THESIS

COMPARATIVE TESTS OF CONCRETE BUILDING BLOCKS

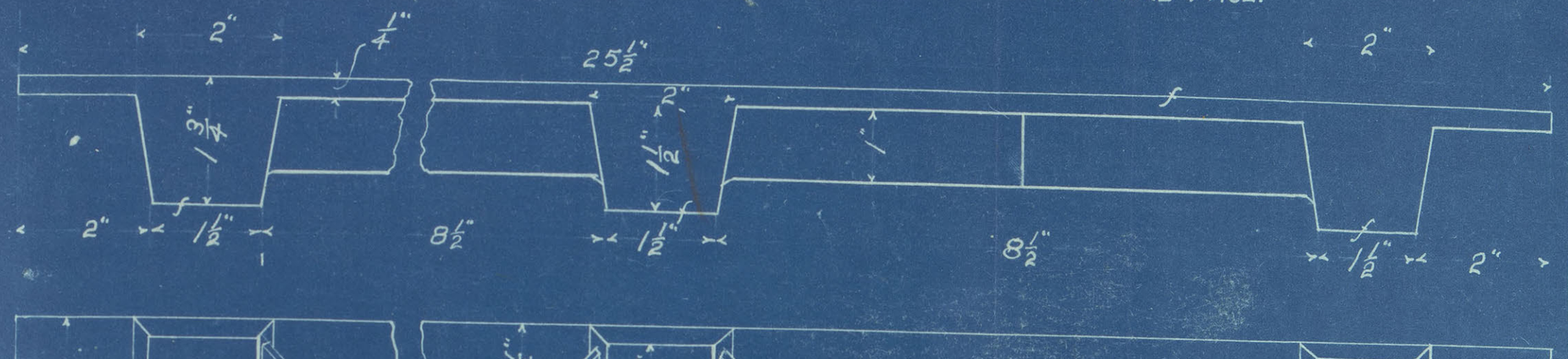
BY

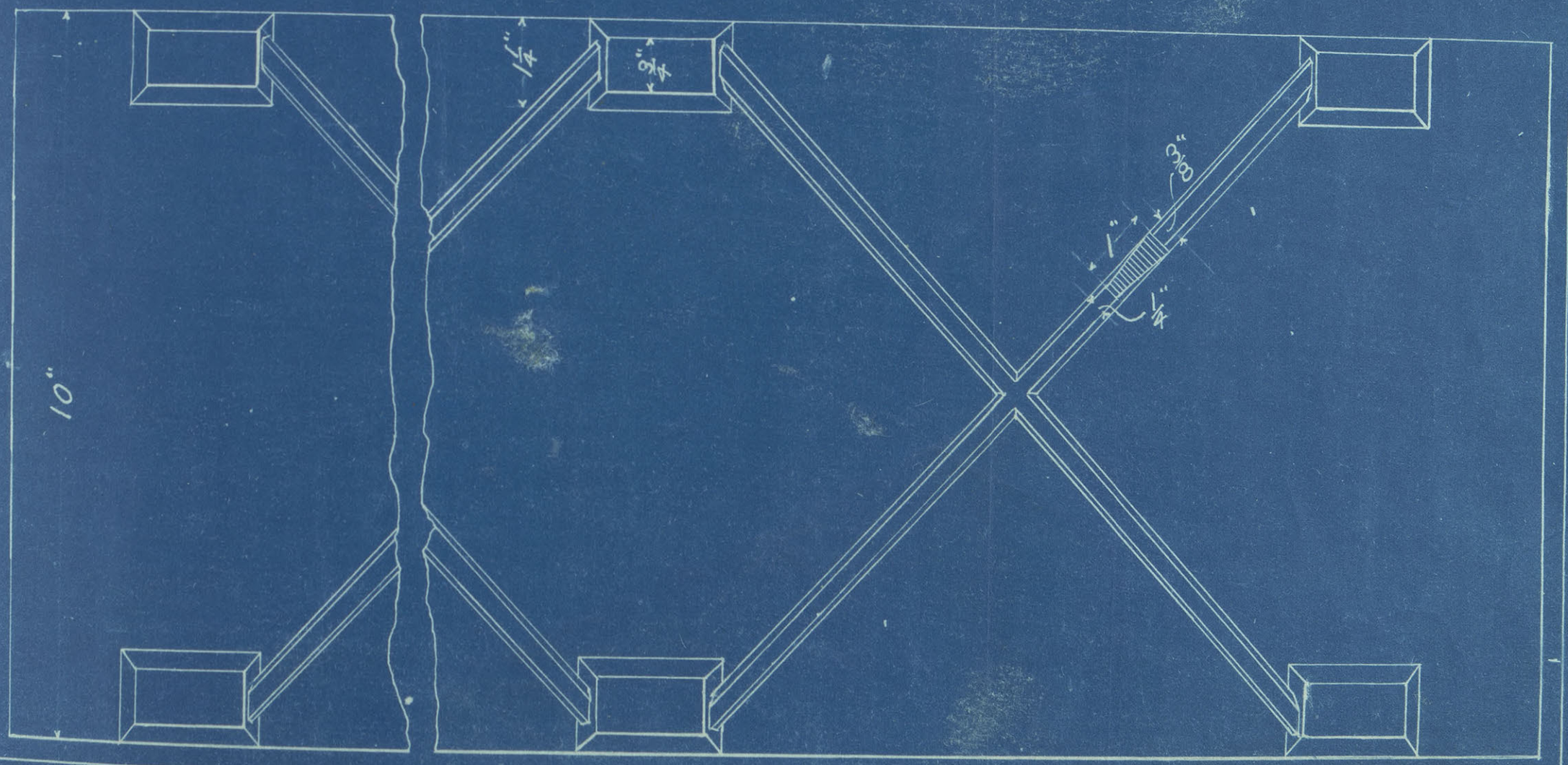
ROY C. BOWMAN

A. H. DENNELER

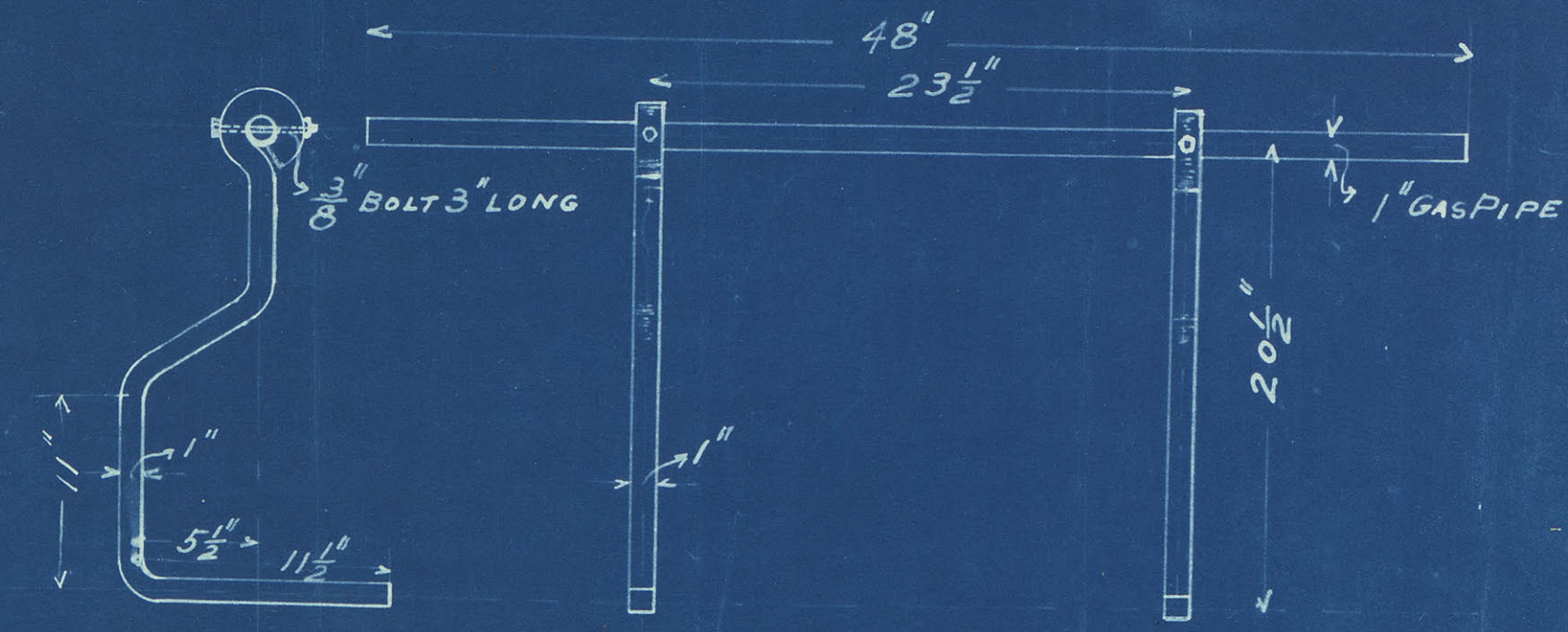
BOTTOM BOARD FOR CONCRETE BLOCK MACHINE CAST IRON SCALE HALF SIZE

MAKE WOOD PATTERN WITH DOUBLE SHRINKAGE AND ALLOWANCE FOR MACHINE FACE.





A.H. DENNELER-4-7-07.



CONCRETE BLOCK

LIFTER

SCALE 1"=8"

The object of this thesis is to determine the relative strength of concrete building blocks, (a) When made of different proportions of cement, sand and grit or gravel. (b) When made wet and dry. (c) When made face down and side down. Also to determine the cost of manufacturing the blocks, their fire resisting qualities and the durability of certain mineral colors when mixed in the face of the blocks.

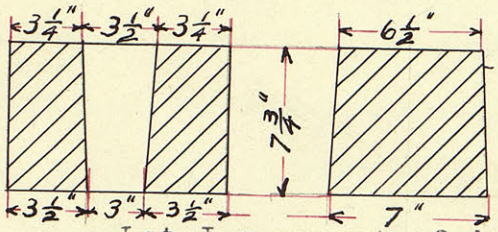
Groups M & N, O & P, I & R, S & T, W & V, and W & X, were made in the fall of 1906 by Mr. A. E. Ridenour for the mechanical engineering department. Some of these blocks were broken in curing so we filled out the groups and made such other blocks as were needed to make a complete test.

Standard Mixture

Through all our process of manufacture of blocks we used the standard method of mixing; that is, we first spread out the sand then added the cement. We mixed the two thoroughly until no streaks were seen, and then wet down the mixture and mixed until no lumps were in it. Lastly we added the grit or gravel and mixed as thoroughly as before. Unless otherwise stated, this method of mixing will be followed throughout our work.

At the outset we were troubled with poor cement, freezing weather and defective bottom boards. We first tried soaking the boards in oil which partly stopped their warping. We then designed cast iron bottom boards, as shown in the 1st blue print, the only objectionable feature of these being the weight. This we overcame by designing and using a lifter as shown by the 2nd blue print.

In our transverse test we placed the blocks in the Reihle' Testing Machine on knife edges 18" apart, and applied the load centrally. The blocks were tested in the same position as they would go in the building. The relative strength was noted from the modulus of rupture which we calculated from the theory of Goodwin. The theory is as follows: The section of the block is massed up into a trapezoid of the following dimensions;



Let I = moment of inertia

B = lower base

b = upper base

$\frac{b}{B}$ = n = ratio of upper to lower base

H = altitude

$$I = \frac{BH}{24}^{3}(n + 1) = \frac{7(7.75)}{24}^{3}(\frac{6.5}{7} + 1) = 261.8$$

Then also let H_1= distance from neutral axis to lower base

S = half of upper base

S_1= half of upper base

y = distance from neutral axis to most strained fibre

in tension.

Then $y = H_1 = \frac{H(2S + S_1)}{3(S + S_1)} = \frac{7.75(6.5 + 3.5)}{3(3.25 + 3.5)} = 3.83"$

If M = bending moment at time of rupture

W = central load

L = distance between supports

f = modulus of rupture

Then $f = \frac{My}{I} = \frac{WLy}{4I} = \frac{W(18 \times 3.83)}{4 \times 261.8} = .0658W = \text{constant}$

We took the average modulus of rupture of each group and found that the blocks made of the 1 : 3 : 2 mixture and mixed according to the standard method had the highest strength, the modulus of rupture being 268, while that of the 1 : 7 : 2 proportion had a modulus of but 169. The 1 : 3 : 2 mixture being thus 58.6% greater in its ultimate strength than the 1 : 7 : 2 mixture. The 1 : 3 : 2 proportion made by the dry process of mixing, (that is, the standard mixture) also showed an increase of 16% over the same mixture made to the usual concrete consistency.

The groups Y & Z were made of neat Atlas Portland Cement. They were mixed to ordinary molding sand consistency. The modulus of rupture for these groups was 208 lbs. per square inch, which did not justify the additional cost of cement used. It too was not as high as the 1 : 3 : 2 mixture. The modulus of rupture would probably increase with the age of the block.

The special group consisted of ten blocks made of 1 : 2 : 4 proportion. Five were made in the machine with face down, while five were made in a special box and made side down as they set in the building. The side down blocks showed the higher moduli of rupture, the average being 23.2% greater than that for those made with face down.

MECHANICAL ENGINEERING LABORATORY
KANSAS STATE AGRICULTURAL COLLEGE
CEMENT AND CONCRETE SERIES

200

Transverse TEST

Group M

Date of making Oct. 24 '06 Barometer 29.39

Date of testing June 1 '07 Age 7 Mo. 8 days.

Kind of Cement used atlas.

Kind of Sand used Blue River.

Kind of Grit used Joplin.

Kind of Gravel used Wild Cat creek.

Proportions used: Body: Cement 1. Sand 3. Grit & Gravel 2.

Face: Cement 1. Sand 2.

Total material used: Body: Cement 4 cuft. Sand 12 cuft. Grit & Gravel 8 cuft. Water 4 pails.

Face: Cement .8 cuft Sand 1.6 cuft Water To temper.

Method of mixing Standard mixture.

Method of curing Under shed. Sprinkled every day.

Number of hours in fire None Action in fire

MACHINE TEST.

No.	Breaking Load.	Modulus of Rupture.	Remarks.
1	4630.	305.	
2	4095.	270.	
3	3815.	251.	
4	4145.	273.	
5	3530.	232.	
6	3655.	240.	
7	3760.	248.	
8	4000.	264.	
9	4295.	283.	
10	4870.	321.	
	Average.	268.	

MECHANICAL ENGINEERING LABORATORY
KANSAS STATE AGRICULTURAL COLLEGE
CEMENT AND CONCRETE SERIES

201

Transverse TEST

Group O.

Date of making Oct. 24 '06 Barometer 29.89

Date of testing June 1, '07. Age 7 Mo 8 days

Kind of Cement used atlas.

Kind of Sand used Blue River.

Kind of Grit used Joplin.

Kind of Gravel used Wildcat creek.

Proportions used: Body: Cement 1 Sand 4 Grit & Gravel 2

Face: Cement 1 Sand 4

Total material used: Body: Cement 3 cu ft Sand 12 cu ft Grit & Gravel 6 cu ft Water 3 3/4 pails

Face: Cement .6 cu ft. Sand 2.4 cu ft. Water To temper.

Method of mixing Standard Mixture.

Method of curing Under shed, sprinkled every day.

Number of hours in fire None Action in fire

MACHINE TEST.

No.	Breaking Load.	Modulus of Rupture.	Remarks.
1	4145.	273.	
2	4635.	305.	
3	4090.	269.	
4	4380.	288.	
5	4730.	311.	
6	3410.	224.	
7	2930.	196.	
8	3745.	247.	
9	3235.	213.	
10	3590.	237.	
	Average	256.	

202

Transverse TEST

Group 2.

Date of making Oct. 25 '06. Barometer 29.98

Date of testing June 1, '07. Age 7 Mo. 7 days.

Kind of Cement used Atlas.

Kind of Sand used Blue River.

Kind of Grit used Joplin.

Kind of Gravel used Wild Cat Creek

Proportions used: Body: Cement 1. Sand 2. Grit & Gravel 2.

Face: Cement 1 Sand 2

Total material used: Body: Cement 4 cuft. Sand 8 cuft. Grit & Gravel 8 cuft. Water 4 pails.

Face: Cement 6 cuft. Sand 12 cuft. Water To temper

Method of mixing Standard Mixture.

Method of curing Under shed. sprinkled every day.

Number of hours in fire None Action in fire

Machine Test.

No.	Breaking Load.	Modulus of Rupture.	Remarks.
1	3570.	235.	
2	5600.	369.	
3	4250.	280.	
4	5035.	332.	
5	4440.	292.	
6	4260.	280.	
7	4050.	267.	
8	2796.	184.	
9	2550.	168.	
10	3285.	217.	

Average 262.

Transverse TEST

Group 8

Date of making Oct. 25, '06. Barometer 30.

Date of testing June 1, '07. Age 7 Mo. 7 days.

Kind of Cement used Atlas.

Kind of Sand used Blue River

Kind of Grit used Joplin.

Kind of Gravel used Wildcat creek

Proportions used: Body: Cement 1 Sand 5 Grit & Gravel 2

Face: Cement 1 Sand 3

Total material used: Body: Cement 3 cu ft. Sand 15 cu ft. Grit & Gravel 6 cu ft. Water 3 pails.

Face: Cement 4 cu ft. Sand 12 cu ft. Water To Temper.

Method of mixing Standard Mixture.

Method of curing Under shed, sprinkled every day.

Number of hours in fire None Action in fire

MACHINE TEST.

No.	Breaking Load.	Modulus of Rupture.	Remarks.
1	4475.	295.	
2	3580.	236.	
3	3645.	240.	
4	4140.	273.	
5	3620.	238.	Age 3 Mo 2 days
6	3505.	165.	
7	3200.	211.	
8	2866.	189.	
9	2195.	145.	
10	2900.	192.	

Average = 218.

Transverse TEST

Group U.

Date of making Oct. 31 '06 Barometer 30.48

Date of testing June 1 '07. Age 7 Mo 1 day

Kind of Cement used Atlas.

Kind of Sand used Blue River.

Kind of Grit used Joplin.

Kind of Gravel used Wild Cat Creek.

Proportions used: Body: Cement 1. Sand 7. Grit & Gravel 2.

Face: Cement 1. Sand 3.

Total material used: Body: Cement 2 cu ft. Sand 14 cu ft. Grit & Gravel 4 cu ft. Water 3 parts.

Face: Cement .4 cu ft. Sand 1.2 cu ft. Water To temper

Method of mixing Standard Mixture.

Method of curing Under shed, sprinkled every day.

Number of hours in fire None. Action in fire

Machine Test.

No.	Breaking Load.	Modulus of Rupture.	Remarks.
1	3375.	222.	
2	2670.	176.	
3	3370.	221.	
4	3575.	235.	
5	3195.	210.	
6	1355.	89.	Age 2 Mo 1 day
7	3956.	260.	
8	885.	58.	" " "
9	1100.	72.	" " "
10	2110.	139.	" " "

Average 168.

Transverse TEST

Group Special (in box)

Date of making Apr. 27, '07. Barometer 30.03

Date of testing June 1. '07. Age 1 Mo. 9 days.

Kind of Cement used Atlas.

Kind of Sand used Blue River.

Kind of Grit used Joplin.

Kind of Gravel used ~~Wildcat creek~~ None

Proportions used: Body: Cement 1 Sand 2 Grit & Gravel 4

Face: Cement No Sand face

Total material used: Body: Cement 1.3 cu ft Sand 2.6 cu ft Grit & Gravel 5.2 cu ft Water 2 pails.

Face: Cement —— Sand —— Water ——

Method of mixing Standard mixture.

Method of curing Under shed, sprinkled every day.

Number of hours in fire None. Action in fire

MACHINE TEST.

No.	Breaking Load.	Modulus of Rupture.	Remarks.
1	4065.	267.	
2	2210.	145.	Made extra wet. age 1 Mo 12 days.
3	2745.	180.	
4	4740.	312.	
5	4860.	320.	
6			
7			
8			
9			
10			

Average 244

206

Transverse TEST

Group Special (in machine)

Date of making Apr 22 '07 Barometer 30.03

Date of testing June 1, '07. Age 1 Mo. 9 days.

Kind of Cement used Atlas

Kind of Sand used Blue River

Kind of Grit used Joplin

Kind of Gravel used None

Proportions used: Body: Cement 1 Sand 2 Grit & Gravel 4

Face: Cement No face Sand

Total material used: Body: Cement 1.3 cu ft. Sand 2.6 cu ft. Grit & Gravel 5.2 cu ft. Water 2 pails.

Face: Cement — Sand — Water —

Method of mixing Standard mixture.

Method of curing Under shed, sprinkled every day.

Number of hours in fire None. Action in fire

MACHINE TEST.

No.	Breaking Load.	Modulus of Rupture.	Remarks.
1	3145.	207.	
2	3190.	210.	
3	3460.	228.	
4	2555.	168.	made extra unit
5	2705.	178.	age.
6			
7			
8			
9			
10			

Average 198.

Transverse TEST

Group W & X

Date of making ..... Barometer .....

Date of testing June 4 '07 Age .....

Kind of Cement used Atlas

Kind of Sand used Blue River

Kind of Grit used Joplin

Kind of Gravel used Wild Cat Creek

Proportions used: Body: Cement 1 Sand 3 Grit & Gravel 2

Face: Cement 1 Sand 3

Total material used: Body: Cement 2.5 cuft Sand 7.5 cuft Grit & Gravel 5 cuft Water 5 pails

Face: Cement .2 cuft Sand .6 cuft Water To temper

Method of mixing Standard mixture with enough water added to make it of usual concrete consistency.

Method of curing Under shed.

Number of hours in fire None Action in fire .....

Machine Test.

No.	Breaking Load.	Modulus of Rupture.	Age	Remarks.
W1 1	4195	276	7 Mo. 6 days	
X1 2	3660	241	7 " 2 "	
W2 3	3085	203	7 " 00 "	
X2 4	3685	242	6 " 29 "	
W3 5	4135	272	6 " 26 "	
X3 6	3800	250	6 " 24 "	
W4 7	2640	174	6 " 21 "	
X4 8	3365	221	1 " 12 "	
W5 9	1750	144	8 "	
X5 10	3430	226	1 " 7 "	
Average		225		

MECHANICAL ENGINEERING LABORATORY
KANSAS STATE AGRICULTURAL COLLEGE
CEMENT AND CONCRETE SERIES

208

Transverse TEST

Group Y & Z

Date of making Nov. 1, '06. Barometer 30.47

Date of testing June 4 '07 Age 7 Mo. 3 days.

Kind of Cement used Atlas.

Kind of Sand used Blue River.

Kind of Grit used Joplin.

Kind of Gravel used Wildcat creek.

Proportions used: Body: Cement 1 Sand 0 Grit & Gravel 0

Face: Cement 1 Sand 0

Total material used: Body: Cement 8 3/4 lbs Sand 0 Grit & Gravel 0 Water 5 pails

Face: Cement — Sand — Water —

Method of mixing Standard mixture.

Method of curing Under shed, sprinkled every day.

Number of hours in fire None Action in fire

MACHINE TEST.

No.	Breaking Load.	Modulus of Rupture.	Remarks.
1	2470.	163.	
2	3660.	241.	
3	4320.	284.	
4	3750.	247.	
5	3850.	253.	
6	3755.	247.	
7	2845.	187.	
8	3010.	198.	
9	2220.	146.	
10	2750.	281.	

Average = 223.

Table of Averages.

Group.	Modulus of rupture.
M.	268.
O.	256.
Q.	262.
S.	218.
U.	168.
Special. Box.	244.
Machine.	198.
W&X.	225.
Y&Z.	223.

Fire Test.

In the fire test the blocks were placed on a specially constructed five sided furnace, used in previous tests by Mr. R. A. Seaton and Mr. R. L. Hammaker. Each of the groups were piled one on top of the other in order of number, thus each group composed one side of the furnace. The furnace was fired with wood for an hour and a half. Water was then turned onto the whole pile, the fire extinguished and the results were noted as shown by the following data sheets. At the end of half an hour we noted that some of the blocks were cracked on the outside. At intervals after that we noticed that other blocks were cracking and this continued until at the end of the test there were only ten blocks that were not cracked. However, these crumbled to pieces on being taken down. The blocks on the top were the first to crack thus showing that the fire was probably the hotter at this portion of the furnace.

Fire TEST

Group 11

Date of making Oct 24 '06 Barometer 29.39

Date of testing June 10 '07 Age 7 Mo 17 days

Kind of Cement used Atlas

Kind of Sand used Blue River

Kind of Grit used Joplin

Kind of Gravel used Wild cat creek.

Proportions used: Body: Cement 1 Sand 3 Grit & Gravel 2

Face: Cement 1 Sand 2

Total material used: Body: Cement 4 cu ft Sand 12 cu ft Grit & Gravel 8 cu ft Water 4 pails

Face: Cement 8 cu ft Sand 1.6 cu ft Water To temper

Method of mixing Standard mixture.

Method of curing Under shed, sprinkled every day

Number of hours in fire 1.5 hrs. Action in fire After 30 min. Nº 3 was broken. At the end none of them was left all having cracked.

MACHINE TEST.

No.	Breaking Load.	Modulus of Rupture.	Remarks.
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Fire TEST

Group P

Date of making Oct 24 '06 Barometer 29.89

Date of testing June 10 '07 Age 7 Mo. 17 days

Kind of Cement used Atlas

Kind of Sand used Blue River

Kind of Grit used Joplin

Kind of Gravel used Wild Cat Creek

Proportions used: Body: Cement 1 Sand 4 Grit & Gravel 2

Face: Cement 1 Sand 4

Total material used: Body: Cement 3 cu ft Sand 12 cu ft Grit & Gravel 6 cu ft Water 3¾ pails

Face: Cement .6 cu ft Sand 2.4 cu ft Water To temper

Method of mixing Standard mixture.

Method of curing Under shed, sprinkled every day.

Number of hours in fire 1.5 hrs. Action in fire After 30 min. four of the group were cracked on face and by end of fire all the blocks were broken.

MACHINE TEST.

No.	Breaking Load.	Modulus of Rupture.	Remarks.
1			Age. 2 Mo. 11 days
2			
3			
4			
5			
6			
7			
8			
9			
10			

213

Fire TEST

Group TP

Date of making Oct 26'06 Barometer 29.98

Date of testing June 10 '07 Age 7 Mo. 16 days.

Kind of Cement used Atlas

Kind of Sand used Blue River

Kind of Grit used Joplin

Kind of Gravel used Wildcat creek

Proportions used: Body: Cement 1 Sand 2 Grit & Gravel 2

Face: Cement 1 Sand 2

Total material used: Body: Cement 4 cuft Sand 8 cuft Grit & Gravel 8 cuft Water 4 pails

Face: Cement 16 cuft. Sand 1-2 cuft. Water To temper.

Method of mixing Standard mixture

Method of curing Under shed, sprinkled every day.

Number of hours in fire 1.5 hrs Action in fire In a short time three of the blocks were cracked and all were broken by the end of the fire.

MACHINE TEST.

No.	Breaking Load.	Modulus of Rupture.	Remarks.
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Fire TEST

Group 7

Date of making Oct 25 '06 Barometer 30.00

Date of testing June 10 '07 Age 7 Mo 17 days.

Kind of Cement used Atlas

Kind of Sand used Blue River

Kind of Grit used Joplin

Kind of Gravel used Wildcat Creek

Proportions used: Body: Cement 1 Sand 5 Grit & Gravel 2

Face: Cement 1 Sand 3

Total material used: Body: Cement 3 cu ft Sand 15 cu ft Grit & Gravel 6 cu ft Water 3 pails

Face: Cement 4 cu ft Sand 12 cu ft Water To temper

Method of mixing Standard Mixture.

Method of curing Under shed. Sprinkled every day.

Number of hours in fire 1.5 hrs. Action in fire In 30 min. three of the blocks were cracked. At end of test all were broken.

MACHINE TEST.

No.	Breaking Load.	Modulus of Rupture.	Remarks.
1			
2			Age 2 Mo. 11 days.
3			
4			
5			
6			" " "
7			
8			" " "
9			" " "
10			

215

Fire TEST

Group V

Date of making Oct 31 '06 Barometer 30.48

Date of testing June 10 '07 Age 7 Mo 11 days

Kind of Cement used Atlas

Kind of Sand used Blue River

Kind of Grit used Joplin

Kind of Gravel used Wildcat creek

Proportions used: Body: Cement 1 Sand 7 Grit & Gravel 2

Face: Cement 1 Sand 3

Total material used: Body: Cement 2 cu ft Sand 14 cu ft Grit & Gravel 4 cu ft Water 3 pails

Face: Cement 4 cu ft Sand 12 cu ft Water To temper.

Method of mixing Standard mixture.

Method of curing Under shed, sprinkled every day.

Number of hours in fire 1.5 hrs Action in fire In a few minutes two blocks were broken and at the end of test not one was left for machine test.

MACHINE TEST.

No.	Breaking Load.	Modulus of Rupture.	Remarks.
1			
2			Age 1 Mo 27 days
3			" " "
4			
5			
6			
7			
8			
9			" " "
10			

Capacity of Machine

On June 3rd we made an all day run to determine the number of blocks that could be made by four men, two at the machine and two mixing the body. In 8 hours we made 65 blocks. Our work was delayed somewhat by having to wash the grit. The men were not used to the work and would probably do more had they been hardened to it. At any rate, the tamping would be very strenous work if more than the above number of blocks were made in 8 hours.

Coloring

In the test we have made over one hundred colored blocks. Several different colors were used; some proving satisfactory, others fading when exposed to the action of the air and water. The colors used were; German Vandyke Brown, Ultra Marine Blue, Italian Burnt Sienne, Judian Red, Lamp Black, Deep Perma Red and White. The results as noted to date are given on the following data sheets. The color test is not complete as yet, but observations will be made at intervals to determine to what degree the colors are permanent when exposed to the weather for long periods of time.

COLOR TEST

Color Deep Perma Red

Date of making June 3, '07 Barometer 29.84

Date of observation June 11, '07 Age 8 days.

Coloring materials used deep Perma Red.

BODY: Proportions: Cement 1 Sand 3 Grit & Gravel 2

Total..... Cement 1.2 cuft Sand 3.6 cuft Grit & Gravel 3.4 cuft Water 1 pail.

FACE: Mixture:..... Cement $\frac{1}{6}$ cuft; Sand $\frac{1}{3}$ cuft; 3# 1 oz. of Deep Perma Red; Water to temper.

Method of mixing Standard mixture.

Method of curing Under shed. sprinkled every day

Results as noted to date of observation Five blocks were made in this group. At the time of making the color was a very deep maroon. The color gradually became lighter until it is a light maroon.

the blocks are numbered A. 1 to 5.

COLOR TEST

Color Deep Perma red

Date of making June 3 '07 Barometer 29.89

Date of observation June 11, '07. Age 8 days

Coloring materials used Deep Perma Red.

BODY: Proportions: Cement 1 Sand 3 Grit & Gravel 2

Total..... Cement 2.4 cuft Sand 7.2 cuft Grit & Gravel 4.8 cuft Water 2 pails

FACE: Mixture:..... Cement 1/3 cuft; Sand 2/3 cuft; 2# 12 oz of Deep Perma Red.;

Method of mixing Standard mixture.

Method of curing Under shed, sprinkled every day.

Results as noted to date of observation The color at first was a deep maroon yet lighter than that of preceding page because of less coloring material in the face. It has changed to a very little lighter color to date.

In this group we made ten blocks numbering A 6-15.

COLOR TEST

Color Light Brown.

Date of making June 3 '04. Barometer 29.89

Date of observation June 11, '07. Age 8 days

Coloring materials used Italian Burnt Sienna.

BODY: Proportions: Cement 1 Sand 3 Grit & Gravel 2

Total..... Cement 2.4 cu ft Sand 7.2 cu ft Grit & Gravel 4.8 cu ft Water 2 pails

FACE: Mixture:..... Cement 1/3 cu ft ; Sand 2/3 cu ft ; 2 # 12 oz. of Italian Burnt Sienna. ;

Method of mixing Standard Mixture.

Method of curing Under shed, sprinkled every day.

Results as noted to date of observation In this group we made ten blocks numbering B 1 to 10. The color at making was a light "Terra Cotta" and is practically the same at date of observation.

COLOR TEST

Color Light Brown

Date of making June 3, '07. Barometer 29.89

Date of observation June 11 '07. Age 8 days.

Coloring materials used Italian burnt sienna.

BODY: Proportions: Cement 1 Sand 3 Grit & Gravel 2

Total..... Cement 2.9 cuft. Sand 7.2 cuft. Grit & Gravel 4 cuft. Water 2 pails.

FACE: Mixture:..... Cement 1/3 cuft.; Sand 2/3 cuft.; 5#8oz. Italian Burnt Sienna; Water to Temper

Method of mixing Standard mixture.

Method of curing Under shed, sprinkled every day.

Results as noted to date of observation In this group we made ten blocks numbering B1 to B20. The color is the same as used in preceding group except that more of the coloring material is used. The color is the same as at the making which was a dark "terra cotta".

COLOR TEST

Color Medium Red.

Date of making Apr. 1 07 Barometer 32.

Date of observation June 11 '07. Age 2 Mo. 10 days.

Coloring materials used Red Oxide of Iron.

BODY: Proportions: Cement 1 Sand 5 Grit & Gravel 2

Total..... Cement 1.5 cu ft. Sand 7.5 cu ft. Grit & Gravel 3 cu ft. Water 2 pails

FACE: Mixture:..... Cement 30# ; Sand 60# 3/4# Red oxide iron. water to temper. ;

Method of mixing Standard mixture.

Method of curing Under shed, sprinkled every day.

Results as noted to date of observation In this group we made ten blocks numbering C 1 to 10 At time of making they were of a good medium red but soon began to fade until at date of observation they are of a fawn color.

COLOR TEST

Color Blue.

Date of making Apr 6 '07 Barometer 32

Date of observation June 11 '07 Age 2 Mo. 15 days

Coloring materials used Ultra Marine Blue.

BODY: Proportions: Cement 1 Sand 5 Grit & Gravel 2

Total..... Cement 1.6 cu ft. Sand 8 cu ft. Grit & Gravel 3.2 cu ft. Water 2 pails.

FACE: Mixture:..... Cement 25# ; Sand 50# 1# Ultra Marine Blue.
Water to temper. ;

Method of mixing Standard Mixture.

Method of curing Under shed, sprinkled every day.

Results as noted to date of observation In this group we made ten blocks numbering D1 to 10 but the last three cracked in the curing. The color was of a dark blue when made but has faded out to a light sky blue.

COLOR TEST

Color White.

Date of making May 6 '07 Barometer 31.50

Date of observation June 11 '07 Age 1 Mo. 5 days.

Coloring materials used Hydrated lime & Marble dust.

BODY: Proportions: Cement 1 Sand 3 Grit & Gravel 2

Total..... Cement 2½ cu ft. Sand 7 cu ft. Grit & Gravel 4⅔ cu ft. Water 2 pails.

FACE: Mixture:..... Cement 32#; Sand 32#; 16# Marble dust.
8# Hydrated lime.;

Method of mixing Standard mixture.

Method of curing Under shed. Sprinkled every day.

Results as noted to date of observation ~~On~~ On this group we made ten blocks numbering E 1 to 10. The first five were made smoothed face ~~stand~~ and on the above date while the last five were made stone faced and 20 days later. Both were very dark when made but after setting they steadily became lighter until now they are of a pearl gray color, the newer blocks being the darker.

COLOR TEST

Color Dark Brown

Date of making May 6 '07 Barometer 30.02

Date of observation June 11 '07 Age 1 Mo 5 days.

Coloring materials used German Vandyke brown.

BODY: Proportions: Cement 1 Sand 3 Grit & Gravel 2

Total..... Cement 3 cu ft. Sand 9 cu ft. Grit & Gravel 6 cu ft. Water 2½ pails

FACE: Mixture:..... Cement 5/6 cu ft; Sand 1⅔ cu ft; 5# German Vandyke Brown.;

Method of mixing Standard mixture.

Method of curing Under shed, sprinkled every day.

Results as noted to date of observation There are thirteen blocks in this group numbering F 1 to 13. At making they were of a dark brown color but have become lighter until now they resemble dark sandstone.

COLOR TEST

Color Dark Brown

Date of making June 3, '07. Barometer 29.89

Date of observation June 11, '07. Age 8 days.

Coloring materials used German Vandyke Brown.

BODY: Proportions: Cement 1 Sand 3 Grit & Gravel 2

Total..... Cement 2⅓ cu ft. Sand 7 cu ft. Grit & Gravel 4⅔ cu ft. Water 2 pails

FACE: Mixture:..... Cement 18# 1 oz; Sand 48# 4# 8 oz of German Vandyke Brown;

Method of mixing Standard Mixture.

Method of curing Under shed, sprinkled every day.

Results as noted to date of observation The color was of a dark brown, apparently black, at making but it soon showed up as a very dark brown at date of observations. In this group we made ten blocks numbering F 14 to 23.

226

COLOR TEST

Color Black

Date of making June 3 '07, Barometer 29.89

Date of observation June 11 '07, Age 8 days

Coloring materials used Lamp Black.

BODY: Proportions: Cement 1 Sand 3 Grit & Gravel 2

Total..... Cement 2⅓ cuft. Sand 7 cuft. Grit & Gravel 4⅔ cuft Water 2 pails.

FACE: Mixture:..... Cement ⅓ cuft ; Sand ⅔ cuft ; 1 lb 10 oz Lamp Black.

Method of mixing Standard mixture.

Method of curing Under shed, sprinkled every day.

Results as noted to date of observation We made ten blocks in this group numbering 1 to 10. At date of making they were of a good black color & no change can be noticed to date of observation.

COLOR TEST

Color Dark Red

Date of making June 3 '07. Barometer 29.89.

Date of observation June 11 '07. Age 8 days.

Coloring materials used Indian Red.

BODY: Proportions: Cement 1 Sand 3 Grit & Gravel 2

Total..... Cement 2⅓ cuft. Sand 7 cuft. Grit & Gravel 4⅔ cuft. Water 2 pails.

FACE: Mixture:..... Cement ½ cuft.; Sand ⅔ cuft; 4" 1 oz. Indian; Red.

Method of mixing Standard mixture.

Method of curing Under shed, sprinkled every day.

Results as noted to date of observation A very deep wine red color when made. The color has become a very little lighter since made. In this group we made ten blocks numbering H.1 to 10.

Conclusions.

It is evident from the test that the M & N group (1 : 3 : 2) proportion, by standard method of mixing is the strongest. The 1 : 3 : 2 mixture by wet process did not show as high a modulus as the 1 : 3 : 2 made by standard method and for practically the same length of making.

From our tests we decided that the 1 : 3 : 2 mixture by the wet process is not economical on account of the length of time it takes to make a block. It takes 24 hours to make each block and besides this there is a danger of breaking the block when removing the core. If a large number of blocks are needed it is easily seen that it would take a long time to make them with one machine. However, if only a few are needed they can be made all right. They are excellent for use where it is desired to keep out moisture as they do not absorb moisture as readily as do the blocks made by the dry process.

We conclude that the W & V group is of little value in building purposes, because the blocks could not be handled roughly without danger of breaking. This is due to the fact that there is not cement enough in the 1 : 7 : 2 proportion for the amount of sand and gravel used.

Our fire test has proved beyond a doubt that the blocks will not withstand a fire. Two tests by fire had been made previously and our results were practically the same as the others. A small fire might do no perceptible damage, yet it must surely weaken the blocks. A fierce fire lasting for any length of time would destroy the blocks. We also must infer, since all of the blocks broke, that the ratio of the mixture did not make any diff-

erence in regard to their ability to withstand fire.

From the results shown by the ten blocks made to test the relative values of force down and side down tamping, we conclude that the side down tamping is the more effective. Since five blocks of each kind were tested and the blocks were made alternately face down and side down from the same mixture, the test would seem to be a fair one. When tested side down (as the blocks are placed in the building), the blocks showed an average of 18% greater than the modulus of rupture of those of the face down.

In the color test, the weaker proportion of coloring is a failure. It fades out rapidly and the effect is soon lost. The better proportions we believe will hold color to an extent of usefulness, but the expense of the amount of coloring material would make them uneconomical. The white is a good color and for fancy places on a house would make a very nice block, but the cost of materials for the coloring would raise the price too high for its use any where else. The Blue will not hold and the German Vandyke Brown cannot be depended upon to any great extent. Our observation shows that the blocks of a very dark brown color when made, after standing a month, lose a large part of their former color.

In the cost of production, we must figure from a supposition of four men working 8 hours and making 65 blocks. The cost of material will be that of 14 cu. ft. of cement, 42 cu. ft. of sand, and 28 cu. ft. of grit. The cost of the labor was four dollars ($4.00). These items all figured up and divided by the total of blocks made, give us the cost per block. Previous work along this line shows that dressed stone of same dimensions, cost one dollar apiece.