorities and to whom we are indebted for the information contained in these pages.

Under Bibliography will be found a list of some of the principal authorities on cement.

We desire to take this opportunity to express our appreciation and gratitude for the many kindnesses extended by our friends. We are especially indebted to Mr. Christian Devries, President of the National Bank of Baltimore, our depositary since our firm started in business in 1867; also to Messrs. Emil Thiele of New York; The Newark Lime and Cement Manufacturing Co.; The Calumet Fire Clay Co., of Calumet, Ohio; and I. C. Johnson & Co., of Gateshead-on-Tyne, England.

A BIT OF HISTORY.

1. There is no more important material employed in building construction than that which binds the several parts into one harmonious whole.

Various materials have been used as a bond for masonry construction, as mud, asphaltum and lime.

The last is the basis of hydraulic cement, which crystallizes or hardens by the application of water.

The necessary materials to form the proper chemical combination are liberally supplied by Nature, and may be found near at hand, only for the seeking.

It is now proposed to manufacture cement from sewerage sludge of large cities.

The use of **lime** as a mortar may be traced back for many hundred years.

Volcanic slags, such as Pozzuolana or Tras, have long been employed in Italy and along the shores of the Mediterranean Sea.

2. **Improved cements** are a comparatively modern discovery.

In 1756, A. D., John Smeaton found the need of having a hydraulic cement in building the famous Eddystone lighthouse.

He discovered that limestone was rendered hydraulic by the admixture of a certain proportion of clay.

Vicat, the eminent French engineer, made a similar discovery in 1818.

3. Parker's "Roman" Cement was discovered in 1796 on the Island of Sheppey, off the coast of England.

4. J. C. Aspdin, a brickmaker of Leeds, England, took out a patent in 1824 for what

he called Portland Cement, owing to its resemblance to the Oölithic limestone quarried on the "Isle of Portland."

Westminster Abbey is built of this Portland stone.

5. In this country, Natural Rock Cement was discovered during the building of the Erie Canal in 1820.

A somewhat similar cement was discovered in 1823 near the town of Rosendale, in Ulster County, New York, during the building of the Delaware and Hudson Canal.

Since then, wonderful improvements have been made in the art of cement-making, so that the Natural Rock Cements are proving ample, for most purposes, in building construction of the greatest magnitude.

6. It was not until about 1848 that Portland Cement began to be well known in the London market.

At this time Mr. I. C. Johnson discovered the proper mixture of lime and clay to make Portland Cement, and also the secret of burning the clinker to the point of vitrifaction to secure the best results.

German progress was slow, and it was not until 1852 that Portland Cement began to be made in that country at Stettin.

English Cements were imported into France for a number of years previous to 1870. In that year French Cements began to displace foreign brands until, in 1885, the latter cements were almost wholly excluded from French territory.

The United States was late in the field.

Portland Cement began to be imported into this country about the year 1865, when it was sold at from $5 to $7 per barrel.

It was not until the year 1872 that Mr. David O. Saylor succeeded in producing a

Portland Cement from argillaceous limestone that he had been employing in the manufacture of Natural Rock Cement.

The United States Government report for 1895 shows that this country held the fourth place among the countries producing Portland Cement, as follows:

OUTPUT IN BARRELS.

1.	Germany	13,500,000
2.	England	8,300,000
3.	France	3,000,000
4.	United States	2,300,000
5.	Belgium	2,250,000
6.	Russia	2,200,000
7.	Austria	1,000,000
8.	Italy	800,000
9.	Norway and Sweden	500,000
10.	Denmark	400,000
11.	All other countries (estimated)	1,000,000
	Total	35,250,000

The remarkable progress now being made by the United States in the production of Portland Cement will no doubt ere long place this country at the head of the list of manufacturers of this very important building material.

CLASSIFICATION OF MORTARS.

7. The base of all hydraulic mortars is lime or the oxide of the metal calcium.

Quick Lime contains 44 parts by weight of carbon dioxide and 56 parts oxide of calcium.

In slaking, 18 parts by weight of water unite with the 56 parts quick lime, making 74 parts calcic hydrate.

The process of slaking is greatly facilitated by the heat that is generated.

8. **Hydraulic Lime** contains 10 to 25 per cent. alumina. It differs from Quick Lime in that it hardens in water.

It is either argillaceous or siliceous.

9. **Natural Rock Cement** is made from argillo-magnesian limestones, the principal ingredients being carbonates of lime and magnesia, silica and alumina.

The quarried rock is burnt in kilns, crushed and ground to powder.

This cement differs from Portland Cement in chemical analysis, specific gravity and temperature at which it is burnt.

The **specific gravity** should be 2.80, and about 70 per cent. of the whole composition of the cement should consist of the carbonates of lime and magnesia, with 10 per cent. alumina and oxide of iron.

The **color** of Natural Rock Cement is due to varying proportions of oxide of iron and impurities, but bears little reation to its ultimate strength.

This cement weighs about seven-eighths as much as the Portland brands, sets in about one-tenth the time and attains about half the ultimate strength.

It is more coarsely ground than Portland Cement, is less uniform in chemical composition, contains a larger percentage of magnesia and carbonate of lime, is more affected by exposure to dampness, freezing and long storage than the latter cement.

10. **Pozzuolana Cement** is so called from the town of Pozzuoli in Italy, near which place the ingredients were found from which it was first made.

This cement is rendered hydraulic by the addition of proper proportion of quick lime.

11. **Artificial Pozzuolana** is made from blast furnace slag, and also from the scales from the blacksmith's forge.

12. Tarras or Tras is a volcanic substance quite similar to Pozzuolana and found at Andernach, in the department of the Rhine.

13. **Roman Cement,** originally called Parker's Cement, is made from nodules found in certain places on the English coast.

The composition of this rock is quite similar to that from which Natural Rock Cement is made in the United States.

This cement is of a rich, dark brown color, is very quick setting, almost as much so as gypsum or calcined plaster.

The strength is about equal to that of Natural Rock Cement.

14. **Portland Cement** is made from various substances in combination, which in themselves possess no hydraulic energy, then burning to the melting point and grinding the clinker to an impalpable powder, having an average chemical analysis as follows:

Carbonate of Lime	62	per cent.
Silica	22	"
Alumina	8	"
Oxide of Iron	3	"
Magnesia	2	"
Sulphuric Acid	1¾	"

There are four groups:

1st. Those cements composed of a mixture of chalk and clay.

2d. Those composed of marl and clay.

3d. Those composed of argillaceous limestone rock of more or less hardness.

4th. A combination of any materials such as blast-furnace slag and lime, and having the above chemical analysis and possessing similar general characteristics.

This cement possesses great specific gravity, density and resisting power.

15. **Magnesian Cement** is made from finely-ground magnesium oxide and a solution of magnesium chloride.

It sets quickly, becoming harder than marble, having an estimated crushing resistance of over 1000 tons per square foot, being by far the strongest cement known.

It is too expensive for ordinary commercial purposes.

The color is white.

16. **Silica-Portland Cement** is a mixture of Portland Cement and siliceous sand ground together into an impalpable powder in a tube mill.

A mixture of equal parts of sand and cement possesses about the same strength as ordinary Portland Cement alone.

A mixture of Silica Cement (1 part cement and 1 part sand) with 3 parts unground sand has the same composition as 1 part cement and 7 parts sand, but possessing the strength of a mixture of 1 part cement and 3 parts sand.

The process was first introduced into Denmark and has the special advantage of making mortar that is impermeable to moisture and able to resist the action of the elements.

Mr. Lytthans Peterson, of Copenhagen, used Silica-Cement Mortar (1C : 12S), 2 unground sand, containing 38 parts sand to 1 part cement, with satisfactory results for concrete building construction exposed to severe freezing.

17. **Slag Cement.**—After many and repeated failures in this country and Europe, it has finally been demonstrated without doubt that it is possible to make a safe and durable hydraulic cement from the slag from blast furnaces.

This wonderful economy utilizes a material that had until recently gone to the waste heap.

The cement seems to possess the good qualities of high-grade Portland Cements, and also the peculiar qualities of **not staining** the most delicate stone, and also of **not swelling.**

"The low percentage of lime, sulphur and oxide of iron, together with the fact that the whole combination has been made complete at the melting point by means of the intense heat of the blast furnace, seems to make this cement safe beyond doubt."

Slag Cement is quite **slow setting** and requires more moisture in crystallizing than other cements to obtain the best results.

"Many examples of ancient architecture now so much admired are worthy monuments to their builders, who used in the construction of these edifices cement composed of volcanic ash or other material reduced by intense heat."

The following should be an average chemical analysis:

Carbonate of Lime	51.57	per cent.
Silica	27.15	"
Alumina	10.80	"
Oxide of Iron	0.90	"
Magnesia	2.70	"
Sulphuric Acid	1.38	"
Water	3.50	"
Undetermined	2.00	"

Specific Gravity 3.10

Slag cements are manufactured in many places in France, England, Switzerland, Germany, Spain and the United States.

TESTING CEMENT.

18. The art of testing cement requires thorough knowledge of the subject as well as experience, accuracy and skill in manipulation in order to obtain results of value for comparison.

Cements are usually tested for (1) color, (2) fineness, (3) time of setting, (4) strength, (5) constancy of volume, (6) proper burning, (7) chemical analysis, (8) specific gravity, including weight and density.

19. **Color** in Natural Rock Cement indicates nothing as to value or ultimate strength.

It is supposed that a perfect cement would be **white.**

Portland Cement should be of a **greenish gray** color.

Slag Cements are of a light gray in color.

20. **Fine grinding** is now a very important test, indicating strength and sand-carrying capacity of cement.

21. **Time of Setting.**—No cement should begin to set or crystallize in less than 30 minutes unless intended for work under water.

There is a Maryland cement that will set in from 3 to 6 minutes. Cement has set when it resists the impression of the finger-nail.

22. **Strength.**—The only fair test for cement is to make briquettes composed of 2 or 3 parts standard sand to 1 part cement and break them after 7 and 28 days, testing some in water and some in air. Clifford Richardson and Uriah Cummings have treated this subject exhaustively.

Crushing resistance varies from 8 to 12 times the tensile strength, the average being 10 times the tensile strength.

Transverse strain equals about one-tenth the tensile strain.

Shearing strain averages about one-fourth the tensile strain.

CONSTANCY OF VOLUME.

23. Mold two pats of neat cement. Allow same to set in air under a damp cloth for 24 hours.

Immerse one in cold water and allow it to remain for 7 days. Examine for warping, checking and cracking.

Immerse the other in water at 212 deg. Fahr. and allow it to remain at this temperature for 24 hours. Examine for disintegration and constancy of volume.

EXPANSION AND CONTRACTION.

Expansion cracks are due to too much free lime or magnesia in the cement. (B, Fig. 1.)

If there is too much free carbonate of lime the trouble may be corrected by allowing the cement to season in the air to allow the free lime to slake.

If there is too much sulphate of lime or magnesia the cement must be rejected as dangerous to use.

Contraction cracks are due to faulty workmanship, and may occur in the best of cements if mixed too rich or if allowed to dry out too quickly, or if not thoroughly mixed and trowelled. (A, Fig. 1.)

24. **Proper burning** may be determined by color and specific gravity.

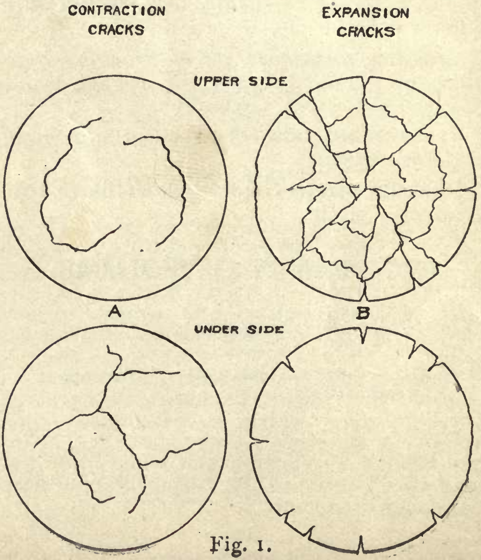

Fig. 1.

25. **Chemical Analysis** of Cements shows the following average constituents:

NAME.	Lime.	Silica.	Alumina.	Oxide of Iron.	Magnesia.	Sulphuric Acid.	Water.	Undetermined.
Portland Cement..	63.60	22.15	8.20	2.50	.85	1.20		1.50
Natural Rock Cement	34.	30.	11.	1.50	16.00	.04		7.46
Slag Cement	51.57	27.15	10.80	.90	2.70	1.38	3.50	2.00

26. **Specific Gravity** of

Portland Cement is about 3.10
Slag " " 3.10
Natural Rock Cement is about 2.80

27. **Weight,**

NAME.	U. S. Striked bushel.	Per cu. ft.
Portland Cement	112 lbs.	80-98 lbs.
Slag "	112 "	80-98 "
Natural Rock Cement ...	100 "	50-60 "

28. The **French specifications** are very rigid, compelling the manufacture of a very high grade of cement.

This industry is virtually controlled by the engineers of the *Ponts et Chaussées*, the celebrated corps which has been in charge of the public works of France for over 175 years.

SAND.

29. Sand of the proper grade and quality is equally as necessary as the right cement in order to obtain the best results.

There are three varieties: Siliceous, Calcareous and Argillaceous.

The first two are generally considered as being the best, while the last should never be used in mortar.

It is much better to pay five dollars per ton for clean washed sand or fine crushed stone than to use soft clayey sand free of cost.

Sand must be coarse and sharp and free from loam.

30. Bank or pit sand is preferable to shore sand because the former has sharp edges which make better bond for the cement than the smooth round grains of shore sand.

Salt in sea sand is objectionable, causing white efflorescence on the mortar.

31. A mixture of **varying size** grains of sand yields **stronger mortar** than sand all of one size, whether coarse or fine alone.

Employ as coarse sand as possible, even to the finer gravels, especially for **concrete.**

In concrete mixtures it is well to allow the smaller particles of crushed rock to remain, excluding only the dust.

32. A good mixture for **impermeable** mortar is composed of 2 parts coarse sand, 1 part fine sand and 1 part cement.

In a mixture of 1 part cement and 3 parts sand, one-fifth of the sand should be fine and four-fifths coarse, to obtain best results.

The strongest mortar is made with sand passing a No. 20 sieve and resting on a No. 30 sieve.

Sand in mortar reduces the changes in volume and prevents cracking.

Table showing weight of Portland Cement necessary to be added to 1 cu. yard of sand to produce given results.

	Compressive resistance in tons per sq. ft.				
	72	144	216	288	360
Pounds of Cement with 1 cu. yard *coarse* sand	400	700	1000	1400	2300
Pounds of Cement with 1 cu. yard *fine* sand	900	1400	1800	2600	4000

Portland Cement weighing		97	lbs. per	cu. ft.
Coarse sand	"	108	"	"
Fine "	"	95	"	"

Mortar with **fine** sand requires twice the quantity of cement to obtain a given strength as when **coarse** sand is used.

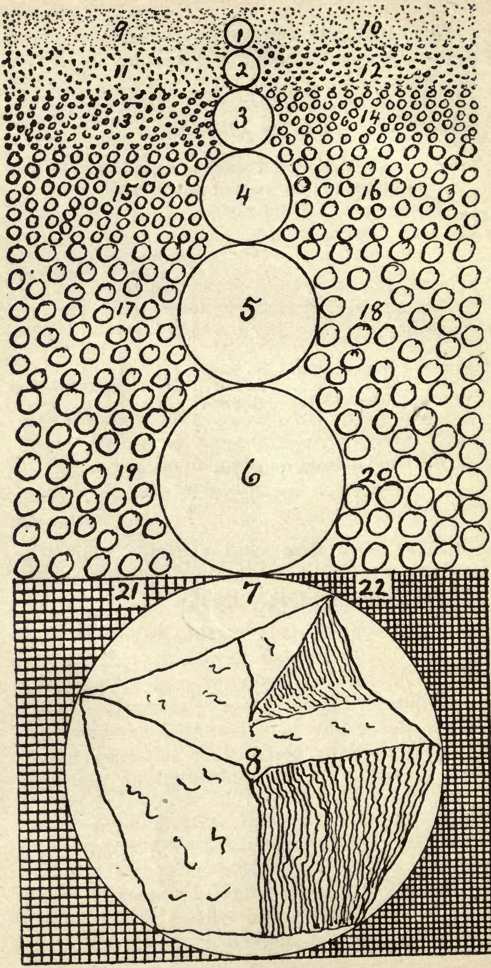

Fig. 2.—Sand and Gravel.

EXPLANATION OF FIG. 2.

33. Nos. 1-7. Gravel.

No. 8. Broken stone to pass 2-in. ring.

Nos. 9-20. Sand.

No. 21. Sieve having 20 meshes to lineal inch.

No. 22. Sieve having 30 meshes to lineal inch.

Sand Nos. 9-11 should **not** be used in cement work unless **absolutely clean.** No. 14 sand is standard size passing a No. 20 sieve and resting on a No. 30 sieve.

34. As a rule, the proportion of each ingredient in concrete should be double that of the next smaller material, as for instance: 1 part cement, 2 parts No. 14 sand; 4 parts No. 3 gravel, 8 parts No. 8 broken stone.

This should nearly fill the voids.

This rule may be accepted in the absence of actual experiments to ascertain the voids in the concrete.

The voids usually vary from 30 to 50 per cent. of the mass.

All voids must be filled in order to obtain an impermeable concrete and one that will stand the greatest crushing resistance.

35. WEIGHTS OF SAND AND STONE.—LBS.

SAND AND STONE.	Cu. yd.	Cu. ft.	Bbl. 3½ cu. ft.
Screened and washed sand.....	2275	84.25	295
River sand, wet..................	2340	86.66	304
River sand, dry..................	2490	92.22	323
Coarse gravel....................	2800	103.70	363
Stone passing 2-inch ring	2350	87.	305
Solid earth......................	3553	....	....
Loose earth......................	2361	....	....
Solid quartz.....................	4455	....	....

1 barrel equals 3½ cu. ft.

1 cu. yd. solid earth or gravel contains 18 heaping bushels before digging and 27 bushels loose after digging.

1 cu. yd. solid stone equals 1$\frac{9}{10}$ cu. yd. loose broken stone.

36. Experiments made by Tommei lead to the conclusion that in the process of hardening, silicates are formed in cement which increase the stability of the mass.

Prepared sand in proper proportion may add to the durability of cement mortar, by the formation of crystals of silica, caused by the chemical combination of the sand and cement.

STRENGTH OF MORTARS.

37. **Tensile strength** varies uniformly inversely with the proportion of sand used in rich mixtures of 2 to 3 parts sand to 1 part cement, but decreases with increased proportions of sand.

38. **Compressive resistance** however varies uniformly inversely with the proportion of sand for all mixtures up to 6 to 8 parts sand to 1 part cement.

39. The best sand is of the quartzose variety, clean washed and coarse grained.

The weight of 1 cubic foot of pure **quartz** is 165 pounds.

40. **Table showing VOIDS in SAND of varying size.**

Weights in pounds per cu. ft. dry..............	80	90	100	110	120
Proportion of solids.....	.485	.546	.606	.667	.748
" " voids......	.515	.454	.394	.333	.252

41. Sand retards setting, so that cement which alone would set in half an hour may not do so for some days if mixed with large proportions of sand.

42. 1 cubic yard of concrete should have 1 cubic yard of broken stone with 50 per cent. voids, requiring one-half cubic yard sand with 50 per cent. voids, requiring one-quarter cubic yard cement.

43. Sand decreases the strength of cement mortar about as follows:

A mixture of 1 volume Cement with the following volumes of Sand yields proportionate strength as compared with neat Cement.

Volume of sand	0	1	2	3	4	5	6
Proportionate strength of the mortar..............	1	$\frac{3}{4}$	$\frac{3}{5}$	$\frac{3}{7}$	$\frac{3}{10}$	$\frac{3}{12}$	$\frac{3}{14}$

WATER OR CRYSTALLIZATION.

44. In order to insure the best results it is absolutely necessary to know the varying effect of water on cement and the value of same.

45. Always use clean water.

Cold water retards setting.

Hot water hastens this action.

1 cubic yard of concrete requires about 22 gallons water.

46. Natural Rock and Slag Cements require more water than do Portland Cements.

Quick-setting cements require more water than do slow-setting brands, and finely ground cements more than those that are coarsely ground.

47. **Too much water "drowns"** cement, retards the setting and weakens the mortar.

48. Water for concrete may be heated to 170 deg. Fahr. to prevent mortar from freezing until after crystallization has commenced.

49. Water should always be added to cement mortar or concrete by sprinkling.

50. Lime requires about 50 per cent. of its weight of **water** in slaking.

Natural Rock Cement, 28 to 31 per cent.

Silica-Portland Cement, 22 per cent.

Portland Cement, 20 to 25 per cent.

Slag Cement, 22 to 28 per cent.

Cement and Sand Mortars, 10 to 23 per cent. to complete the process of crystallization.

51. Dr. Wm. Michaëlis says: "All hydraulic cements require, in order to remain perfectly sound, protection against drying out, and therefore, need moisture.

"Contraction cracks, even though only hair cracks, must, in the course of time, lead to destruction by weathering.

"The fact that WATER is the only element in which hydraulic cements reach their maximum strength, in our opinion, is too often lost sight of."

52. **Salt water** is recommended for use in mixing concrete for marine work.

53. **Hydraulic Cements are said to absorb 3 times as much water 3 days after setting as they will take up during the initial set.**

54. The following table shows the effect upon Portland Cement of various mineral waters:

SOLUTION.	Initial Set. Hr. Min.	Final Set. Hr. Min.	Result.
Washing Soda	..12	..32	Fair.
Salt Water	..25	1..25	Good.
Hot Water	..42	1..	Good.
Buff Coloring	..45	2..40	Very good.
Red Iron Oxide	..53	2..18	Very good.
Brick Dust	1..	1..40	Very good.
Quick Lime	1..	1..40	Good.
Carbon, Black	1..	2..23	Very good.
Duresco	1..10	2..	Good.
Alum-Soap	1..10	1..50	Very good.
Muddy Water	1..20	3..15	Unreliable
Nitrate of Potash	1..27	4..47	Good.
Fresh Water	1..30	2..15	Good.
Borax Water	1..55	5..	Good.
Gypsum Water	2..52	4..22	Good.
Sweetened Water	0.. 8	1..	Poor.

Cement containing sugar did not stand the boiling test and is evidently only intended for use in air in **dry places.**

CONCRETE.

55. Béton or Agglomere is composed of cement and sand mortar combined with aggregates composed of crushed bricks, stones, furnace cinders, etc., in varying proportions, depending on the nature of the work to be done.

The advantages of this method of construction are economy, strength, durability and rapidity of workmanship.

56. Successful operations require—

1st. Good cement, with knowledge of the rapidity of setting.

2d. Clean water and tools.

3d. Smallest possible amount of water at the beginning or until the cement has set.

4th. Thorough manipulation.

5th. Placing in position before crystallization shall have commenced.

6th. Necessary moisture to be applied after cement has crystallized.

7th. The finished work to be protected from the sun's rays, from drafts of air or changes of temperature during crystallization.

57. With proper knowledge and workmanship it is frequently possible to employ 20 to 30 parts of aggregates to 1 part cement, and secure satisfactory results.

This economical method of building construction seems to have been brought to the highest state of perfection in Denmark and Austria.

PREPARATION OF CONCRETE.

58. Make a water-tight box or platform.

Measure the correct proportions of cement and sand, then mix thoroughly, **dry.**

Moisten slightly with clean water to make a stiff plastic paste.

Drench the aggregates (broken stone, etc.) with water.

Spread the proper proportion of aggregates over the mortar (cement and sand) and mix quickly and thoroughly.

Deposit quickly in place and ram well into a compact mass.

Place layer upon layer until the required height is reached.

One layer should be allowed to harden over night before the next layer is put in place, each of which should be 6 to 12 inches deep.

Always clean and wet the surface of the concrete thoroughly before applying the next layer.

Connect the ends of layers with neat cement mortar, always breaking joints.

After 24 hours keep the concrete well supplied with moisture for two weeks and keep well covered.

The temperature should be kept between 35 and 70 deg. Fahr. until crystallization has set in, or 24 hours after mixing the concrete.

59. **Machine-mixed mortar** and concrete is much preferable to that mixed by hand.

It is more quickly and thoroughly mixed and is more economical.

The cost of labor in mixing by machine is claimed to be one-third the cost of hand mixing.

Ten per cent. less cement for a given amount of aggregates may be used.

Uniform mixing prevents unequal expansion and contraction of the mass of concrete.

It is said that machine mixing has been done at a cost of fifteen cents per cubic yard for labor.

60. When cement and sand have been mixed they must be used at once, otherwise the damp sand will destroy the hydraulic properties of the cement

61. A simple method of ascertaining the proper proportions of ingredients for concrete is as follows:

Provide a water-tight Portland Cement barrel.

Bore a hole 1 inch in diameter in the bottom of the barrel and stop with a long plug.

1st. Fill the barrel level with broken stone.

2d. Fill to overflowing with water.

3d. Draw off the water in buckets and measure carefully. The quantity of water indicates the voids in the stone to be filled with mortar.

4th. Empty out the broken stone and put the measured water into the barrel. Mark the level of the water in the barrel and then draw off the water.

5th. Fill to this water-level with sand. This is the quantity of sand required to fill the interstices in the stone.

6th. Turn in water to the level of the sand. This water indicates the quantity of cement required.

7th. Add the quantities of cement and sand and increase this amount 10 per cent. of the whole.

This indicates the proportion of sand and cement to be used to fill the voids and surround the stones.

62. Another method of ascertaining the voids is to measure 1 cubic foot of the aggregates and subtract this weight from the weight of a **solid cubic foot** of the same material. The difference will be the voids.

Example: If sand weighs 108 lbs. per cubic foot, and solid quartz weighs 165 lbs. per cubic foot, the voids in the sand will amount to $165 - 108 = 57$ lbs., or $\frac{57}{108}$ of the mass.

63. For general purposes it is usually safe to assume the voids to be equal to one-half the solids in the mass.

The mortar to surround the aggregates should be at least 60 per cent. of the mass

TIME OF SETTING REGULATED.

64. 1. **To prolong the setting** add solution of sulphates or chloride of calcium.

2. Two per cent. calcined plaster.

3. Increase the proportion of water, reducing the temperature to 40 deg. Fahr.

Initial set of slow setting should not be less than 30 minutes; final set not over 12 hours.

To quicken the setting use—

1. 2 lbs. carbonate of soda in 1 gallon of water, boiled and mixed in concrete in proper proportion.

This solution protects from freezing and costs 37 cents per cubic yard of masonry. Caustic potash will produce similar results.

2. Use smallest possible proportion of water.

3. Heat both sand and water.

Quick-setting cement should become quite hard set in 30 minutes.

IMPERMEABLE CONCRETE.

65. **Impermeable Concrete,** having all voids filled, is necessary for sea walls and also for frost-proof building construction.

Duresco, an English silicate water paint, may be used to close the pores of masonry. Solution of **magnesium fluosilicate** is also recommended.

A solution of **barium chloride** equal to 2 per cent. by weight of the cement may also be used in the water employed in mixing the concrete.

THE ALUM-SOAP SOLUTION.

Add 1 per cent. by weight of powdered **alum** to the dry cement and sand, mixing thoroughly.

Add 1 per cent. of **potash soap** (soft soap made from wood ashes) dissolved in the water for mixing.

Hydraulic cement mixed neat to the consistency of thick cream and applied with a brush will close the pores of masonry. **Non-staining cement** should be used on surfaces exposed to view.

66. **The action of sea water** is injurious to all over-limed Portland Cements.

These may be generally ascertained by their remarkably high, short time neat tests.

Dr. Wilhelm Michaëlis says: "The addition of tras or of an efficient pozzuolana to hydraulic cement containing an excess of lime, such as Portland Cements, can increase the strength of mortars two or three times, and renders them stable in sea water."

67. **Frost-proof mortar** made of 1 part Portland Cement, 1 part slaked lime and 3 parts clean sharp sand, mixed with a solution of soda, costs $6.50 per cubic yard.

Without the lime the cost is $15 per cubic yard.

Hydrochloric acid is sometimes substituted for soda.

Solutions of sugar or strontia also aid crystallization.

Fresh ground Natural Rock Cement that **sets quickly** may be used.

Freezing is injurious to low-testing Portland Cements and to Natural Rock Cements containing a large percentage of magnesia, and to all cements saturated with water.

Portland Cement is not affected by freezing after it has set.

Natural Rock Cement should never be used during freezing weather unless well protected from the action of frost.

Salt in mortar is permissible in freezing weather when Natural Rock Cement is used.

Mix 1 pound salt with 18 gallons of water to be used in mortar when the thermometer registers 30 deg. Fahr.

Add 3 ounces of salt for each additional degree of lower temperature.

The masonry to be laid must be dry and free from ice.

The process of crystallization is partially suspended by the action of frost, but is resumed as the temperature rises.

68. **Fire-proof concrete** may be made of 1 part Portland Cement, 2 parts sand and 5 parts hard-burned furnace cinders.

The great advantages of cement concrete as a **fire-resisting** material are its small expansion and low heat-conducting power.

Portland Cement concrete is said to stand a heat of 1700 deg. Fahr.

CONCRETE AND STEEL.

69. **Steel in Concrete** is one of the most durable forms of building construction known and also possesses the advantages of economy, strength and fire-resisting qualities.

The expansion of Concrete and Steel is nearly the same.

800 units of length are required to give 1 unit of change of length for 180 deg. Fahr. change of temperature.

Heat conductivity is not proportioned to the coefficients of expansion.

Steel is a better conductor of heat than concrete.

Expansion depends on the density of the material. There is as much difference between dumped and rammed concrete as between cast iron and steel.

When combined in building construction, steel should always be bedded in the concrete in order to equalize the effect of atmospheric changes and to protect the metal from oxidation.

This form of construction is employed for foundations, walls, floors and roofs of buildings, interior and exterior coverings for steel ships, coverings for wooden piles in sea water, railroad ties, etc.

The Alabama Hotel at Buffalo, N. Y., is built of a framework of twisted iron rods bedded in cement concrete. and costing 25 cents per square foot of outside surface. The concrete consisted of 1 part Portland Cement and 6 parts aggregates.

In Italy small boats are constructed of cement concrete on wire netting stretched on iron rods. The outer surface is polished like marble. It is said to be more economical than wood or steel construction.

In the little town of Calbe on the Saale there is a water tower supporting a tank 34 feet in diameter and 20 feet deep. The tank is constructed of cement concrete on a steel framework. Its walls are 8 inches thick at the bottom and 4 inches at the top, and the construction is said to be very satisfactory.

Armor plates of many layers of wire netting bedded in concrete are being tested.

SAFE LOADS.

70. **Safe loads** on foundations are fixed by law in many cities.

The maximum loads permitted by the laws of New York to be placed on various foundations are as follows:

	Tons per sq. ft.
Marshy soil	½
Wet clay	1
Clay and sand	1½
Clay foundation 15 ft. thick	1¾
Dry sand	2
Dry clay 15 ft. thick	4
Natural earth	4
Broken rock	5–25
Gravel packed and confined	8
Bed rock	200

The laws of Chicago permit a load of **four tons per square foot** ultimate resistance, with a factor of safety of 6, on concrete foundations.

When twisted iron or steel bars are bedded in concrete foundations the safe load should be from 28 to 78 tons per square foot.

Natural Rock Cement may be employed in piers loaded with 10 to 20 tons per square foot.

The average crushing resistance of ordinary concrete is 40 tons per square foot, or permitting a safe load of 4 tons, with a factor of safety of 10.

The working strength of good brickwork in cement mortar is 10 to 14 tons per square foot.

The working strength of masonry is one-sixth to one-tenth the crushing resistance.

The factor of safety for brick and stonework is taken as follows by some authorities:

Steady stress	15
Varying load	25
Vibration of machinery	30

The foundation of the Merchants' Shot Tower in Baltimore, that is 246 feet high, sustains a load of 6½ tons per square foot.

The weight on the lower foundation of the Washington Monument in Washington, D. C., is $20\frac{2}{10}$ tons per square foot, which is increased under wind pressure to $25\frac{4}{10}$ tons.

The load on the granite masonry of the towers of the Brooklyn Bridge is about 28½ tons per square foot.

The mortar was made with Natural Rock Cement, 1 part cement to 2 parts sand.

The crushing resistance of concrete for the New York City Docks was 30 tons per square foot.

The granite columns in the Rookery Building, Chicago, sustain a load of 30 tons per square foot.

COST OF CONCRETE.

71. The most economical concrete for any purpose may readily be ascertained when the ultimate load to be carried and the tensile strength of the cement are known.

Broken stone of good quality does not weaken concrete, **provided all voids are filled.**

Any concrete having all the voids filled, and being well rammed, should be equally as strong as the mortar that binds the aggregates.

In practice, however, the factor of safety of 4 should be employed to allow for careless workmanship.

For general practice it is safe to assume the crushing resistance to be 10 times the tensile strength.

See Secs. 37-43 on Strength of Mortars.

72. The following table shows the average crushing resistance of Cement Mortars, in tons per sq. ft.

Proportions in MORTAR.		Natural Rock Cement.			Portland Cement.		
		AGE.			AGE.		
Cement	Sand.	1 mo.	6 mos.	1 yr.	1 mo.	6 mos.	1 yr.
1	0	130	200	**210**	280	320	360
1	1	72	130	**162**	180	245	270
1	2	43	90	**123**	108	170	**209**
1	3	29	58	86	79	126	**158**
1	4	18	43	65	54	93	**122**
1	5	11	36	58	47	79	93
1	6	7	32	54	36	65	72

73. Silica-Portland Cement Mortar shows the following crushing resistance in tons per square foot:

Cement and Sand ground together.	Sand.	Age 1 mo. Tons.	Age 1 yr. Tons.
(1c— 2s)	— 2s = (1c— 8s)............	129	242
(1c— 3s)	— 2s = (1c—11s)............	78	178
(1c— 6s)	— 2s = (1c—20s)............	39	98
(1c—12s)	— 2s = (1c—38s)............	28	62
(1c—24s)	— 2s = (1c—74s)............	19	28

74. The following tables have been made from an average of a large number of tests.

Comparative value of
NATURAL ROCK CEMENT CONCRETE.

Cement.	Sand.	Mortar.	Gravel.	Stone.	Concrete.	Cost per cu. yd.	Crushing strength tons per sq. ft.	Cost per unit of strength.	
Bbl.	Bbl.	Bbl.	Bbl.	Bbl.	Bbl.				
1	0	1				8.00	210	.01	
1	1	1.5				5.47	162	.034	
1	1½	1.8		4	4.08	3.20	100	.032	Economical.
1	2	2				4.25	122	.035	
1	2	2		4	4.28	4.30	98	.044	
1	2	2		5	5.4	4.28	85	.05	
1	3	3				4.75	86	.055	
1	3	3		5	5.95	3.66	80	.046	
1	3	3		7½	8.1	2.50	75	.033	Economical.
1	2	2	3	4	6.7	2.70	75	.036	Economical.
1	2	2		6	5.91	3.00	65	.046	
1	2	2	2	4	5.95	2.70	65	.04	
1	2	2	7		6.7	2.11	65	.032	Economical.
1	3	3	1½	6	6.6	2.50	65	.04	
1	2¼	2.25	8		8.73	2.11	60	.035	Economical.

OBSERVATIONS. (See Sec. 72.)

75. The crushing resistance of Natural Rock Cement (1c—2s) is about equal to Portland Cement (1c—4s).

Portland Cement neat is about 60 per cent. stronger than Natural Rock Cement after 12 months.

Portland Cement (1c—3s) has nearly twice the strength of Natural Rock Cement (1c—3s) after 12 months.

Portland cement (1c—3s) has about one-half the strength of neat cement after 12 months.

Portland Cement gains a large part of its strength the first month.

These tables will vary with every cement used and with the cost of materials in differ-

Comparative value of
PORTLAND CEMENT CONCRETE.

Cement.	Sand.	Mortar.	Gravel.	Stone.	Concrete.	Cost per cu. yd.	Crushing strength tons per sq. ft.	Cost per unit of strength.	
Bbl.	Bbl.	Bbl.	Bbl.	Bbl.	Bbl.				
1	0	1				23.00	360	.064	
1	1	1.5				8.50	270	.031	
1	2	2				7.96	209	.038	
1	2	2		5	5.4	6.00	213	.03	
1	2	2		6	5.91	6.00	205	.03	
1	2	2	3		4.04	6.50	209	.03	
1	2	2	2	4	5.95	6.00	204	.03	
1	2	2	6		5.91	5.00	203	.024	Economical.
1	2	2	3	3	6.12	6.00	198	.03	
1	3	3				6.42	158	.04	
1	3	3		5	5.95	5.56	158	.035	
1	2	2	3	4	6.70	6.00	155	.039	
1	3	3		6	6.6	5.50	153	.036	
1	2.76	2.76	1.46	5	7	4.00	153	.027	Economical.
1	3	3		7½	8.03	4.00	150	.027	Economical.
1	3	3	9½		9.8	4.00	120	.033	
1	4	4				5.10	122	.04	

ent cities, but they will be found of value as showing a fair average and comparative value of various mixtures of concrete.

OBSERVATIONS. (See Sec. 72.)

Natural Rock Cement gains most of its strength between 6 and 12 months.

Natural Rock Cement (1c—1s) in 1 year is about equal in strength to Portland Cement Mortar (1c—3s).

Natural Rock Cement Mortar in 12 months is about equal in strength to Portland Cement Mortar in 1 month.

In large admixtures of sand, Natural Rock Cement increases nearly 5 times in strength after 11 months, while Portland Cement Mortar only gains double its strength for the same time.

Portland Cement reaches its greatest strength in **water.**

Natural Rock Cement reaches its greatest strength in **air.**

These deductions are of the greatest importance in determining the most economical mortar to employ for any purpose.

76. In Philadelphia the cost of concrete foundations for streets has been $3.00 to $3.30 per cubic yard.

On the Boston Subway the prices for labor and materials were as follows, per cubic yard:

Natural Rock Cement Concrete..$5.00 to $8.00
Portland Cement Concrete...... 6.50 to 9.50

The cost of labor and materials on the C. M. & St. P. R. R. work was for Natural Rock Cement Concrete, $4.15 per cubic yard, in the following proportions: 4 cement, 6 sand, 15 broken stone.

NOTES ON CEMENT CONCRETE.

77. The best aggregates are crushed granite, sienite, gneiss, the older limestones, trap, hard burned bricks, washed and screened coarse gravel and pebbles.

78. Trap rock is recommended by Mr. James Christie when heavy concrete is required that will stand great crushing strain.

To obtain an extra strong foundation, add to the concrete one-half, by weight, of the mass, of iron cuttings and one pound of sal ammoniac for each fifty pounds of iron.

The resulting mixture weighs about 200 pounds per cubic foot, and in 1 month will stand a crushing strain of 216 tons per square foot.

79. Macadamized turnpike roads are successfully made of cement concrete in Scot-

land, forming, when properly mixed and rolled, a solid roadway standing heavy traffic and saving cost of repairs.

80. **Electrical conductivity** of cement concrete is **poor** when **dry** and **good** when **wet.**

When intended for electrical purposes, cement concrete should be covered with a thin layer of a non-conducting coat composed of 50 parts crushed stone, 20 parts clean coarse gravel, 12 parts asphalt, 8 parts coal tar pitch, 10 parts German coal tar.

81. **Artificial stone** may be made by first mixing 100 parts Portland Cement and 35 parts clean water, ground together in a suitable mill until the result is a plastic viscous and sticky paste of a peculiar character.

The excellence of the stone depends upon careful workmanship.

Add the clean washed sand partially dried. Mix thoroughly and ram into moulds.

Two to twelve parts sand of varying sizes, with one part cement paste, may be used in this mixture, depending on the class of work and strength required.

82. **Architectural work** in cement should be made of slow-setting cement.

Medium fine sand should be used in the facing.

The finished concrete should be allowed to remain in molds until set hard, then place in a damp room, protecting from sun and drafts of air by **covering with wet cloths.**

SIDEWALKS AND FLOORS.

83. 1. To 1 part cement add 3 parts clean, sharp sand. To this mortar add 6 parts broken stone, bricks or other suitable material that will pass a 2-inch ring.

Proceed as for concrete work. See Sec. 58.

2. When there is danger of frost, dig out the foundation 11 inches below the surface except at the outside edges, where a narrow trench 2 feet deep should be dug.

Fill to within 5 inches of the surface with screened and washed **furnace cinders** well rammed and levelled.

On this foundation place the concrete base 4 inches thick, well rammed. For extra heavy traffic this concrete should be 6 inches thick.

For very important work iron rods or expanded metal laths are frequently bedded in the concrete to prevent cracking.

There are a number of patent processes based on this system.

The top coat should be 1 inch thick, composed of 1 part cement, 1 part sand and 1 part fine crushed granite.

The concrete base must first be roughened, cleaned and made thoroughly wet before applying the finishing coat.

Level the surface with a wooden float and straight-edge, obtaining the proper grade.

This mortar should have just sufficient water to make it of the consistency of fresh-dug earth that will stick in a ball when pressed in the hands.

When about to set, trowel hard with a steel trowel or roll with a brass roller.

Cut the surface into blocks of proper size to prevent unsightly cracks and to allow for expansion and contraction.

Cover with boards, paper, straw or sand to protect against atmospheric changes and to keep in the moisture.

After 24 hours **keep the surface wet for at least two weeks.**

The top coat should be applied before the foundation is dry, to keep the top from separating from the foundation.

Floors are laid at a cost of 10 to 60 cents per square feet, depending upon the thickness, strength and workmanship.

Good work should be done for twenty cents per square foot.

As a rule, 2½ barrels cement are sufficient to lay 100 square feet of walk.

One finisher with two helpers have laid from 300 to 1000 square feet of walk in one day, depending on the style of finish.

For ordinary cellar floors 3 inches thick, 1 barrel Portland Cement and 3 barrels sand will cover 5 square yards.

For ordinary floors 1½ barrels Natural Rock Cement may take the place of 1 barrel Portland Cement.

84. For **colored walks** employ pigments that will not weaken the cement. See Sec. 115.

85. **Barnyards** should be paved with concrete, so that the drainage may all be carried to a water-tight pit. This drainage is more valuable for field and garden than the most expensive fertilizers.

FLOORS FOR WET CELLARS.

86. When water flows into a cellar and cannot be drained by terra cotta pipe, it is necessary to make a very strong floor to resist the outside water pressure—

1st. Prepare the bottom of the cellar in the shape of a shallow dish with the lowest part in the center.

2d. Dig a shallow well in the center and lead all the water to this well by cutting shallow ditches from the four corners of the cellar and laying 2-inch drain tile to the well or fill the ditches with loose broken stone. Keep the cellar pumped dry.

3d. Pave the cellar with hard burned bricks, set on edge, laid in cement mortar, working from the four sides towards the center, keeping the well open in order to pump out the water.

4th. On this foundation lay the cement concrete floor.

5th. When the floor is hard plug up the hole in the center with bricks and quick-setting cement.

FLAT TILE ROOFING.

87. Lay the concrete foundation of roof to the proper grade, making smooth and even surface.

When dry, coat this concrete with best quality coal tar roofing pitch (Warren's Crescent brand or equal).

Into this coating lay five thicknesses of best quality roofing felt (Warren's Crescent brand or equal) thoroughly mopped between each sheet and over the entire surface with the said pitch. Upon this waterproof foundation lay hard burned tile 1 inch thick, in asphaltic cement, and fill the joints with Portland or Pozzuolana Cement.

NOTES.

88. **The Cathedral of St. John the Divine in New York** rests on a concrete foundation composed of 1 part Portland Cement, 2 parts sharp sand and 3 parts quartz gravel (1½ to 2 inches).

The concrete was mixed by machine and deposited **quite dry** in layers 10 inches thick, and rammed with 20-pound rammers.

When stopping for the night the layers were left with long sloping edges.

In the morning these edges were plastered with a mortar composed of 1 part Portland Cement and 2 parts sand before the concrete work was resumed.

This foundation sustains a load of about 12 tons per square foot.

89. It is said that the **Eddystone Lighthouse** was built by John Smeaton on a foundation exposed to sea water and laid in cement mortar that would hardly stand a tensile strain of 25 pounds per square inch in 7 days neat, yet this famous tower stood for over 120 years until removed to make room for a larger structure. See Sec. 2.

90. In **Austria** important concrete work is sometimes placed **dry** in 8-inch layers and then rammed and wetted.

This is claimed to be the best and cheapest method.

91. **Natural Rock Cement Mortar** was the best obtainable fifty years ago.

There are abundant examples of important work proving that this cement does not deteriorate with age.

92. **Portland Cement** has been used at Bristol, Va., instead of **lead** for closing the joints of gas mains. Pure cement slightly dampened was rammed into the joints with a calking tool.

PLASTERING.

CEMENT STUCCO FOR WALLS.

93. 1st coat, one-half inch thick.

For best results, the wall should be furred off with spruce lath put on vertically, 12 inches apart and well nailed.

On these fasten firmly expanded metal lath. Add fibre to the mortar for lathwork.

Wet thoroughly the surface to be plastered.

Mix 1 part Non-staining Portland Cement with 2 parts medium sand, 1 part fine sand and one-half part lime flour. When this coat has set hard, wet the surface thoroughly and apply the second coat (one-quarter inch thick) with a wooden float.

Mix 1 part cement as above, 1 part fine sand and 2 parts medium sand or crushed granite.

Before the 2d coat has set hard, it may be jointed to present the appearance of stonework.

A small addition of lime flour increases the adhesion of the mortar.

The finished surface should be protected for at least two weeks with **canvas curtains** or bagging saturated with water.

Defects are liable to appear on cement plastered walls when (1) too much cement is used; (2) not supplied with sufficient moisture; (3) not troweled sufficiently; (4) not protected from variations in temperature and drafts of air.

94. **Stainless cements should always be used for plastering.** When ordinary Portland or Natural Rock Cements are used the surface should be well coated with **Duresco** or other solution to prevent efflorescence and staining.

95. Plastering-work should be done in the spring and never during freezing weather.

96. Calcined gypsum or hard plaster is sometimes used for the first coat to secure a strong bond.

97. The final coat is frequently colored. See Sec. 115.

For **White Mortar** mix 1 part stainless cement, one-half part lime flour and 3 parts white silica sand or marble dust.

When cement plastered walls are to be painted, first coat thoroughly with Duresco or other solution to completely close the pores in the surface.

PEBBLE-DASH.

98. When first coat is thoroughly dry (see Sec. 93), mix 2 parts stainless cement and 1 part lime flour to the consistency of thick cream.

Add clean washed pebbles.

This mixture is dashed on to the wall with a wooden paddle about 6 inches wide.

A whitewash brush is also dipped into the mortar and used to smooth the surface and obtain a uniform color and appearance.

99. COVERING CAPACITY OF CEMENT PLASTERING.

Cement.	Sand.	Producing Mortar.	Thickness in Inches.			
			½	¾	1	2
Bbl.	Bbl.	Bbl.	Sq. ft.	Sq. ft.	Sq. ft.	Sq. ft.
1	0	1	91	68	45	22
1	1	1.5	136	101	67	33
1	2	2	182	136	90	44
1	3	3	272	202	134	66
2	1	2.5	228	171	114	57
1	4	4	364	272	180	88

Use medium fine sand.

1 barrel cement (300 pounds) will make 3.8 cubic feet of stiff paste.

Cement, Bbl.	Sand, Bbl.	Lime Flour, Bbl.
1	1½	0
1	2½	½
1	3	1
1	5	1½
1	6	2
2	8	1

100. **Cement Plastering for Cisterns.**— Mix equal parts sand and cement.

Apply mortar in two coats about one-half inch thick each.

The brick or stone backing must first be thoroughly wet, then apply the first coat, trowelling well with a wooden float, leaving a rough finish.

When a small section of wall has been plastered, return and apply the finishing coat before the first coat is dry. Trowel well with a steel trowel to a smooth polished surface.

101. **Waterproof coating for cisterns** and reservoirs is made by mixing pure Pozzuolana Cement and water to the consistency of cream and applying with a whitewash brush.

102. **Hot water cisterns** should have the inside surface dried artificially and then thoroughly coated with boiled linseed oil.

103. **Fire-proof Plaster** may be made of 4 parts pulverized asbestos rock and 1 part prepared **lime flour,** gauged with one-half part calcined plaster.

Finishing coat may be made of soapstone mortar, plain or colored.

104. **Pointing Mortar** for stone and brick masonry should be made of equal parts **stainless cement** and clean fine sand, with coloring matter as desired. See Sec. 115.

LIME AND CEMENT.

105. **The addition of lime to cement is recommended by the Association of German Portland Cement Manufacturers when the work is not to be done in water or wet ground.**

Some of the advantages are:

1. Economy.
2. Rapid hardening.
3. Remarkable hydraulic properties.
4. Great firmness when exposed to the air.
5. Power to resist the weather.

106. **Sugar in Lime Mortar** has been employed in India for many hundred years. 1 part sugar to 20 parts lime flour increases the strength of the mortar and quickens the setting.

Add 1 pound syrup to 1 bushel of Portland Cement.

This cement is not suitable for work in wet places.

107. **Brick Dust** mixed with lime flour produces a feebly hydraulic mortar and adds greatly to its strength.

108. **Mortar for Chimneys** to prevent disintegration may be made of 1 bbl. lime, 1 bbl. brick dust, 2 bbl. sand

109. **Hard Plaster, French Process.**—Mix 6 parts calcined plaster with 1 part lime flour.

Spread quickly on surface to be covered. Do not trowel too long. Dry thoroughly. Saturate with sulphate of iron.

Apply a coat of linseed oil boiled with litharge, then apply a coat of copal varnish to obtain a beautiful **mahogany** color.

If **white** surface is desired, when the lime and plaster mortar has dried thoroughly, saturate with sulphate of zinc.

110. COST OF LIME MORTAR TO LAY 1100 BRICKS.

1 bbl. quick lime, 240 lbs. =	8 cubic ft. paste	$0 90
5 " sand,	19 " "	50
	19 cubic ft. mortar......	$1 40

Cost of mortar $7\frac{4}{10}$ cts. per cubic foot.

One mason and one helper should lay 150 cubic feet stone or 1500 common bricks per day.

111. MORTAR FOR 1 CUBIC YARD MASONRY.

Volume of mortar in cubic yards.

Brickwork, ⅛ inch joints ...	.15
" ¼ " "	.25
" ½ " "	.40
Ashlar, 20-inch courses	.06
Squared Stone Masonry	.20
Rubble Masonry	.25
Concrete, broken stone	.55

MORTAR TO LAY 1 CUBIC YARD RUBBLE MASONRY OR BRICKWORK.

1 bbl. cement, 2 bbls. sand.
574 bricks with ¼ inch joint = 1 cubic yard.

112. MORTAR TO LAY 25 CUBIC FEET OR 1 PERCH OF STONEWORK.

½ bbl. cement and 2 bbls. sand.
⅓ bbl. lime and 2 bbls. sand.

113. COST OF 100 SQUARE YARDS PLASTERING.

Materials and Labor.	3 Coats.		2 Coats.	
	Quantity.	Price.	Quantity.	Price.
Lime	4 bbls.	$4.00	3½ bbls.	$3.50
Lump Lime.......	⅔ "	.85	....	....
Calcined Plaster ..	½ "	.85	....	....
Laths.............	2000	4.00	2000	4.00
Hair..............	4 bus.	.80	3 bus.	.60
Sand (ordinary)...	7 loads.	4.90	6 loads.	4.20
White Sand........	2½ bus.	.25	....	....
Nails	13 lbs.	.90	13 lbs.	.90
Mason, labor......	4 days.	12.00	3½ days.	10.50
Hod Carrier.......	3 days.	3.75	2 "	2.50
Cartage...........	....	2.00	....	1.20
		$34.30		$27.40

EFFLORESCENCE.

114. **White efflorescence** is a crystalline powder frequently covering the surface of masonry and concrete walls and cement mortar joints, greatly disfiguring the appearance of the wall.

This powder may consist of crystals of sulphates of soda, lime or magnesia or bi-sulphuret of iron.

Yellow efflorescence is organic in character and is caused by the action of vegetable micro-organisms.

Green efflorescence is inorganic in character and is caused by soluble vanadiate salts.

Volumes have been written regarding the cause and prevention of this disfigurement.

Some of the leading authorities on the subject are—

Dr. Oscar Gerlach, of Berlin.

Prof. John C. Smock, State Geologist of New Jersey.

Prof. F. J. H. Merrill, State Geologist of New York.

Prof. Wm. Bullock Clark, State Geologist of Maryland.

Prof. Ira O. Baker, C. E. of University of Illinois.

Gen. Q. A. Gillmore, U. S. A.

Prof. Gunther, of England.

Prof. Edward Orton, Jr., E. M., Ohio State University.

F. E. Kidder, C. E., F. A. I. A., Denver, Col.

REMEDY.

Avoid the use of bricks, cement or mortar colors containing large percentage of **sulphur.**

The chemical analysis of these materials should be known.

Some sandstones, especially the gray varieties, containing bi-sulphuret of iron, are very liable to stain.

Less trouble is noticeable where lime mortar and bank sand are used.

Avoid the use of (1) Natural Rock or ordinary Portland Cement on important face work; (2) porous bricks; (3) mortar colors made from iron pyrites.

Use a solution of barium chloride in the mortar, equal in quantity to the amount of sulphate in the cement.

Some authorities recommend Sylvester's solution of soap in the water employed in the mortar, and powdered alum in the cement, and afterwards combined. See Sec. 65.

Bricks should be thoroughly well burnt to prevent absorption of moisture necessary for the extraction of the soluble salts.

Cement mortar should be mixed with as little water as possible, and no grouting of any kind should be allowed.

All joints should be filled solid by good workmanship.

Gen. Q. A. Gillmore, U. S. A., recommends a mortar composed of 10 parts animal fat, 100 parts quick lime, 300 parts hydraulic cement.

A solution of hydro-fluosilicic acid is sometimes used.

Employ Stainless Portland Cement.

MORTAR COLORS.

115. Mortar colors should be made from the best metallic oxides, free from sulphur.

Never use venetian red or lamp black, as they run and fade, and soften the mortar.

Excelsior Carbon Black is the strongest black known.

Mix the following colors with either Prepared Lime Flour or Stainless Portland Cement Mortar to obtain excellent results:

Black	2 per cent. Excelsior Carbon Black
Red	10 per cent. Best Raw Iron Oxide.
Brown	6 per cent. Best Roasted " "
Buff	10 per cent. Best Ochre.
Blue	6 per cent. Ultramarine.
White	Marble Dust or white Silica Sand.

WEIGHTS AND MEASURES.

Weight per cubic foot.

Portland Cement	80 to 98	lbs.
Natural Rock Cement	50 to 60	"
Quartz	165	"
Limestone	160	"
Sand	84 to 110	"
Gravel	105 to 120	"
Concrete, average	125 to 140	"
Slag	110	"
Crushed Coke Concrete	70	"
Brickwork	110 to 140	"
Bricks	118 to 130	"
Lime	60 to 70	"
Dry Mortar	103	"
Masonry	165	"
Distilled Water	62½	"

$27\frac{68}{100}$ cubic inches distilled water, 39.2°F=1 pound.

1728 cubic inches=1 cubic foot.

2150.4 cubic inches=1 bushel.

24.75 cubic feet=1 perch of stone.

A box $12\frac{15}{16}$ in. x $12\frac{15}{16}$ in. x $12\frac{15}{16}$ in.=1 bushel measure.

5280 feet=1 mile.

3.2808693 feet=1 metre.

39.370432 inches=1 metre.

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Lawrence Cement Co.
Lehigh Portland Cement Co.
Vulcanite Portland Cement Co.
The Newark Lime & Cement Mfg. Co.
Wayland Portland Cement Co.
Ransome & Smith Co.
E. Thiele.
Southern Expanded Metal Co.
Charles Warner Co.
Western Cement Association.
Coplay Cement Co.
Union Akron Cement Co.
Fort Scott Cement Association.
New York & Rosendale Cement Co.
Ridgemont Cement & Mfg. Co.
C. A. Brockett Cement Co.
Carson Lime Co.
P. H. Jackson & Co.
L. F. Smidth & Co.
Charles Zunz.
I. C. Johnson & Co.
Bridges & Henderson.
University of Illinois.
Johns Hopkins University.
Cornell University.
University of Pennsylvania.
Columbia University of Washington, D. C.
Columbia University of the City of New York.
University of the State of New York.
Lehigh University.
Harvard University.
Ohio State University.
Leland Stanford, Jr., University.
Dartmouth College.
Pennsylvania State College.
Massachusetts Institute of Technology.
Franklin Institute.
Department of Public Works, Philadelphia.
Boston Transit Commission.
Francis H. Creuss, Archt.
International Correspondence Schools.

Spon & Chamberlain.

Prof. F. J. H. Merrill, New York State Geologist.

Prof. Edward Orton, Jr., Ohio State Geologist.

Prof. W. S. Blatchley, Indiana State Geologist.

Prof. Wm. Bullock Clark, Maryland State Geologist.

Prof. John C. Smock, New Jersey State Geologist.

Julian O. Hargrove, C. E., Asst. Inspector, Washington.

J. F. Coleman, Asst. City Engineer, New Orleans.

E. S. Dorr, Chief Engineer, Boston, Mass.

F. V. E. Bardol, Chief Engineer, Buffalo, N. Y.

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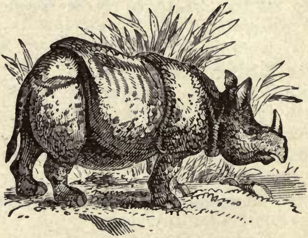

BUREAU OF INFORMATION.

Prices and general information regarding the following

BUILDERS' SUPPLIES

will be cheerfully supplied, by addressing

W. W. CLARKE & SON,
BOX 156, BUILDERS' EXCHANGE, BALTIMORE.

PORTLAND CEMENTS.

Star Stettin German Cement.
Dyckerhoff " "
Heyn Bros.' " "
Mannheimer " "
Teutonia " "
Hemmoor " "
Hanover " "
Germania " "
Höxter " "
Breitenberger " "
Alsen & Sons " "
I. C. Johnson & Co.'s English Cement.
Brooks, Shoobridge & Co.'s " "
Hilton " "
Royal Crown Belgian Cement.
Rhinoceros American Portland Cement.
Buckeye " " "
Saylor's " " "
Vulcanite " " "
Lehigh " " "
Hercules " " "
Atlas " " "
Alpha " " "
Warner's " " "
Star " " "
Giant " " "

STAINLESS CEMENTS

La Farge French Portland Cement.
Rhinoceros American " "
H. H. Meier & Co.'s Puzzolon "
Vicat French Cement.

NATURAL ROCK CEMENTS.

Union Akron Star Cement.
Cumberland "
"B. & H." Natural Rock Cement.
Round Top Cement
Improved Lehigh Cement.
Improved Union "
Improved Rosendale Cement.
Old Newark Rosendale "
Hoffman " "
F. O. Norton " "
Ridgemont " "
Louisville " "
Utica " "

LIME.

Texas Alum Lime.
Virginia Lump Lime.
Bottom Lime
Hydraulic Lime.
Prepared Lime Flour.
Paris White.
Shell Lime.
Glass Makers' Lime.
Varnish Makers' Lime.
Poultry Lime.
Cochina Shells.
Whiting.
Prepared Mortar (dry) in barrels.

BUILDING PLASTER.

Old Newark Calcined Plaster.
" Casting "
" Pottery "
" Dentist "
Red Beach Calcined Plaster.
J. B. King's Diamond Calcined Plaster.
Higginson's Newburgh " "
Snow Flake " "
Clarke's " "
Keystone " "
Michigan " "
American Soapstone Wall Finish.
Keene's Marble Cement.
King's Windsor "
Acme Cement Wall Plaster.
Asbestic Cement Wall Plaster.
Adamant " " "
Higginson's " " "
Ivory " " "
Blackboard Wall Finish.

PLASTERING HAIR AND FIBRE.

No. 1 Goat Hair in 1 Bushel Packages.
No. 1 Cattle " 1 " "
Cocoa Fibre.
Palmetto Fibre.

MORTAR COLORS.

Clinton Hematite Colors.
Milwaukee "
Peerless "
Pecora "
Potters' Soapstone "
Excelsior Carbon Black.
"Duresco" English Petrifying Paste.

SHINGLE STAINS.

Cabots' Creosote Stains.
Dexter Bros.' English Stains.

SAND, GRAVEL AND STONE.

White Front Sand.
Cement "
Silver "
Scouring "
Filtering "
Silica "
Lithographers' "
Moulding "
Roofing "
Fire "
Bird "
Concrete Gravel.
Poultry Gravel.
Pebbles.
Silicite.
Roofing Gravel.
Concrete Stone.
Crushed Granite.
Granite Flour.
Crushed Flint.
Marble Dust.
Infusorial Earth.
Furnace Cinders.

CLAYS.

White Clay.
Red "
Yellow "
Blue "
Fire Clay.
Puddling Clay.
Kaolin.

BRICKS.

White Front Bricks.
Gray " "
Buff " "
Red " "
Mottled " "
Rock Faced Bricks.
Enamelled "
Furnace "
Mill "
Hollow Building Bricks.
Vitrified Street Paving Bricks.
Adamantine Clinker Paving Blocks.
Floor Tiles.

TERRA COTTA.

Architectural Terra Cotta.
Fire-Proof Terra Cotta.
Porous " "

CLAY GOODS.

Sewer and Culvert Pipe.
Channel "
Drain Tile.
Vases and Flower Pots.
Chimney Pipe.
" Tops.
Umbrella Stands.
Flue Lining.
Stove Thimbles.
Drip Stones.
Gutter Tile.
Well and Spring Tops.
Wall Coping.

PAPER AND FELT.

Warren's Asphalt Roofing Felt.
" " Sheathing Felt.
" Coal Tar Roofing "
"P. & B." Waterproof Roofing Felt.
Bird's Waterproof Sheathing Paper.
Manilla Rope Sheathing Paper.
Manahan's Pine Tar Sheathing Paper.
Asbestos Fire-Proof " "
Deadening Felt.

INSULATION.

Silica Fibre—Mineral Wool.
Bird's Insulating Felt.
Warren's Asphalt Damp Course.
Slate Damp Course.
"Duresco" Damp Proof Coating.

ROOFING MATERIALS.

Vitrified Roofing Tile.
Warren's Asphalt Roofing Paint.
Clinton Silk Fibre Roofing Cement.
Webster's Elastic " "
Peach Bottom Roofing Slate.

PAVING MATERIALS.

Trinidad Asphalt, Refined.
Rock Asphalt Mastic.
Slate Flagging.
Blue Stone Flagging.

METAL LATH.

Expanded Metal Lath.

MACHINES AND TOOLS.

Concrete Mixing Machines.
Cement Paver's Tools.

The City of Newark,

with a population of over 250,000 people, located on the Passaic River, nine miles from the City of New York, is the principal city of New Jersey, and one of the most flourishing manufacturing centres in the United States.

Here is located the home office of THE NEWARK LIME AND CEMENT MANUFACTURING COMPANY, who have been in business for over sixty years manufacturing the well-known "OLD NEWARK" brand of Cement and Plaster.

Their brand of dark ROSENDALE CEMENT, produced at Rondout, Ulster Co., N. Y., has been largely used on U. S. Government and other public works, and is noted for its uniformity in quality and hydraulic properties.

THEIR PLASTER is made from rock imported from the celebrated quarries of "The Albert Manufacturing Co.," at Hillsborough, New Brunswick, B. A. For stucco and manufacturing purposes their brands of Plaster bring a higher price than others on the market and those who know the difference find it more satisfactory and economical to buy the best.

PORTLAND CEMENT was first manufactured in Germany at Stettin in the year 1852. To-day there are more than one hundred cement factories in Germany with an annual output of nearly fifteen million barrels.

The manufacture of this product is under the control of the German Cement Association, which is the most important association of manufacturers in the world. Their object is to improve the quality of their product, and to this end the most eminent chemists and specialists in their respective professions are employed.

One of the ablest members of the Association, and one who takes the greatest interest in the technical side of cement making, is Mr. Rudolph Dyckerhoff.

MR. FREDERICK H. LEWIS, M. Am. Soc., C. E. has visited the principal cement factories of England and the Continent, and makes a most interesting report. Below is a brief extract of his report on the Dyckerhoff Works:

"NO brand of cement is better known in America than the Dyckerhoff. This factory is one of the most important in Germany and has an annual output of nearly eight hundred thousand barrels. The works are located on the river Rhine at Amöneburg, near Biebrich, a few miles below the city of Maintz.

"Coal is brought direct to the mill in barges. Clay is brought from the Main, a tributary stream a few miles away.

"The supply of Limestone is obtained from a quarry about a mile from the works. This quarry contains three grades of stone—hard and soft limestone and a soft marl. With the clay, these four raw materials are combined in the manufacture of cement. There are two mills; one to grind the raw material, the other to grind the burnt clinker.

"In one of these mills is a 1000 horse-power triple expansion engine, probably the handsomest piece of machinery in any cement works in Europe. The greater part of the product is shipped by water. Cement for export is sent on barges to Antwerp and Rotterdam."

IN view of the firm hold which the Dyckerhoff Cement has obtained in this market, dealers in other brands of cement are sparing no efforts to persuade those interested in Portland Cement that such and such a brand that they have for sale is "*just as good as Dyckerhoff*," or is made near the Dyckerhoff Works. This demonstrates that the quality of the Dyckerhoff Portland Cement is considered even by its competitors as the highest obtainable, a compliment fully deserved.

Many brands which may show a high tensile strength at a short period will not stand the test of time and are subject to contraction and expansion in volume to the great injury to the work in which they may have been employed. This is due to imperfections in their chemical composition or manufacture.

The Dyckerhoff works produce not only the strongest, but also the safest and most reliable Portland Cement, unalterable in volume, not liable to crack and of a uniform, never-varying quality.

While the price of the Dyckerhoff, owing to its more careful and expensive manufacture, is a trifle higher than that of most brands, its vastly greater strength permits a very much larger addition of sand, which really makes it the cheapest and most reliable cement on the market.

E. THIELE,

78 WILLIAM STREET,
NEW YORK CITY.

Sole Agent, United States.

GATESHEAD and Newcastle-on-Tyne are among the oldest cities of England and contain many relics of interest, dating from Roman occupation and also from the Norman Conquest. Here will be found some of the finest examples of Norman architecture.

Among the leading manufacturers here are located the old established firm of I. C. Johnson & Co., Cement Makers.

Local interest is due to the fact that over twenty thousand barrels of their cement were used in the foundations of the immense stacks and furnaces of The Maryland Steel Co., at Sparrow's Point, Md., near the mouth of Baltimore harbor.

TRADE MARK.

I. C. JOHNSON & CO.,

CEMENT MAKERS,

GATESHEAD-ON-TYNE, ENGLAND.

THERE is an interesting group of German Portland Cement Works that employ "Mergel" (English Marl, French Marne) as their principal raw material. "Mergel" is a natural mixture of Clay and Carbonate of Lime, and generally contains shells or other fossils.

Mr. Fred'k H. Lewis, M. Am. Society, C. E., gives an interesting account of his visit to the principal cement factories of Europe.

There are several important plants at Misburg, a few miles east of the City of Hanover, on the railroad from Cologne to Berlin. Here are located the Teutonia, Hanover and Germania Cement Mills. These cements are manufactured from the marl and clay by what is called the dry process. Just below the surface of the ground is a bed of marl about 40 feet thick. Under this is the clay. These two materials are dried, ground, and mixed in proper proportion and conveyed to the Silo, an immense stock-house similar to an American grain elevator. Thence the pulverized mixture is conveyed to the brick machines, where it is pressed into blocks to be burnt. The burnt clinker is then ground and prepared for shipment.

☙ ☙ ☙

THE Misburger Portland Cement Works, Teutonia, with office at Hanover, are the manufacturers of the Teutonia brand of cement. This factory has just been completed, and contains all the latest and best appliances for the manufacture of a first-grade cement. The annual capacity of this plant is two hundred and fifty thousand barrels.

THERE are many disadvantages with which to contend in the cement business, and not the least is the fact, that almost invariably when cement work does not give satisfactory results, the cement is blamed for the fault or lack of skill of the workman.

For many years we have handled one brand of cement especially, that we never hesitate to recommend to inexperienced persons for use in foundations, cellar floors, cisterns, reservoirs, etc.

It seems to be so strong that one can hardly help obtaining good results even with the most ignorant workmen.

THIS IS THE

"Red Star" Brand of Akron Cement,

MANUFACTURED BY THE

Union Akron Cement Co.

OF BUFFALO, N. Y.

Their product has been in successful use for the past fifty years, and their works have a daily capacity of 2000 barrels.

W. W. CLARKE & SON,

BALTIMORE.

RHINOCEROS PORTLAND CEMENT.

For Setting Fine Brick, Stone or Marble Work. For backing the most delicate Mosaics. For Stucco and Pebble Work.

FACTORY TEST.

Tensile strength per sq. in. neat.

24 hrs.	170 lbs.
7 days	431 "

1 Cement—3 sand.

24 hrs.	112 lbs.
7 days	190 "

PHILADELPHIA TEST.

7 days	434 lbs.
28 days	591 "

3 Sand to 1 Cement.

28 days	147 lbs.

U. S. GOVERNMENT TEST.

Neat.

6 days	568 lbs.
14 days	741 "

2 Sand to 1 Cement.

15 days	473 lbs.

CHEMICAL ANALYSIS.

	Percentage.
Silica	27.15
Alumina	10.80
Lime	51.57
Magnesia	2.70
Sulphur	1.38
Oxide of Iron	.90
Combined Water	3.50
Undetermined	2.00
	100.00

FINENESS.

No. 50	Sieve	100 per cent.
" 100	"	98 "
" 200	"	90 "

SPECIFIC GRAVITY 3.10.

Hot Water Test Satisfactory. Slow Setting.

DOES NOT STAIN OR EFFLORESCE.

WM. WIRT CLARKE & SON,
115 GAY STREET, S.,
BALTIMORE, MD.

bring to light many interesting and instructive facts regarding the comparative value of building and paving materials in general, and Cements in particular. In the report for 1897, p. 161, we find the following comparisons:

	Tensile strength in lbs. per sq. in. in 1 year.
NATURAL ROCK CEMENT with 2 parts sand	485 lbs
PORTLAND CEMENT with 3 parts sand	474 lbs.

COMPARATIVE VALUE OF THE MORTAR.

1 bbl.	NATURAL ROCK CEMENT,	3.8 cu. ft.	$1.20
2 "	Sand	7.6 "	.20
	Yielding mortar	8.05 "	$1.40

or about 17½ cts. per cubic foot of mortar having crushing resistance of 349 tons per square foot.

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1 bbl.	PORTLAND CEMENT,	3.8 cu. ft.	$2.60
3 "	Sand	11.24 "	.30
	Yielding mortar	11.24 "	$2.90

or about 25¾ cts. per cubic foot of mortar with crushing resistance of 341 tons per square foot.

NATURAL ROCK CEMENT W. W. CLARKE & SON B.&H. 300 lbs. BALTIMORE. STANDARD QUALITY

Making a clear saving of over 40 per cent. in cost with better results by using "B & H" BRAND OF NATURAL ROCK CEMENT, having strength sufficient to carry a load of 34 tons per square foot (allowing the factor of safety of 10).

PROFESSOR EDWARD ORTON, State Geologist, of Ohio, has published an interesting report on the Clay Working Industries of his State, which should be read by all Clay Workers.

"Ohio is the leading **Sewer Pipe** producing State of the Union, containing some of the largest factories of this class in the world.

The manufacture of Sewer Pipe demands the use of vitrifying clays, requiring intense heat. One of the most interesting sights may be viewed by taking a trip up the Ohio River at night, where immense factories on both banks of the stream are at work day and night, and their furnaces are continually belching forth fire and smoke.

In this busy centre, at Calumet, is located the immense Sewer Pipe plant of

THE CALUMET FIRE CLAY CO.,

which is one of the largest in the State, having a capacity of over two hundred carloads of manufactured product per month.

Their large press will make the heaviest 30″ Culvert Pipe, 2½″ thick and weighing over 325 lbs. per foot, at one stroke of the piston and without refilling the clay cylinder.

They have been in this business for over twenty years and thoroughly understand the requirements of the trade and can please the most exacting.

They are prepared to ship promptly by rail or water, making a specialty of furnishing large contracts, and making special designs when required.

They have issued a very complete catalogue of all the grades they manufacture for municipal, structural and ornamental purposes. The book contains valuable tables and information of interest to Engineers and Architects, and will be sent free to those making application.

Their Postoffice is at Calumet, Jefferson County, Ohio, and Telegraphic address, Elliottsville, via Steubenville, Ohio. Via W. U. T. Co. or via Postal Tel. Co.

SEWER PIPE ILLUSTRATIONS.

PRICE LIST.

STOVE PIPE THIMBLES.

Inches,	4½	5	5½	6	6½	7	Short, (6 In.)
Per Doz.,	$1.00	1.25	1.35	1.50	1.75	2.00	
Retail,	10	12	15	18	20	25	
Inches,	4½	5	5½	6	6½	7	9 Inches Long.
Per Doz.,	$1.75	2.00	2.25	2.50	2.75	3.00	
Retail,	20	25	30	35	40	45	
Inches,	4½	5	5½	6	6½	7	12 Inch. Long.
Per Doz.,	$2.75	3.00	3.25	3.50	3.75	4.00	
Retail,	30	35	40	45	50	55	

REVISED PRICE-LIST OF 1887.

VITRIFIED, SALT-GLAZED SEWER PIPE.

Calibre of Pipe.	Pipe per ft.	Elbows, Bends and Curves, 2 ft. long or less, each.	Pipe 2 ft. long with Branch or Inlet.	Traps each.	Weight per ft.
2 inch.	$ 14	$ 40	$ 63	$1 00	5
3 "	16	50	72	1 50	8
4 "	20	65	90	2 00	10
5 "	25	85	1 13	2 50	14
6 "	30	1 10	1 35	3 50	16
7 "	38	1 50	1 71	4 50	25½
8 "	45	1 80	2 03	5 50	27½
9 "	55	2 25	2 48	6 50	32½
10 "	65	2 75	2 93	7 50	35
12 "	85	3 50	3 83	10 00	50
15 "	1 25	4 75	5 63	15 00	65
18 "	1 70	6 50	7 65		84
20 "	2 25	7 50	10 13		100
21 "	2 50	8 25	11 25		110
24 "	3 25	11 00	14 63		130
30 "	5 50	20 00	24 75		260

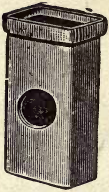
Stoppers or plugs ½ of 1 foot of pipe of the size of the Stopper.

Liberal discounts on above prices.

24 and 30-inch Pipe not subject to the regular discount.

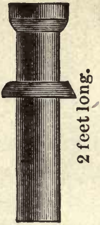
All shipments at the risk of the purchaser. No allowances to be made for breakage in any case.

FIRE CLAY CHIMNEY FLUE PIPE.

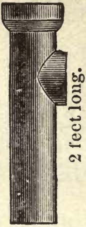


Pipe Hole.

Plain Piece.



Chime Bottom.

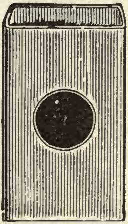


Opening.

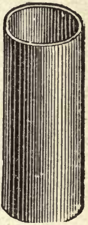
Drop Bottom.

WITHOUT SOCKETS.

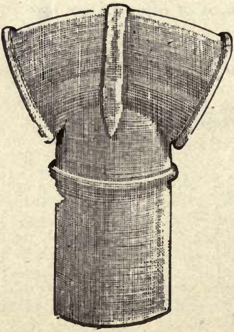
Straight.



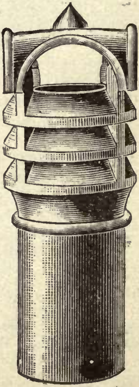
Pipe Hole.



Round Flue.



Anchor Bonnet.



Windguard Bonnet.

PRICE-LIST of CHIMNEY FLUES or STOVE PIPE,

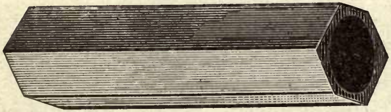
Adopted by the Terra Cotta Manufacturers' Association, January 27, 1887.

Calibre Round Flues inside.	Plain per foot.	Bonnets, 2 feet long each.	Bottoms, 2 feet long each.	Openings, single, 2 feet long each.	Openings, double, 2 feet long each.	Openings, single, closed ends, 2 feet long each.	Drop Bottoms, 3 feet long each.	Elbows, each.
5 inch.	$ 35	$1 40	$1 05	$1 05	$1 40	$1 40	$2 10	$1 40
6 "	40	1 60	1 20	1 20	1 60	1 60	2 40	1 60
7 "	50	2 00	1 50	1 50	2 00	2 00	3 00	2 00
8 "	60	2 40	1 80	1 80	2 40	2 40	3 60	2 40
9 "	70	2 80	2 10	2 15	2 80	2 80	4 20	2 80
10 "	85	3 40	2 55	2 55	3 40	3 40	5 10	3 40
12 "	1 10	4 40	3 30	3 30	4 40	4 40	6 60	4 40
15 "	1 50	6 00	4 50	4 50	6 00	6 00	9 00	6 00
18 "	1 80	7 20	5 40	5 40	7 20	7 20	10 48	7 20
20 "	2 20	8 80	6 60	6 60	8 80	8 80	13 20	8 80
21 "	2 50	10 00	7 50	7 50	10 00	10 00	15 00	10 00
22 "	2 75	11 00	8 25	8 25	11 00	11 00	16 50	11 00
24 "	3 50	14 00	10 50	10 50	14 00	14 00	21 00	14 00

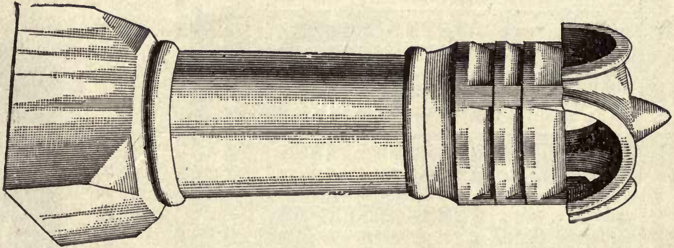
Additional lengths, charged in proportion. Bottoms closed, Openings or Flanges added, each to be charged one foot of pipe of the same size.

Chimney Bases 18 inches high or under, to be the price of 5 feet of Pipe of size of Bowl; over 18 inches in height, the additional length is to be charged.

DRAIN TILE.



Size of Bore, Inches.	Per 1000 feet.	Weight, per foot, pounds.
2	$25 00	2¼
2½	30 00	3½
3	35 00	4½
4	55 00	6½
5½	80 00	9½



"ACME"
Height, 3 feet.
Base, 12 inches square.
Our best and most complete Chimney top.
Price, $5.00.

CHIMNEY TOPS.

No. 1 "Acme,"	height	3 feet,	base	12x12 in.	$5 00
No. 0	"	2½ "	"	12x12 in.	2 50
No. 0	"	2 "	"	12x12 in.	2 25
No. 11	"	2½ "	"	13x13 in.	2 75
No. 14	"	2½ "	"	12x16 in.	3 00
No. 20	"	2½ "	"	12x12 in.	3 25
No. 30 Imperial	"	3 "	"	12x12 in.	4 50
No. 32 Open Leaf	"	3 "	"	13x13 in.	3 00
No. 29 Wallingford	"	4 "	"	13x17 in.	8 00
Indianapolis,	"	5 "	"	13x13 in.	10 00
No. 12	"	6 "	"	13x13 in.	12 00

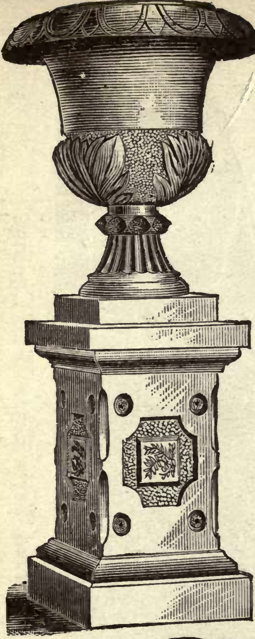
SEE ILLUSTRATED SHEET.

FLUE OR CHIMNEY LININGS.

Outside Measure. In 2 ft. Lengths.

4½ x 8½ inches	per foot,	$ 30
4½ x 13 "	"	45
4½ x 18 "	"	1 00
6 x 12 "	"	50
8½ x 8½ "	"	45
8½ x 13 "	"	65
8½ x 18 "	"	90
13 x 13 "	"	85
13 x 18 "	"	1 20
18 x 18 "	"	2 00

Openings and Registers 50 per cent. added.



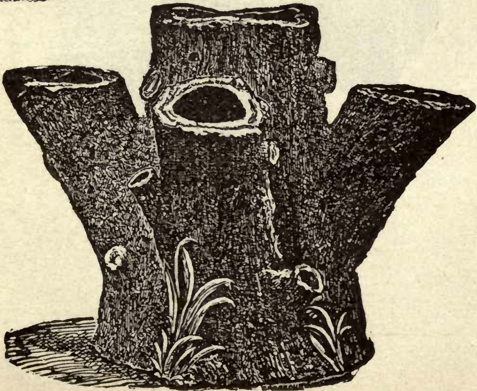
LAWN VASES.

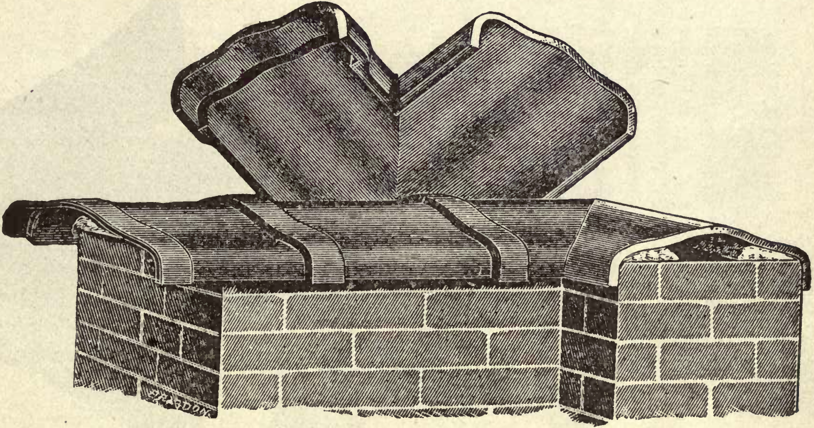
No. 1. Vase.

Height, 3 ft. 4 in.
Vase, 21 in. high,
11 in. diameter.
Pedestal, 19 in. high,
12 in. square.
Price, complete, $4.00
Vase without
Pedestal, $2.50
Pedestal, $1.50

No. 2. Rustic Stump.

Height, 22 in.
Diameter of base, 14 inches,
Price, $4.00





Improved Salt Glazed Terra Cotta Wall Coping.

Price List of Wall Coping.

Coping for 8 inch walls, all lengths, per foot	$0 26	Weight, 12 lbs.
" " 12 " " " " "	34	" 16 "
" " 17 " " " " "	52	" 23 "
Bends and Angles for 8 inch wall—each.........	90	
" " " " 12 " " "	1 10	
" " " " 17 " " "	2 50	

LIBERAL DISCOUNT.

IN YE OLDEN.....
CITY OF ANNAPOLIS, MD.

may be found many beautiful examples of Colonial Architecture in a good state of preservation. The rich dark-red bricks set in gray mortar are a prominent feature in these ancient landmarks.

The coloring is exquisite—a soft velvety dark-red hue verging almost to purple, has a life and sparkle in the ever changing sunlight that is fascinating, and of which one never tires.

Moss and lichens on the old shingle roofs and ivy on the sides of the buildings add to the picturesque beauty.

After many fruitless attempts to find a Clay that would burn to match these so-called "Old English" Bricks, we have at last found the material in the brick yards of Wm. H. Perot of Baltimore.

The bricks are made by the soft mud process on the Martin Machine.

They are burned at a high heat, almost to vitrifaction, so that many of the bricks have black heads. Being almost impervious to moisture, there will be little danger of efflorescence.

They are styled

"Old Colonial Red" Bricks.

Write for samples and prices to

WM. WIRT CLARKE & SON,

BALTIMORE, MD.

THE tide of progress has at last turned in the manufacture of plastering mortar from Carbonate of Lime. A process has been invented by which Quick Lime is reduced to a flour and brought into a condition that it will keep indefinitely without losing its strength. When made into mortar it will neither heat, swell nor change. Being free from lumps, there will be no possibility of popping or map cracks on the walls. Mortar colors when mixed with it do not bleach out but retain their full strength. It is also used as a retarder with quick-setting Hard Mortars.

PROFESSOR FREDK. J. H. MERRILL, State Geologist of New York gives an interesting report on the **Fossil Iron Ore** found near the town of Clinton, Oneida County, New York.

This is the noted red **Hematite Ore** that has been mined for the past hundred years, and is remarkable for its strong coloring properties and is largely used as a pigment.

There are often very unsatisfactory results had with **Mortar Colors,** because they run and streak the walls or fade.

Efflorescence on Brickwork is sometimes attributed to the use of mortar colors made from iron pyrites, containing a large percentage of **Sulphur.**

F. E. Kidder, C. E., in his excellent work on **"Building Construction,"** mentions **"Clinton Hematite,"** at the head of the list of **Standard Mortar Colors.**

The highest award of merit was given to this mortar color at the **World's Columbian Exposition, in 1893.**

CLINTON

Metallic Paint Co.

Color Grinders,

CLINTON, N. Y.

W. W. CLARKE & SON,
BALTIMORE,

Write for Illustrated Catalogue.

TEMPORA painting or "distemper" has been used for ages by civilized peoples. The Egyptians worked almost exclusively in distemper, and the colored fragments remaining from their temple-palaces are in many instances as clean and bright to-day as they were when executed, three or four thousand years ago. Whiting or Paris White has been generally used.

A water paint called "Duresco," the base of which is calcined zinc, is manufactured by The Silicate Paint Co., of London.

The cementing substance is a silica obtained from a mineral of volcanic origin.

It appears that this silica, being in such an extremely fine state of division, is conveyed into the pores of the stone, plaster or brick, and combines with any moisture already in the wall, when exposed to the atmosphere for a few hours, causing it to petrify and return to flint.

THE Island of Penang, the most northerly seaport of the Malacca Straits, is noted as the headquarters of the cocoanut palm.

This growth is simply wonderful. The tree gives annually several crops without artificial cultivation. Three hundred and sixty uses, it is said, can be made of its trunk, branches, leaves, fruit and juice. From the fibrous shell are made floor matting, door mats, plastering fibre, etc. This latter is especially useful in stucco, pebble-dash and general wall plastering. It is strong, durable, light and pliable, and from 3 to 6 inches in length. One bushel loose weighs less than two pounds. It is cleaner than cattle or goat hair, and very healthy, being free from decayed animal matter that is found in hair.

ARCHITECTS SPECIFY

Cocoa Plastering Fibre

FOR IMPORTANT WORK.

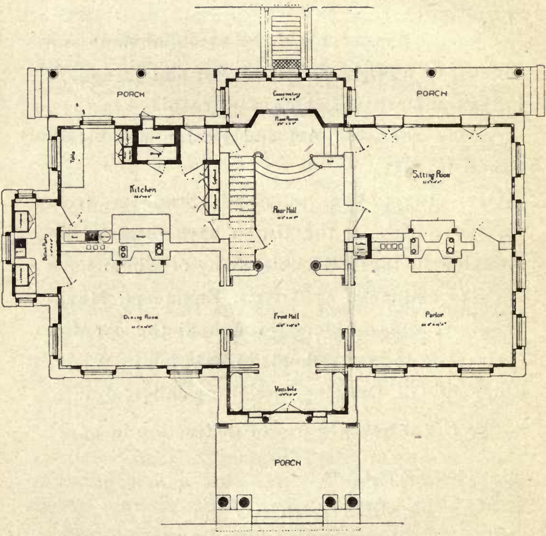
THE many large office buildings now being erected throughout the country must have thoroughly protected damp-proof walls and floors and flat tile water-tight roofs.

The WARREN CHEMICAL AND MANUFACTURING CO., of New York, are manufacturers of this class of materials.

A roof of one of our buildings was covered with their Asphalt Ready Roofing over nine years ago, and it is good to-day.

Suburban Residence.

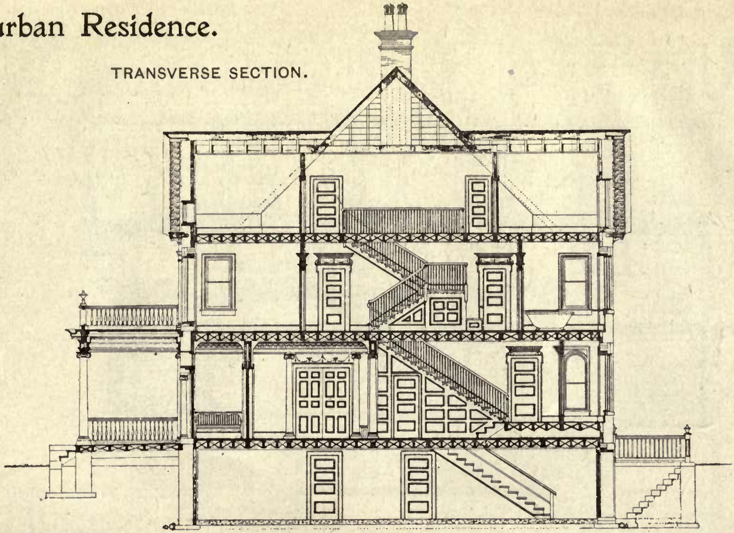
FIRST FLOOR PLAN.



STUDENT'S DESIGN. MARYLAND INSTITUTE.

Suburban Residence.

TRANSVERSE SECTION.

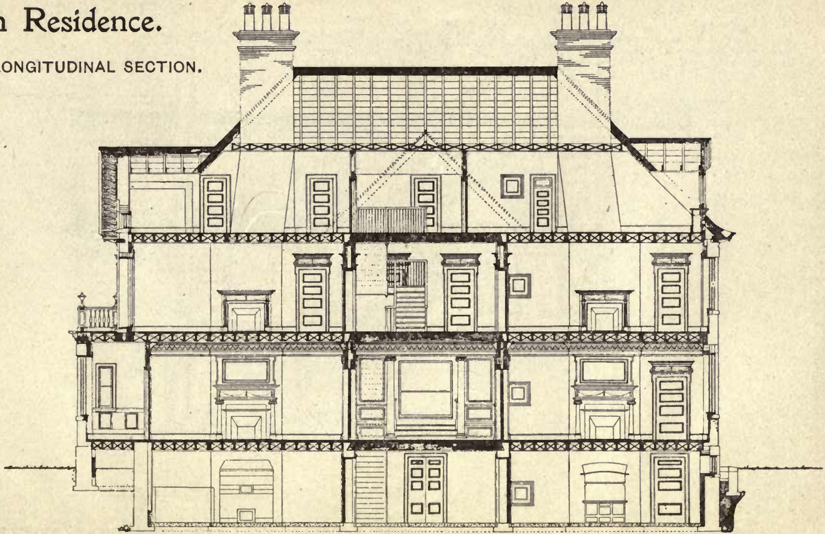


STUDENT'S DESIGN.

MARYLAND INSTITUTE.

Suburban Residence.

LONGITUDINAL SECTION.

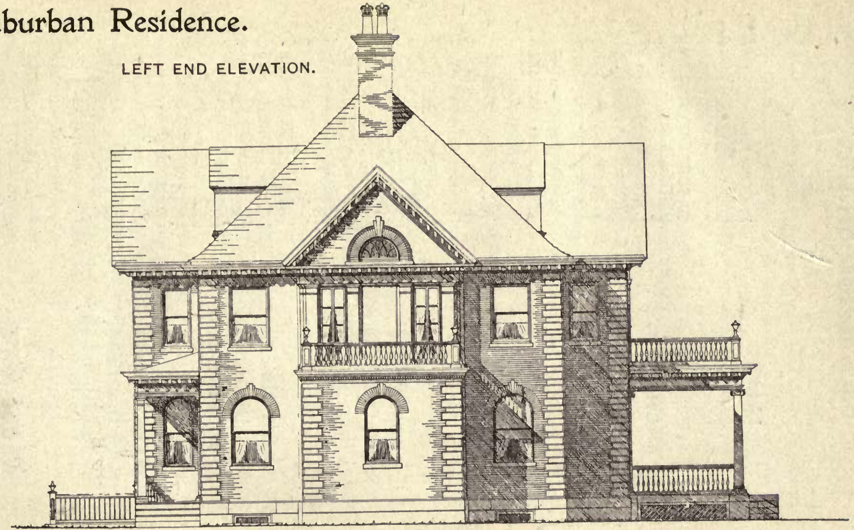


STUDENT'S DESIGN.

MARYLAND INSTITUTE.

Suburban Residence.

LEFT END ELEVATION.

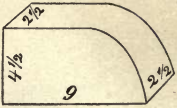


STUDENT'S DESIGN.

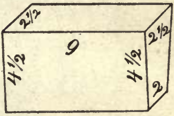
MARYLAND INSTITUTE.

FIRE BRICK SHAPES.

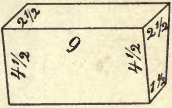
JAMB.



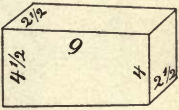
ARCH No. 1.
4 Ft. Dia. Inside.
72 Brick to Circle.



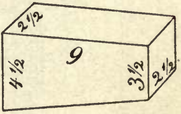
ARCH No. 2.
2 Ft. Dia. Inside.
42 Brick to Circle.



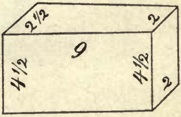
KEY No. 1.
12 Ft. Dia. Inside.
112 Brick to Circle.



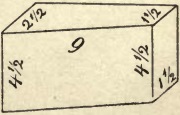
KEY No. 2.
6 Ft. Dia. Inside.
65 Brick to Circle.



WEDGE No. 1.
5 Ft. Dia. Inside.
102 Brick to Circle.



WEDGE No. 2.
2 Ft. 6 In. Dia. Inside.
63 Brick to Circle.



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