

THESES
on
CONCRETE AS A MATERIAL FOR ENGINEERING CONSTRUCTION WORK.

Submitted to the Faculty of the
O R E G O N A G R I C U L T U R A L C O L L E G E .

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by

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CONCRETE AS A MATERIAL FOR ENGINEERING CONSTRUCTION WORK.

Concrete is really one of the first materials used with the building trade. It was used by the ancient people extensively, and to this day their way of mixing concrete, is as a lost art to us. At this late date it is perfectly evident that concrete was used in Rome as well as in Greece and by the Indians of Mexico. The use of concrete with the Romans dates as far back as 509 B.C. The Pantheon at Rome, one of the most artistic architectural buildings in the world after 2,000 years, it yet stands, giving to the world a convincing evidence of the strength, durability, and permanence of concrete construction work.

Coming to modern times we find that concrete was largely used in the construction of many buildings in the early history of England which are still standing to this day.

What is concrete? The word concrete means to unite or coalesce into a mass or solid body, or to form into a mass by the coalescence of separate particles.

SELECTIONS OF CEMENT.

The first and most important thing nowadays is the selection of a good cement.

Since the chief manufactures of Portland cement have combined into one large firm, much more care should now be taken than when each Company worked for itself striving to put out the best cement.

An association of German Portland Cement Manufactures has given a definition of Portland Cement, thus binding its members to give a nearly uniform article. The substance of the definition is thus---the calcining of a thorough mixture consisting essentially of calcareous and clayey substances, and then grinding the same to fineness of flour, any article made different shall not be regarded as a Portland Cement.

DIFFERENT GRADES OF CEMENT.

The two most common cements are the natural and Portland Cements.

Natural cement as its name implies, is made from a lime stone rock containing from 30 to 40 % of clay. The burning of this cement is not carried on so long as in the burning of the Portland Cement, the resulting product being much lighter and quicker-setting. The natural cement varies in the different places it is mined and grades right into the Portland cement.

Portland Cement, named so because a rock was found near Portland, Maine, very much resembling the Portland Cement. The making of this cement was for a long time regarded as a secret. Now the secret is known, and any

body can make the cement by combining, burning, and grinding carbonate of lime and clay. The proportions are 72 to 77 % of carbonate of lime to 20 or 25% of clay. This mixture is ground to a fineness, mixed thoroughly, then the mixture is put into a calcined furnace where it is subjected to a very high heat, almost to fusion.

In this furnace it is reduced to a double silicate of lime and carbonate. This hard substance is lastly ground to a fineness and called Portland Cement.

As has been said there are many manufacturing plants of Portland Cement, whose brands of cement vary slightly according to the % of the different ingredients, but they all have certain definite limits which they are not allowed to go beyond.

The following blue-print gives an analysis of the two cements.

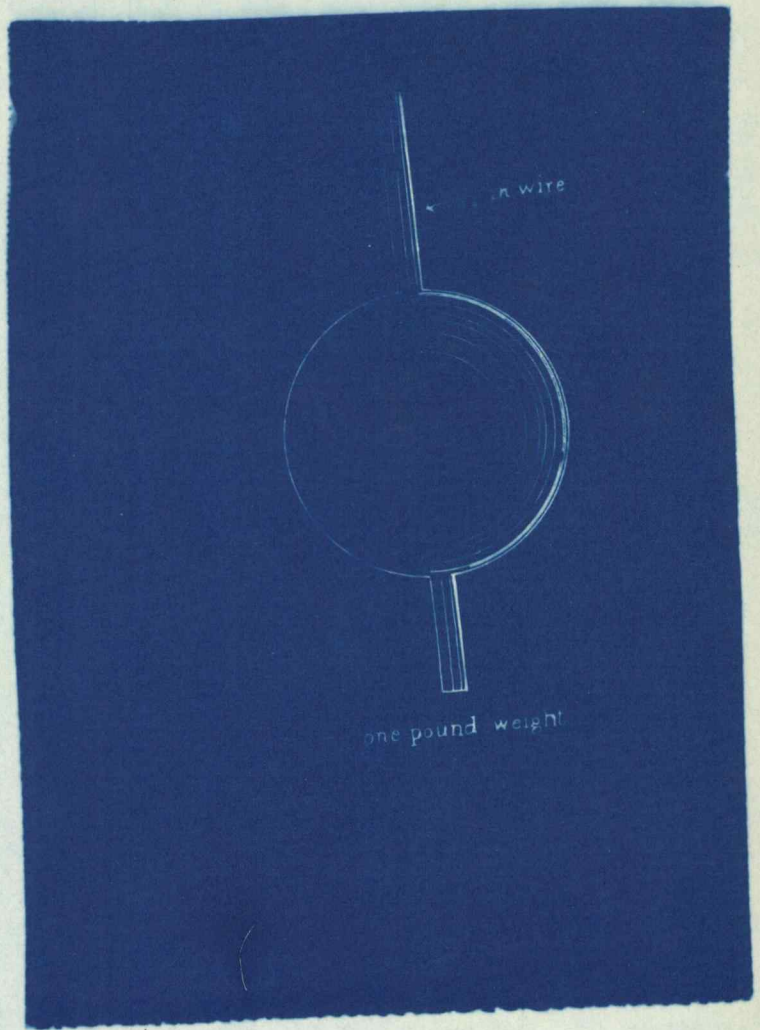
Comparing them we see that the natural cement has a higher % of Silica, about the same amount of alumen and a hydraulic index is also higher than in Portland Cement.

ANALYSES of PORTLAND CEMENTS

	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	Na ₂ O-K ₂ O	SO ₃	H ₂ O-&Loss
Atlas	21.30	7.65	2.85	60.95	2.95	1.13	1.81	1.41
Empire	22.04	6.45	3.41	60.92	3.53	—	2.25	—
Germania	21.14	6.30	2.50	66.04	1.11	—	—	2.91
Vyandotte	23.20	8.00	2.40	62.10	2.00	—	—	0.80
Giant	23.36	8.07	4.83	58.93	1.00	0.50	0.50	2.46

ANALYSES of NATURAL CEMENTS

Brand	Silica	Al	Fe. Oxide	lime	Magnesia	Potash and Soda	Carbon Acid, and Loss
Buffalo	24.30	2.61	6.20	39.45	6.16	5.30	15.2
Utica	34.66	5.10	1.00	30.24	18.00	6.16	4.8
Milwaukee	23.16	6.33	1.71	36.08	20.38	5.27	7.0
Hoffman	27.30	7.14	1.80	35.98	18.00	6.80	2.9



SCIENTIFIC TESTS OF CEMENT.

No.1.

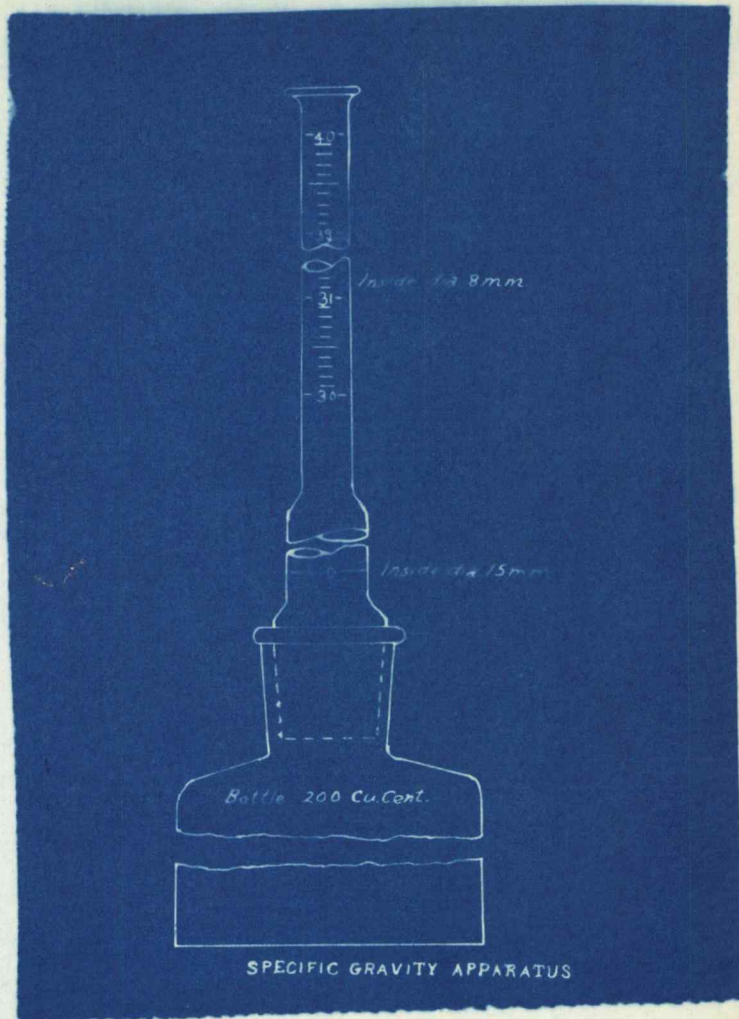
Test of Strength.

This includes the cement mixed with different portions of sand as well as the neat cement.

No.2.

Test of Fineness of Grinding.

All cement being required through a certain specified seive.



No. 3.

The test of thoroughness of burning.

No. 4.

Test of the Rate of Setting.

No. 5.

Perminancy of volume or the test of Soundness.

The fourth test is the test of the rate of setting.

When a needle $1/12$ of an inch in diameter with a one quarter pound weight, does not affect the cement when standing upon it upright, the setting has commenced.

When a needle 1/24 of an inch in diameter with a one pound weight has no effect, the setting is perfect.

Small pieces of cement 3 inches in diameter and about one-half inch thick are kept in moist air 24 hours. This pot is then watched for about thirty days at a normal temperature.

A third is put in the atmosphere of steam in a loosely closed vessel for five hours.

To stand the test these pieces should show no distortion, disintegration, checking, or cracking.

Here are some requirements that are generally made in the purchase of Portland cement.

1st. Specific gravity not less than 3.1

2nd. It shall not leave more than 8% on a No. 100 sieve and not more than 20% on a No. 200 sieve.

3rd. It shall take an initial set in not less than thirty minutes, and a hard set in not less than one hour nor more than 10 hours.

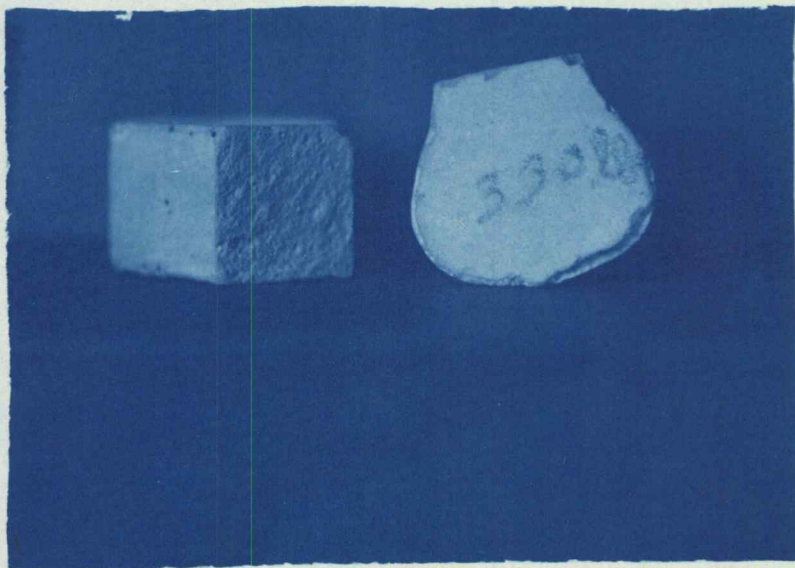
No. 4.

NEAT CEMENT.

A briquette 24 hrs. in moist air shall have a tensil strength of 150 to 200 pounds.

A briquette 7da. (6da in water) (1da in air) have a tensil strength of 450 to 550.

A briquette 28da (27 da. in water) (1 da. in moist air) shall have a tensil strength of 550 to 650.



The above briquette tested a tensile strength of 330 lbs.
after seven days. One day it being in moist air and
six days in
six days in water.



THE TESTING OF CEMENT.

All tests of cement are usually done by the tensile test. Cement is tested in this way by putting small pieces of cement called briquettes in a testing machine.

These briquettes have a cross section of one inch at the breaking point.

Fig. 1. shows a briquette one day old, which has been broken by a tensile pull of 330 lbs.

Here are some actual tests with different grades of Portland Cement made in laboratories at O.A.C.

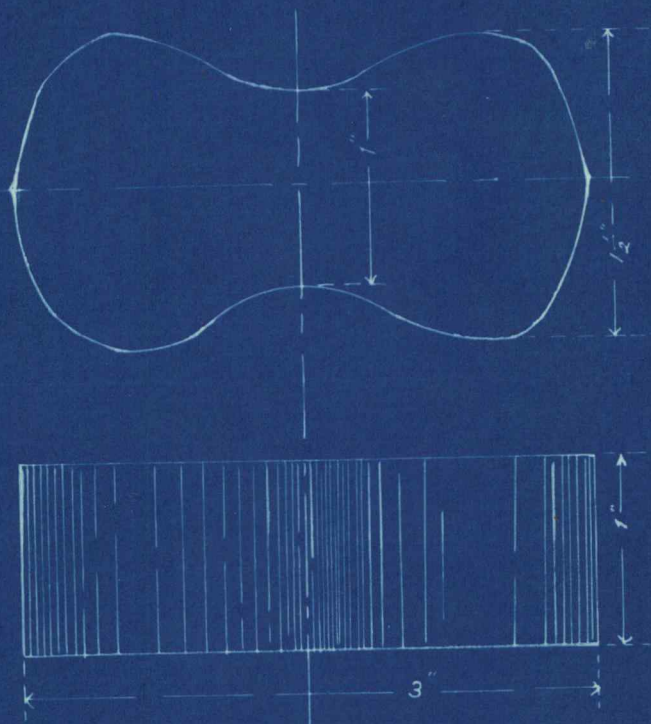
Brand	Briquette	age	strength.
Atlas	No. 1	24 hrs. in mois.	140 lbs.
Atlas	No. 2	" " " "	145 "
Atlas	No. 3	7da.--6da. in wat.	350 "
Atlas	No. 4.	1da. in moist air	330 "
<hr/>			
Wyand-	No. 5.	24hrs in moist air	130 "
otte	No. 6.	" " " "	" 140 "
"	No. 7.	7da.--1da in moist	" 400 "
"	No. 8.	6da. in water.	400 "
<hr/>			
Atlas	No. 1.	7da. 6 in water	135 "
"	No. 2.	1 " in moist air	140 "
One part cement to three parts standard sand.			

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The compressive strength of cement is very seldom made in the U.S. as the tensile strength is thought to be enough, as it gives results which always indicate the compressive stress. In making the test with parts of 1 and 3, the sand was not of the best quality which accounts for the low strength.

After the tensile strength test comes the test of "Fineness of grinding. It is very important that cem-

Briquet Detail.



Actual Size

ent should be ground to a regulation degree of fineness, for if the cement is not of the proper size it is as valueless for adhesive power as that much sand.

The third test known as the test of "Thoroughness of Burning." The specific gravity bottle is used for this test. If the cement is not burnt enough the specific gravity will be very light. The specific gravity of Portland cement averages about 3.05.

The three desirable elements in cement are:

- a. When treated in a certain way it shall develop a certain strength at the end of a specified period.
- b. It shall contain no ingredients that shall cause it to become weaker when becoming older.
- c. It shall keep a constant volume under all conditions.

If these three requirements are met ^{with} the cement is bound to be a good brand.

Color of Cement.

Before cement was known very well, many men judged its strength by its color, but this has of late been proven erroneous. The different colors come from the impurities.

For a long time a dark colored cement was thought the strongest, and therefore many dealers put ingredients in their cement to give it a dark color.

Colored Stone.

Satisfactory coloring of concrete, building blocks

is a new and a very good accomplishment. A house or building of these colored building stones indeed makes a very pretty building. In using coloring it should always be used with the dry cement before any water or sand is mixed.

Concrete is made from a mixture of crushed rock, trap rock or clean screened gravel size varying from a walnut to a hen's egg, clean coarse sand and cement. The proportions are so arranged that the voids between the rock are filled with sand, and the sand voids are filled with cement.

One way of telling how much cement it takes to fill the sand voids, is to put a given amount of sand in a jar, and then put in as much water as the sand will absorb, keeping account of water which will give nearly the amount of sand needed to fill the voids. A great deal depends on the character of stone used in the strength of concrete. It has been shown that when concrete is broken the line of fracture will run through the rock.

Sandstones, soft lime stones, slate, and shale should be avoided. Gravel is used more than any other aggregate, and it has proven very successful. ~~Cinder~~ broken brick, and terra cotta may be used.

All rock before use should be thoroughly cleaned, giving the cement a chance to get a hold.

The selection of a sand is very important in the mixing of concrete. Bad sand keeps the cement from setting as well as destroying its strength. Sand should be clean and coarse. Sand of angular grain is preferable. Sand that is very fine is injurious to the concrete, as the voids are so small it will not mix well with the cement. The grains of sand should run between $1/32$ to $1/16$ of an inch in diameter, and even as high as $1/8$ and $1/4$ if there is not too many large grains.

There are two or three ways to tell whether the sand is clean or not.

1. Rub it between the hands and see if it colors them.
2. Fill a jar $2/3$ full of sand and shake it well. After settling if there is a layer of mud over the sand it should not be used.

Too much attention can not be given to the mixing of concrete. All parts should be accurately measured. The mixing should be done on flat water-tight platforms.

The sand should first be measured and spread in an even layer on the platform. The cement is placed on top of the sand and these two ingredients are thus thoroughly mixed until it has a uniform color. When mixing by shovel as a rule it is turned three times. The gravel or stone is then put on top of this mixture and it is again turned about three times, water being added.

All gravel or stone before being used is thoroughly wash-

ed, so that the cement has a chance to adhere to the clean surface. When large rocks weighing from 10 to 50 lbs. are used, they are thrown into the concrete mixture immediately after it has been put in the forms. All concrete must, be set into the forms shortly after mixing for if concrete should start in setting on the mixing platform it loses much of its strength.

The selection of materials as a rough guide for various classes of work.

A RICH MIXTURE.

As for reinforced, floors, beams, columns, engine foundations etc. Proportions are 1:2:4 3.8 cu. ft. of cement, 7.6 cu. ft. of sand and, 15.2 cu. ft. of broken stone.

A MEDIUM MIXTURE.

As for side walks, ordinary floors, foundations, walls, etc: proportion 1: $2\frac{1}{2}$: 5 ---- 3.8 cu. ft. of cement, 9.5 cu. ft. of sand and 19 cu. ft. of loose gravel or broken stone.

AN ORDINARY MIXTURE.

As for heavy walls, piers, abutments, etc. The proportions are 1;3:6---3.8. cu. ft. of cement 4.4 cu. ft. of sand and 22-8 cu. ft. of gravel or broken stone.

A LEAN MIXTURE.

For ^{un}important work, where the concrete is subject to a compressive strain only, the proportions are 1:4:8.

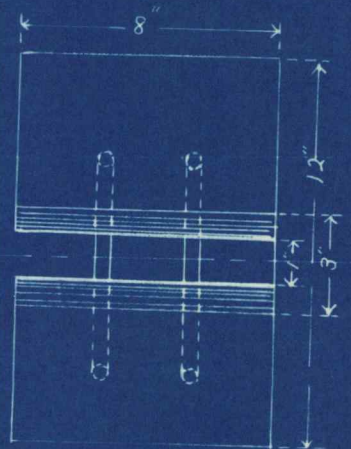
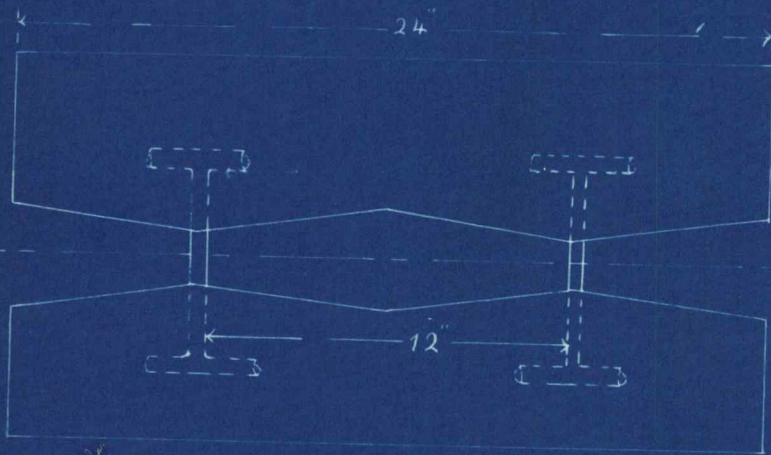
3.8 cu. ft. of cement, 15.2 cu. ft. loose sand and 30.4 cu.ft. of loose gravel or broken stone.

CONCRETE FORMS.

Dry lumber is not a good material for concrete forms as it will warp. Green timber is preferable, such as fir, yellow pine or spruce. If a smooth surface is desired of course the inside of the form lumber must have a smooth surface. It is a good idea to wet the forms before putting the concrete in, for by doing this the lumber will come off without tearing away the concrete with it. Sometimes the boards are greased with linseed oil or soap which keeps the concrete from adhering to it, but this plan is not advisable if the wall is to be plastered after wards.

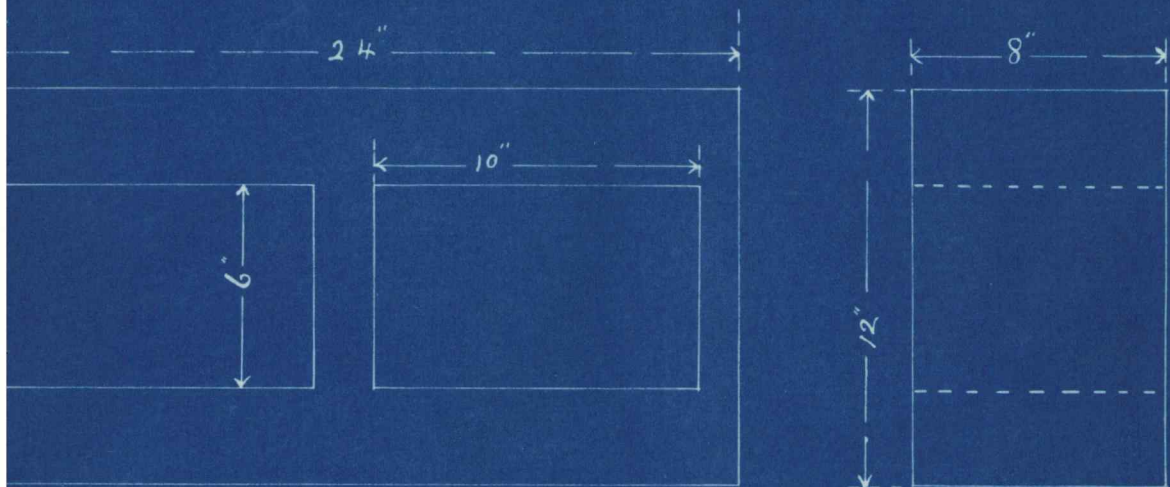
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DETAIL OF BLOCK.



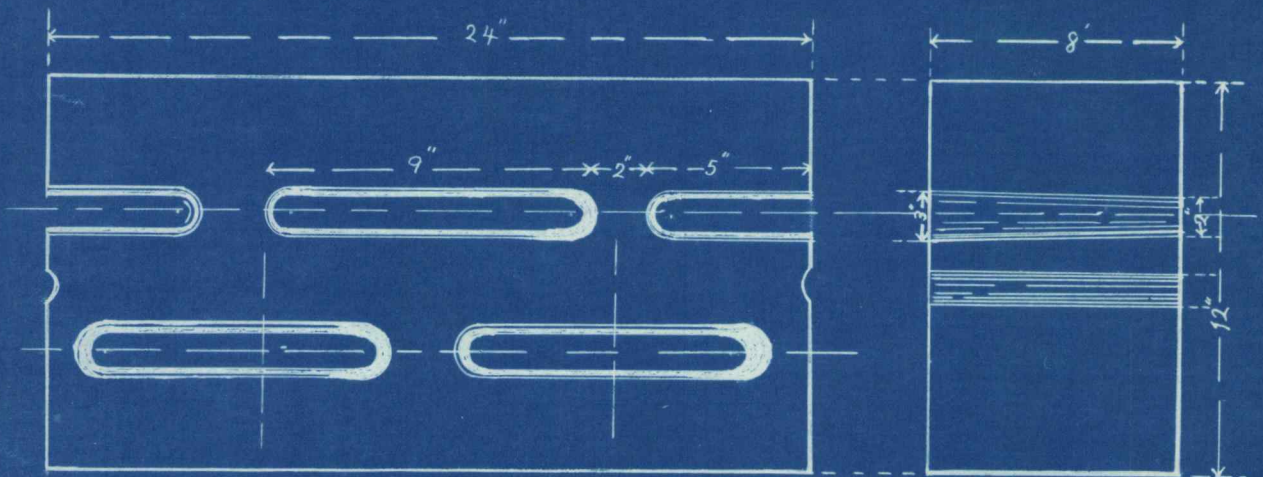
Scale - 1" = 6"

Single Air Space
Concrete Block Detail

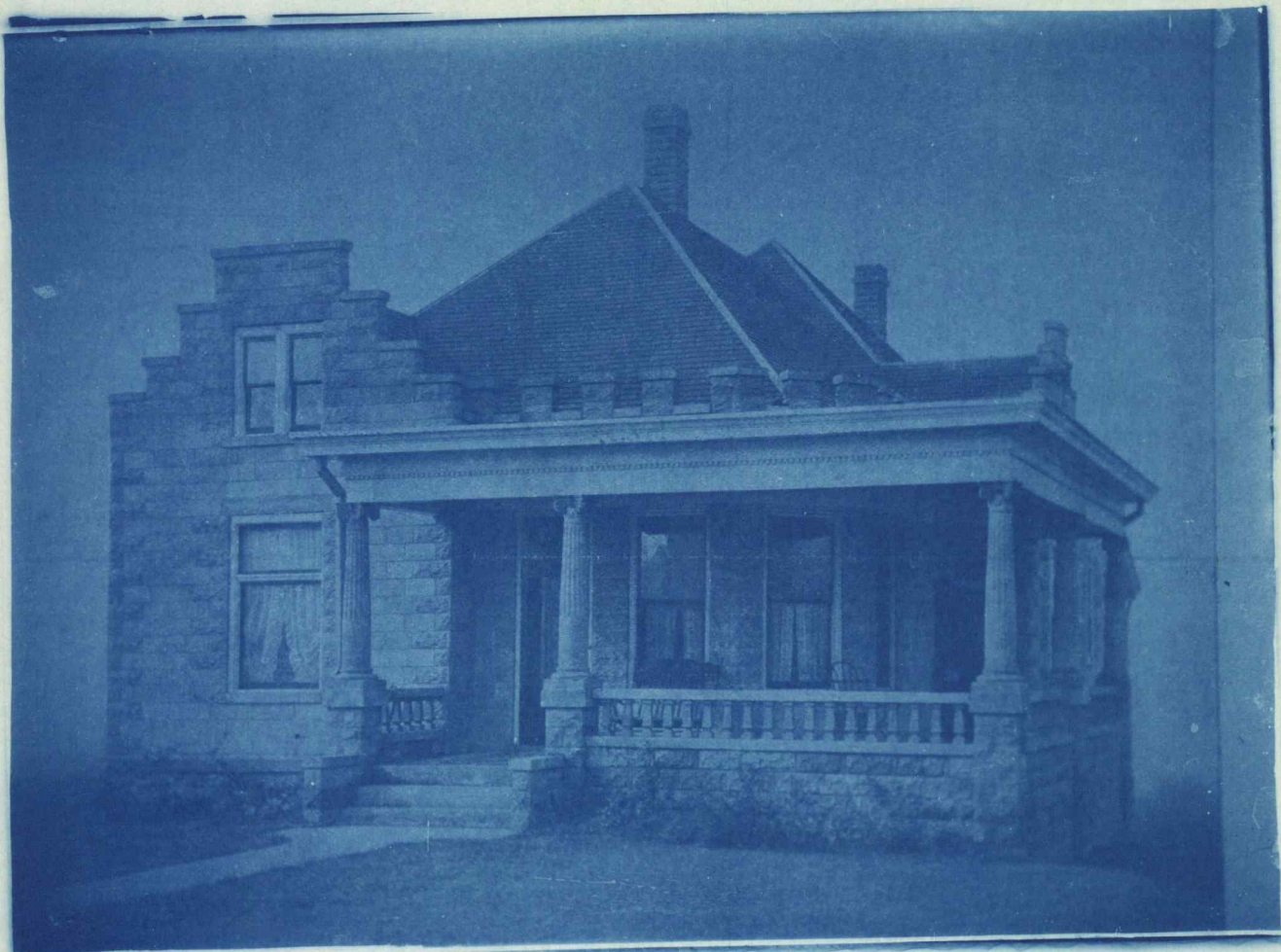


Scale - 1" = 6"

CONCRETE BLOCK DETAIL



Scale - 1" = 6"



CONCRETE BLOCKS.

For a long time concrete was not regarded as the cheapest and best material for buildings, especially dwelling houses. The one thing that was not liked was the easy manner in which heat and cold are conducted by concrete, but this has been offset by air spaced building blocks.

The blocks are of many different shapes, sizes, colors, and finishes.

The three blue prints of block details, are kinds used most.

There are many valuable features connected with the concrete building blocks that are making it very desirable for construction work of all kinds.

As lumber becomes scarce these concrete building blocks will be used more and more, for it is regarded as a much better material by constructing engineers than either brick or stone.

The reasons are that it opens a larger field for architectural design.

The air spaces make it a non-conductor of heat and cold.

The blocks are ^{more} easily handled than brick or stone. They can be made any color desired.

STANDARD SPECIFICATIONS OF CONCRETE BUILDING BLOCKS.

Owing to the lack of proper instruction many inferior concrete blocks have been made, for which reason the following specifications have been drawn up by the National Association of Concrete Machinery Manufacturers.

Definitions.

Sand that will pass through a screen $\frac{1}{4}$ inch mesh and be retained by a screen having a mesh of $\frac{1}{64}$ of an inch.

Gravel that will be retained by a screen having a $\frac{1}{4}$ inch mesh.

Crushed stone that can be retained in a $\frac{1}{4}$ inch screen.

Cement that will pass the tests of the American



Society for testing materials.

Sand must be sharp and gritty, free from loam or any other foreign material.

Enough cement should be used^{so} that it will thoroughly fill the sand voids, and this resulting mortar should fill the voids of the aggregate.

The determination of voids in sand is done by the water test. The average sand will absorb from 20 to 30 % of water which indicates that the relations of sand and cement should be about 3 and 4 to one.

MIXING OF MATERIALS FOR THE BLOCKS.

The cement and sand should be so mixed that it will have a uniform color. The amount of water used should be as great as possible without causing the material to stick in the moulds.

Batches of cement that are to be used should not be allowed to stand more than thirty minutes for it will greatly decrease its strength.

The tamping should be thorough.

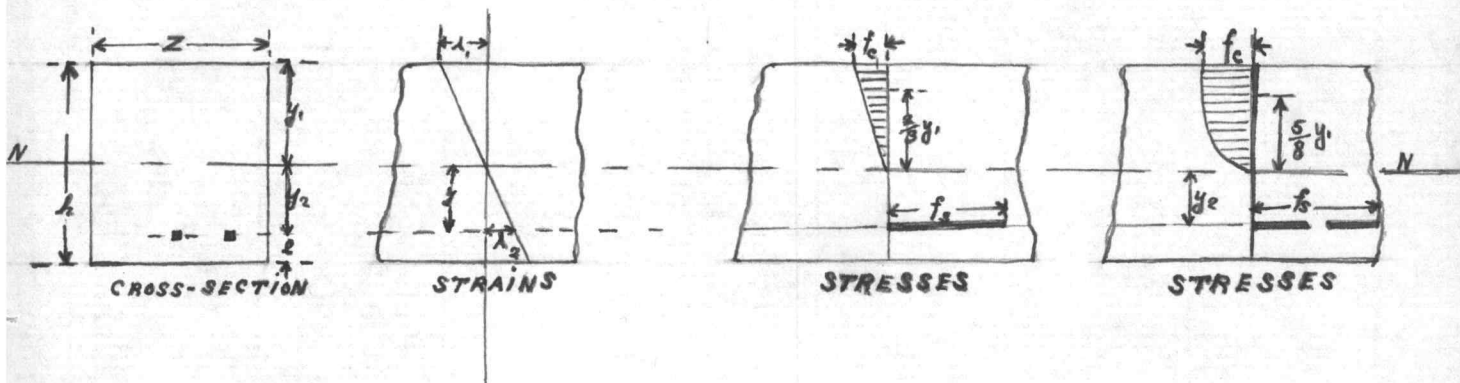
The block should be kept wet at least ten days after mixing.

The average cost of making blocks 8"X 9"X 24".

3 men at \$2.00 per day	equals	\$6.00
6 bbls of cement @ \$2.50	"	\$15.00
3½ yds of sand @ .50	"	<u>1.75</u>

Total for 120 blocks \$22.75

Cost per block -----19 ¢



Reinforced Concrete.

The compressive strength of concrete is from 5 to 10 times as great as its tension strength. Therefore concrete alone, cannot be used to resist a tension such as in beams.

Men began to think of some way that the concrete might be reinforced to hold together, and after many experiments iron which has about the same expansion when heated as concrete, was found to be the material needed to give the concrete reinforcement.

The growing demand of concrete reinforced buildings has been marvelous, and constructing engineers say it is the coming material for engineering purposes.

In figuring the tensile strength of reinforced concrete beams the tensile strength of concrete is neglected.