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The transmission of pressure in the dry pressing of typical building brick and fire brick mixes as affected by the variation in grog size

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THE TRANSMISSION OF PRESSURE IN THE DRY PRESSING OF TYPICAL BUILDING BRICK AND FIRE BRICK MIXES AS AFFECTED BY THE VARIATION IN GROG SIZE

By

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THESIS

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Professor of Ceramic Engineering

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ACKNOWLEDGMENT

This work has been done in accordance with the particular research investigations of the committee on Dry Press Process of the National Brick Manufacturers Association which has been carried on during the past two years at the Missouri School of Mines and Metallurgy at Rolla, Missouri.

The writer therefore wishes to take this time to thank the members of the Committee through whom this work was possible. Also to Doctor M. E. Holmes, for his kind assistance and cooperation throughout the entire time of the research, which he gave us willingly.

Also to my copartner, H. R. Herron, who shared in all the work, I wish to extend my heartiest congratulations and sincere thanks for his cooperation.

INTRODUCTION

In the formation of dry pressed ware, the transmission of pressure is of vital importance to the quality and charaater of the finished product as regards the resistance to spalling, load at high temperatures, slag action, abrasion and other physical properties. Furthermore, the transmission of pressure is a limiting factor as regards the size and irregularity of shape of a product manufactured by the dry press process

Prior to the time of this investigation several companies have succeeded in producing ware up to six (6) inches in depth; but an increase over six inches has resulted, in every case, in failure due to lamenations, soft centers, and air cracks, which were caused by entrapped air.

An ideal material for dry pressing would be one, which possesses the inherent characteristics of water, i.e., transmits pressure equally in all directions. Clay, unfortunately, does not posses this desirable property and it is the aim of dry press investigators to approach the ideal pressure transmission, which water possesses to such a marvelous degree.

The cause for unequal distribution of pressure in a clay mix is due to differences in grain size, friction between the grains, absence of lubrication in between the grains, and the difference in physical properties of the varius grains.

The Ceramic Industries of the United States have decided to conduct a series of investigations concerning the dry press problems of manufacturing bigger and better ware. So the National Brick Manufacturers Association have appointed a Committee on the Dry Press Process to work in Coordination with the Ceramic Department of the Missouri School of Mines and Metallurgy on a series of investigations relative to the important problems of the dry press process. This Committee has secured a hydraulic press, which is established at the Missouri School of Mines and Metallurgy.

The first problem investigated by the dry press Committee was conducted by C. M. Dodd[1], G. A. Page[2], F.F.Netzeband[3] on "The Transmission of Pressure in the Dry Pressing of Typical Building Brick and Fire Brick Mixes As Affected By the Degree of Pressure, Physical Character of the Mix Ingredients, and the Moisture Content of the Mix."

From this problem it was discovered that the more fines present, the less uniform is the pressure transmission. The building brick contained more fines that the fire brick, and the building brick mix, with its excess fines, transmitted pressure less uniformily than the fire brick mix did. It was also established that the most practical water content for dry press work was 7 - 8%. The most efficient pressure was found to be 2000 pounds per square inch for good pressure transmission.

(1) C.M.Dodd - Assistant Professor of Ceramic Engineering at the Missouri School of Mines and Metallurgy.

(2) G.A.Page - Senior Student of Ceramic Engineering at the Missouri School of Mines and Metallurgy in 1930.

(3) F.F.Netzeband - Senior Student of Ceramic Engineering at the Missouri School of Mines and Metallurgy in 1930.

This paper maybe obtained at the Technical Library of The Missouri School of Mines and Metallurgy at Rolla, Missouri.

The second problem studied was "The Effect of Occluded Air in Dry Press Mixes" by W. R. Powell[4]. From this problem it was discovered that the effect of a vacuum on the removal of occluded air increased the porosity. This was found to be true between 500 and 2000 pounds per square inch only. Above these pressures there was no decided effect produced by a vacuum.

The third problem investigated concerned "The Effect of Grog on Pressure Transmission in Dry Pressing." The investigators were C. M. Dodd[1] and M. E. Holmes[5]. It was determined that the addition of grog increased the pressure transmission, and near 50% addition of grog gave the maximum effect, although small additions aided materially. The more fines present in a mix, such as the building brick mix, the more grog was required to give good pressure transmission. The smaller the pressure, the more grog was required. It was concluded that through the use of a substantial amount of grog, shapes as thick as ten (10) inches could be formed with a minimum loss through physical defects arising from differential shrinkage.

The foregoing study has a direct bearing on this paper, since both are concerned with grog. Since optimum amount of grog was found, a problem in direct coordination with the above would be the optimum size of grog. Therefore, this paper originated from the above relationship and concerns the

(4) W.R.Powell - Senior Student of Ceramic Engineering at the Missouri School of Mines and Metallurgy in 1930.

(5) M.E.Holmes - Professor of Ceramic Engineering At the Missouri School of Mines and Metallurgy.

size of grog and the best pressure transmission.

MATERIALS USED

The clays used are representative of the various types of clays employed in dry press work. A mixture of 30% grog and 70% clay was used in each case. The grog used throughout the experiment was obtained from Cheltenham Brick.

The following list gives the clays used and the sizing to which they were ground:

(1) North Missouri Semi-flint Clay - 8 Mesh

(2) North Missouri Plastic Fire Clay - 8 Mesh

(3) Cheltenham Fire Clay - 8 Mesh

(4) St. Louis Surface Clay - 10 Mesh

SIZING OF MATERIAL

CLAY:

The primary crushing was performed in a jaw crusher and the lumps reduced to a maxium of one (1) inch. Then the secondary crushing was done by dry panning in a three foot, convertible, wet and dry pan, running at a speed of sixty (60) R.P.M. The openings in the screen plates of the dry pan were 1/8 inches in width and 5 inches in length. The milled material was screened through the desired mesh on a Great Western Manufacturing Company Gyratory Riddle. The tailings were returned to the dry pan and reground until the entire batch passed through the desired mesh.

GROG:

The grog was sized in exactly the same manner as the clay. The grog was ground in the dry pan and screened through six (6) different meshes, which were:

Through 2.5 mesh
" 4 "
" 8 "
" 20 "
" 40 "
" 60 ".

It must be emphasized that the grog was ground to the desired fineness so that it all passed through the required mesh. Therefore, the material that passed through 2.5 mesh contained all the different size grains which range below the size of the 2.5 mesh openings, while the grog which passed thru the 60 mesh screen contained only the grain sizes below the 60 mesh openings.

The reason for grinding the grog through the various meshes maybe explained by the fact that in the manufacturing operations of the industry, a separation of the different grain sizes is very seldom made. An attempt was made to approximate as nearly as possible the actual operative conditions in practice.

MIXING AND TEMPERING

The first step was to weigh out the grog and clay in the correct proportions - 30% and 70% respectively. In each case the total mixture weighed 35 pounds, as this weight gave a plentiful allowance for each test block. Then the mixture was placed in a small kneading machine, and allowed to mix dry for one minute. An eight (8) per cent addition of water was added to the mixture, and the mixer allowed to run for five minutes in order to provide an equal distribution of water. The weight of water added in each case was 2 pounds - 12.8 ounces. The resulting mixture was dumped from the kneading machine onto a 2.5 mesh screen, and brushed through in order to remove all lumps of coagulated clay.

Each batch was covered with a damp cloth and allowed to age for twenty-four hours before being formed in order to insure a homogeneity of the mix.

Samples for moisture determination were taken from each batch before forming into blocks.

FORMING

A hydraulic dry press made by the Hydraulic Press Manufacturing Company of Mount Gilead, Ohio, was used for forming all test blocks.

The operating specifications of this press are as follows: The maximum pressure obtainable on this press is 5840 pounds per square inch, which gives a total pressure of 135 tons on the mold box surface of $9\frac{3}{4}$ inches by $4\frac{3}{4}$ inches. The maximum depth of the mold box is 22 inches, which permitted blocks to be formed up to 10 inches in depth. The possible lower ram travel was 22 inches, and the mold box itself traveled $1\frac{3}{4}$ inches.

A gauge was located between the electric plunger pump and the compression cylinder of the dry press, indicating at all times of compression the pressure on the clay column. The forming pressure on all blocks in this investigation was 500 pounds per square inch.

In the actual formation of the blocks the lower ram was first raised to within two inches of the top of the mold box. Then a weighed amount of the aged mixture was introduced into this two inch depression, and a flinted tissue towel was placed on top as a separating medium between layers. The ram was lowered another two inches, and the same operation repeated until the column of clay was built up into eight 2 inch layers.

Since each layer was of the same weight and thickness, the test block was kept uniform throughout.

After the required number of layers had been placed in the mold box, the compressing machinery was set into operation, and the required pressure of 500 pounds per square inch was applied for two seconds and instantly released. The resultant block was removed from the mold box and its total height measured.

TEST SPECIMENS

There were several proposed methods of obtaining the pressure transmission in the whole block, but due to labaratory limitations, lock of time, and lack of financial backing it was finally decided upon to measure the pressure transmission by Means of the variation in Apparent Porosity between the layers throughout the entire block.

The next item to consider was a method of obtaining representative samples from each layer, on which to measure the Apparent Porosity. This was solved by breaking each layer into four equal parts, and selecting two opposite corners on which an average porosity could be obtained for the entire layer. The flinted tissue towel permitted the layers to be separated easily. Then each layer was broken into its four quarters by striking sharply over a knife edge.

23-4	23-4X'
23-4'	23-4X

The above illustrating the practice employed throughout in numbering the test specimens. This diagram pictures layer No. 4 in block No. 23. The specimens used were 23-4 and 23-4x, the other two being reversed and saved in case of a necessity of repetition in measuring the Apparent Porosity.

DRYING

After the test specimens were selected and trued up, in order to eliminate all the loose corners, they were placed on a pallete board and allowed to dry at room temperatures for five days. At the end of this time the specimens were mechanically dried for 14 hours or more at 235°F.

At the end of the drying period the samples were taken out of the dryer and allowed to cool in a dessicator. Then they were removed from the dessicator and given a thorough brushing to remove all loosely adhering particles.

The test specimens were then ready for the final operation.

APPARENT POROSITY DETERMINATIONS

The first sep in the determination of Apparent Porosity was in obtaining the dry weight of the specimens.

Immediately after each specimen had been weighed dry, it was immersed in kerosene to prevent the moisture in the air from entering into the pores of each sample. The next step was to place the specimens, immersed in kerosene, in an evacuating chamber and to apply a vacuum of 29 inches of mercury. These specimens were subjected to this treatment for two hours. They were, then, removed from the container and placed in kerosene until they were needed. Then, the saturated and suspended weight of each specimen were obtained and tabulated.

CALCULATIONS

From the dry, saturated and suspended weights obtained on the test specimens, the Apparent Porosity for each sample was calculated by use of the following formula:

$$\%\ \text{App. Por.} = \frac{\dfrac{\text{Saturated wt} - \text{Dry wt}}{\text{Sp. Gr. of Kerosene}}}{\dfrac{\text{Saturated wt} - \text{Suspended wt}}{\text{Sp. Gr. of Kerosene}}} \times 100$$

Since the Specific Gravity of the Kerosene remains constant throughout, the formula was reduced for the calculations to:

$$\%\ \text{App. Por.} = \frac{\text{Saturated wt} - \text{Dry wt}}{\text{Saturated wt} - \text{Suspended wt}} \times 100$$

GRAPHICAL REPRESENTATION OF DATA

The drawing of conclusions and discussion of results was facilitated by transforming statistical data to graphical representation.

On the following pages are the data and curves obtained.

Only one block was run on each grog size with the exception of blocks Nos. 4, 6, 10, and 14, where it was found necessary to run check blocks. The curves plotted were taken as an average of both the original and check blocks.

In order to observe the effect in variation of grog size, it was necessary to keep everything constant except the size of grog.

CONSTRUCTIVE DATA ON ALL BLOCKS

No.	Grog Size	Layer Wgt	Total Height	% Moisture	Clay
1	- 2.5	3#-14oz	8-9/16"	8.65	No.Mo.Semi-Flint
2	- 4.0	3#-12oz	8-5/16"	8.78	"
3	- 8.0	3#-11oz	8-3/16"	9.00	"
4	-20.0	3#- 8oz	7-15/16"	8.46	"
5	-40.0	3#-11oz	8-6/16"	8.65	"
6	-60.0	3#- 6oz	7-13/16"	8.86	"
7	- 2.5	3#- 4oz	7-14/16"	8.88	St.Louis Surface
8	- 4.0	3#- 6oz	8-4/16"	7.86	"
9	- 8.0	3#- 1oz	7-8/16"	8.36	"
10	-20.0	3#- 3oz	7-10/16"	8.49	"
11	-40.0	3#- 0oz	7-9/16"	8.28	"
12	-60.0	3#- 1oz	. 8"	8.21	"
13	- 2.5	3#- 8oz	7-12/16"	8.63	Cheltenham
14.	- 4.0	3#-10oz	8-6/16"	8.06	"
15	- 8.0	3#- 6oz	7-10/16	8.45	"
16	- 20.0	3#-10oz	7-11/16"	7.80	"
17	-40.0	3#- 5oz	7-11/16"	8.15	"
18	-60.0	3#- 5oz	7-9/16"	8.63	"
19	- 2.5	3#-11oz	8-3/16"	8.26	No.Mo.Plastic Fire
20	- 4.0	3#-11oz	8-4/16"	8.45	"
21	- 8.0	3#- 9oz	8-1/16"	8.17	"
22	-20.0	3#- 8oz	8"	8.43	"
23	-40.0	3#- 9oz	8-5/16"	8.40	"
24	-60.0	3#-10oz	8-12/16"	8.38	"

COMPLETE DATA ON ALL BLOCKS

Block	Dry	Sat	Sus	Sat-Sus	Sat-Dry	% Por.	Aver.Por
1-1	372.5	410.5	261.5	149.0	38.0	25.50	22.32
1-2	379.5	414.0	263.0	151.0	34.5	22.85	21.40
1-3	342.0	375.0	237.5	137.5	33.0	24.00	22.13
1-4	357.0	392.0	247.0	145.0	35.0	24.14	21.86
1-5	393.0	430.5	272.5	158.0	37.5	23.74	22.42
1-6	390.0	426.0	270.0	156.0	36.0	23.08	22.01
1-7	347.3	379.0	241.5	137.5	31.7	23.06	21.57
1-8	376.0	409.5	260.5	149.0	33.5	22.48	20.98
1-1x	406.5	439.0	278.5	160.5	32.5	20.25	
1-2x	395.0	426.0	270.5	155.5	31.0	19.94	
1-3x	386.5	417.5	264.5	153.0	31.0	20.26	
1-4x	414.5	451.0	284.5	186.5	36.5	19.57	
1-5x	415.5	450.5	284.5	166.0	35.0	21.09	
1-6x	425.5	459.5	292.0	203.5	34.0	16.71	
1-7x	371.0	400.5	253.5	147.0	29.5	20.07	
1-8x	394.0	424.0	270.0	154.0	30.0	19.48	
2-1	356.0	387.5	246.0	141.5	31.5	22.26	21.46
2-2	357.5	390.5	248.0	142.5	32.0	22.46	22.28
2-3	343.0	376.0	238.5	137.5	33.0	24.00	22.88
2-4	343.0	375.0	238.0	137.0	32.0	23.36	23.37
2-5	367.5	402.0	254.0	148.0	35.5	23.99	22.49
2-6	350.0	383.5	243.0	140.5	33.5	23.84	21.65
2-7	345.5	377.0	240.0	137.0	31.5	22.99	21.33
2-8	351.0	382.5	243.5	139.0	31.5	22.66	20.94
2-1x	387.5	418.0	265.5	152.5	31.5	20.66	
2-2x	435.0	473.0	301.0	172.0	38.0	22.09	
2-3x	415.5	451.5	286.0	165.5	36.0	21.75	
2-4x	407.5	445.5	283.0	162.5	38.0	23.38	
2-5x	383.0	415.0	262.5	152.5	32.0	20.98	
2-6x	420.5	452.5	288.0	164.5	32.0	19.45	
2-7x	389.5	419.5	267.0	152.5	30.0	19.67	
2-8x	388.0	417.0	266.0	151.0	29.0	19.21	
3-1	361.0	394.0	250.0	144.0	33.0	22.92	21.49
3-2	360.5	394.5	249.5	145.0	34.0	23.45	22.19
3-3	320.5	352.0	222.0	130.0	31.5	24.23	22.70
3-4	335.5	370.0	233.0	137.0	34.5	25.18	23.45
3-5	328.5	362.0	228.5	133.5	33.5	25.09	23.19
3-6	329.0	360.0	228.0	132.0	31.0	23.49	21.75
3-7	325.5	355.5	225.5	130.0	30.0	23.08	21.61
3-8	347.5	378.0	241.0	137.0	30.5	22.26	20.82
3-1x	399.5	431.0	274.0	157.0	31.5	20.06	
3-2x	385.5	417.5	264.5	153.0	32.0	20.92	
3-3x	385.0	417.5	264.0	153.5	32.5	21.17	
3-4x	406.5	442.0	278.5	163.5	35.5	21.71	
3-5x	371.0	402.5	254.5	148.0	31.5	21.28	
3-6x	387.0	417.5	265.0	152.5	30.5	20.00	
3-7x	398.0	429.5	273.0	156.5	31.5	20.13	
3-8x	405.5	436.0	278.5	157.5	30.5	19.37	

Block	Dry	Sat	Sus	Sat-Sus	Sat-Dry	% Por.		Aver.Por
4-1	310.5	339.0	214.5	124.5	28.5	22.89		21.45
4-2	311.5	339.5	215.5	124.0	28.0	22.58		21.54
4-3	364.0	398.5	253.0	146.5	34.5	22.03		21.81
4-4	342.0	375.0	236.5	138.5	33.0	23.83		22.54
4-5	345.5	378.0	239.5	138.5	32.5	2347		22.20
4-6	308.0	336.0	213.5	122.5	28.0	22.86		21.54
4-7	325.0	355.0	225.0	130.0	30.0	23.08		21.36
4-8	328.5	358.0	228.0	130.0	29.5	22.69		21.01
4-1x	382.0	412.0	262.0	150.0	30.0	20.00		
4-2x	365.0	394.5	250.5	144.0	29.5	20.49		
4-3x	332.0	362.0	230.0	132.0	30.0	21.59		
4-4x	381.5	414.0	261.0	153.0	32.5	21.24		
4-5x	327.0	354.0	225.0	129.0	27.0	20.93		
4-6x	361.0	389.5	248.5	141.0	28.5	20.21		
4-7x	352.0	379.0	241.5	137.5	27.0	19.64		
4-8x	338.0	363.5	231.5	132.0	25.5	19.34		
4'-1	210.0	230.5	146.5	84.0	20.5	24.40		24.26
4'-2	217.0	239.5	151.5	88.0	22.5	25.58		25.29
4'-3	195.5	217.0	137.0	80.0	21.5	26.88		26.02
4'-4	216.0	240.0	150.5	89.5	24.0	26.81		26.31
4'-5	199.0	220.0	139.0	81.0	21.6	25.92		25.92
4'-6	199.0	219.0	139.0	80.0	20.0	25.00		24.80
4'-7	180.5	198.5	126.0	72.5	18.0	24.82		24.76
4'-8	187.5	205.0	131.0	74.0	17.5	23.65		23.59
4'-1x	213.0	233.5	148.5	85.0	20.5	24.12	Aver.	22.86
4'-2x	203.0	223.5	141.5	82.0	20.5	25.00	of	23.47
4'-3x	210.0	231.5	146.0	85.5	21.5	25.16	4 & 4'	23.92
4'-4x	228.0	252.0	159.0	93.0	24.0	25.91		24.43
4'-5x	196.5	218.5	137.5	81.0	22.0	27.18 (omit)		24.06
4'-6x	231.5	254.5	161.0	93.5	23.0	24.60		23.17
4'-7x	202.0	222.0	141.0	81.0	20.0	24.69		23.06
4'-8x	214.0	234.0	149.0	85.0	20.0	23.52		22.30
5-1	320.5	356.0	223.0	133.0	35.5	26.69		25.16
5-2	297.0	331.0	206.0	125.0	34.0	27.20		25.86
5-3	135.5	152.0	94.5	57.5	16.5	28.70		27.21
5-4	247.5	278.5	171.5	107.0	31.0	28.97		27.78
5-5	319.5	357.0	221.5	135.5	37.5	27.68		27.75
5-6	281.0	313.0	195.0	118.0	32.0	27.12		25.56
5-7	317.0	352.5	219.5	133.0	35.5	26.69		25.13
5-8	312.5	347.0	217.0	130.0	34.5	26.54		25.02
5-1x	354.0	388.5	242.5	146.0	34.5	23.62		
5-2x	367.5	405.0	252.0	153.0	36.5	24.51		
5-3x	332.0	368.0	228.0	140.0	36.0	25.72		
5-4x	279.5	311.0	192.5	118.5	31.5	26.58		
5-5x	363.5	406.5	252.0	154.5	43.0	27.82		
5-6x	243.0	267.0	167.0	100.0	24.0	24.00		
5-7x	359.0	394.0	245.5	148.5	35.0	23.57		
5-8x	359.0	394.0	245.0	149.0	35.0	23.49		

Block	Dry	Sat	Sus	Sat-Sus	Sat-Dry	% Por.		Aver Por
6-1	162.5	176.0	112.5	63.5	13.5	21.26		21.83
6-2	168.5	183.0	117.0	66.0	14.5	21.97		21.87
6-3	176.0	191.5	121.5	70.0	15.5	22.14		22.14
6-4	172.0	187.5	119.5	68.0	15.5	22.80		22.51
6-5	104.5	113.5	73.5	41.0	9.0	21.95		21.75
6-6	110.0	119.5	76.0	43.5	9.5	21.84		21.91
6-7	173.0	187.0	120.0	67.0	14.0	20.90		21.12
6-8	172.0	186.0	119.5	66.5	14.0	21.05		21.34
6-1x	169.0	184.0	117.0	67.0	15.0	22.39		
6-2x	187.5	203.5	130.0	73.5	16.0	21.77		
6-3x	187.0	205.0	130.0	75.0	18.0	24.00(Omit)		
6-4x	123.5	134.5	85.0	49.5	11.0	22.22		
6-5x	166.0	180.0	115.0	65.0	14.0	21.54		
6-6x	115.5	125.5	80.0	45.5	10.0	21.98		
6-7x	192.0	208.0	133.0	75.0	16.0	21.33		
6-8x	191.0	207.0	133.0	74.0	16.0	21.62		
6'-1	196.0	217.5	137.0	80.5	20.0	24.83		25.54
6'-2	196.0	218.5	137.0	81.5	22.5	27.60		27.21
6'-3	200.5	224.0	140.0	84.0	23.5	27.98		27.85
6'-4	171.0	190.5	119.0	71.5	19.5	27.28		27.50
6'-5	163.5	181.0	113.5	67.5	17.5	25.92		26.06
6'-6	158.0	174.5	110.0	63.5	16.5	25.98		25.40
6'-7	158.0	174.0	110.5	66.5	16.0	25.20		25.01
6'-8	146.0	161.0	102.0	59.0	15.0	25.41		25.49
6'-1x	195.0	216.0	136.0	80.0	21.0	26.25		23.69
6'-2x	198.0	220.0	138.0	82.0	22.0	26.82	Aver	24.54
6'-3x	176.5	197.0	123.0	74.0	20.5	27.71	of	25.00
6'-4x	177.5	198.0	124.0	74.0	20.5	27.71	6 &6'	25.00
6'-5x	176.5	195.5	123.0	72.5	19.0	26.20		23.91
6'-6x	173.0	190.5	120.0	70.5	17.5	24.82		23.66
6'-7x	179.0	197.0	124.5	72.5	18.0	24.82		23.07
6'-8x	162.5	178.0	113.5	64.5	16.5	25.57		23.42
7-1	293.5	330.5	203.0	127.5	37.0	29.02		28.45
7-2	361.0	408.5	251.0	157.5	47.5	28.95		28.85
7-3	353.0	400.5	245.0	155.5	47.5	30.55		29.38
7-4	331.0	376.5	228.0	148.5	45.5	30.64		29.95
7-5	266.0	302.0	184.0	118.0	36.0	30.51		29.47
7-6	330.0	373.5	227.5	146.0	43.5	29.80		29.28
7-7	302.5	342.0	209.0	133.0	39.5	29.70		28.82
7-8	278.0	314.5	194.5	120.0	36.5	30.42		28.83
7-1x	335.0	375.5	230.0	145.5	40.5	27.84		
7-2x	304.0	344.5	212.0	132.5	40.5	28.75		
7-3x	313.0	351.5	215.0	136.5	38.5	28.21		
7-4x	285.0	322.0	195.5	126.5	37.0	29.25		
7-5x	318.0	357.5	218.5	139.0	39.5	28.42		
7-6x	260.0	292.5	179.5	113.0	32.5	28.76		
7-7x	314.0	352.0	216.0	136.0	38.0	27.94		
#7-8x	324.0	362.0	222.5	139.5	38.0	27.24		

Block	Sat	Dry	Sus	Sat-Dry	Sat-Sus	% Por	Aver Por
8-1	366.0	323.5	224.0	42.5	142.0	29.92	29.04
8-2	403.0	355.0	245.5	48.0	157.5	30.47	29.54
8-3	380.5	335.0	231.5	45.5	149.0	30.53	29.97
8-4	435.0	382.0	264.0	53.0	171.0	30.99	30.38
8-5	465.5	409.0	283.0	56.5	182.5	30.95	30.22
8-6	363.0	320.0	221.0	43.0	142.0	30.28	29.39
8-7	372.5	328.0	227.0	44.5	145.5	30.58	29.25
8-8	368.0	327.0	226.0	42.0	142.0	29.57	28.48
8-1x	408.0	363.5	250.0	44.5	158.0	28.16	
8-2x	400.5	356.0	245.0	44.5	155.5	28.61	
8-3x	393.0	348.0	240.0	45.0	153.0	29.41	
8-4x	379.0	334.5	229.5	44.5	149.5	29.76	
8-5x	399.5	353.5	243.5	46.0	156.0	29.48	
8-6x	417.5	371.5	255.5	46.0	162.0	28.39	
8-7x	419.5	374.0	256.5	45.5	163.0	27.91	
8-8x	421.5	377.0	259.0	44.5	162.5	27.38	
9-1	197.0	174.0	120.5	23.0	76.5	30.07	30.24
9-2	226.0	199.5	138.0	26.5	88.0	31.11	30.15
9-3	218.0	191.5	133.0	26.5	85.0	31.18	31.33
9-4	206.0	180.5	125.0	25.5	81.0	31.48	31.33
9-5	212.0	180.0	129.0	32.0	83.0	38.56 (Out)	30.30
9-6	192.5	170.0	117.5	22.5	75.0	30.00	29.83
9-7	217.5	192.5	133.5	25.0	84.0	29.76	29.68
9-8	233.0	207.0	143.5	26.0	89.5	29.05	29.63
9-1x	251.0	221.5	154.0	29.5	97.0	30.41	
9-2x	206.0	182.0	126.5	24.0	79.5	30.19	
9-3x	253.0	222.0	154.5	31.0	98.5	31.47	
9-4x	237.5	208.5	144.5	29.0	93.0	31.18	
9-5x	210.0	185.0	127.5	25.0	82.5	30.30	
9-6x	222.0	196.5	136.0	25.5	86.0	29.65	
9-7x	254.0	225.0	156.0	29.0	98.0	29.59	
9-8x	262.0	231.5	161.0	30.5	101.0	30.20	
10-1	338.5	289.5	200.5	49.0	138.0	35.51	28.77
10-2	357.0	315.5	218.0	41.5	139.0	29.86	29.22
10-3	360.0	318.0	219.5	42.0	140.5	29.88	29.80
10-4	338.0	296.0	204.5	42.0	133.5	31.46	30.61
10-5	335.0	293.0	203.0	42.0	132.0	31.82	30.57
10-6	346.0	304.0	210.5	42.0	135.5	31.00	30.56
10-7	345.0	304.0	211.0	41.0	134.0	30.60	29.59
10-8	317.0	280.0	194.5	37.0	122.5	30.21	29.35
10-1x	378.0	337.0	232.0	41.0	146.0	28.08	
10-2x	379.0	337.0	232.0	42.0	147.0	28.58	
10-3x	352.0	311.0	214.0	41.0	138.0	29.71	
10-4x	322.5	285.0	196.5	37.5	126.0	29.76	
10-5x	242.5	214.5	147.0	28.0	95.5	29.32	
10-6x	397.0	350.5	240.5	46.5	156.5	29.71	
10-7x	351.5	312.5	215.0	39.0	136.5	28.57	
10-8x	388.5	345.5	237.4	43.0	151.0	28.48	

Block	Dry	Sat	Sus	Sat-Dry	Sat-Sus	% Por		Aver Por
10'-1	173.5	198.0	121.5	24.5	76.5	32.02		31.52
10'-2	170.5	197.5	119.0	27.0	78.5	34.39		33.35
10'-3	167.0	192.5	117.0	25.5	75.5	33.78		33.92
10'-4	149.0	172.0	104.0	23.0	68.0	33.83		34.14
10'-5	149.5	172.5	105.0	23.0	67.5	34.08		33.83
10'-6	163.4	187.0	114.0	23.5	73.0	32.20		32.32
10'-7	157.0	180.0	111.0	23.0	69.0	33.33		32.98
10'-8	163.0	186.0	113.0	23.0	73.0	31.51		32.15
10'-1x	179.5	204.0	125.0	24.5	79.0	31.01		30.15
10'-2x	148.5	169.5	104.5	21.0	65.0	32.31		31.29
10'-3x	158.5	183.0	111.0	24.5	73.0	34.05	Aver	31.86
10'-4x	159.5	185.0	111.0	25.5	74.0	34.45	of	32.38
10'-5x	160.0	184.5	111.5	24.5	74.0	33.58	10	32.20
10'-6x	169.0	193.5	118.0	24.5	75.5	32.44	&	31.34
10'-7x	160.0	183.0	112.5	23.0	70.5	32.62	10'	31.29
10'-8x	141.0	161.5	99.0	20.5	62.5	32.79		30.75
11-1	166.0	189.5	115.0	23.5	74.5	31.54		31.93
11-2	176.0	202.0	122.5	26.0	79.5	32.71		33.14
11-3	144.5	167.0	101.0	22.5	66.0	34.09		33.99
11-4	97.0	112.0	67.5	15.0	44.5	33.71		33.98
11-5	174.0	200.0	120.5	26.0	79.5	32.71		32.89
11-6	180.5	206.0	125.0	25.5	81.0	31.48		31.65
11-7	154.5	176.5	107.0	22.0	69.5	31.66		31.27
11-8	173.0	197.5	120.0	24.5	77.5	31.61		30.97
11-1x	144.5	165.5	100.5	21.0	65.0	32.31		
11-2x	153.5	177.0	107.0	23.5	70.0	33.57		
11-3x	134.0	154.5	94.0	20.5	60.5	33.89		
11-4x	121.0	140.0	84.5	19.0	55.5	34.24		
11-5x	141.0	162.0	98.5	21.0	63.5	33.07		
11-6x	146.5	167.5	101.5	21.0	66.0	31.82		
11-7x	154.0	175.0	107.0	21.0	68.0	30.88		
11-8x	150.0	158.5	97.5	18.5	61.0	30.33		
12-1	289.5	338.5	200.5	49.0	138.0	35.51		34.68
12-2	298.0	349.5	206.5	51.5	143.0	36.01		35.22
12-3	302.0	355.5	209.5	53.5	146.0	36.64		35.76
12-4	303.0	357.5	210.0	54.5	147.5	36.95		36.05
12-5	295.5	347.0	205.0	51.5	142.0	36.27		36.35
12-6	296.0	346.5	204.5	50.5	142.0	35.56		34.40
12-7	330.0	386.0	229.0	56.0	157.0	35.67		34.50
12-8	228.0	265.5	158.0	37.5	107.5	34.88		34.11
12-1x	342.5	397.0	236.0	54.5	161.0	33.85		
12-2x	32215	375.0	222.5	52.5	152.5	34.43		
12-3x	316.0	368.5	218.0	52.5	150.5	34.88		
12-4x	306.0	358.0	210.0	52.0	148.0	35.14		
12-5x	348.5	409.5	242.5	61.0	167.5	36.42		
12-6x	324.5	375.5	222.0	51.0	153.5	33.23		
12-7x	308.0	356.5	211.0	48.5	145.5	33.33		
12-8x	313.0	362.0	215.0	49.0	147.0	33.33		

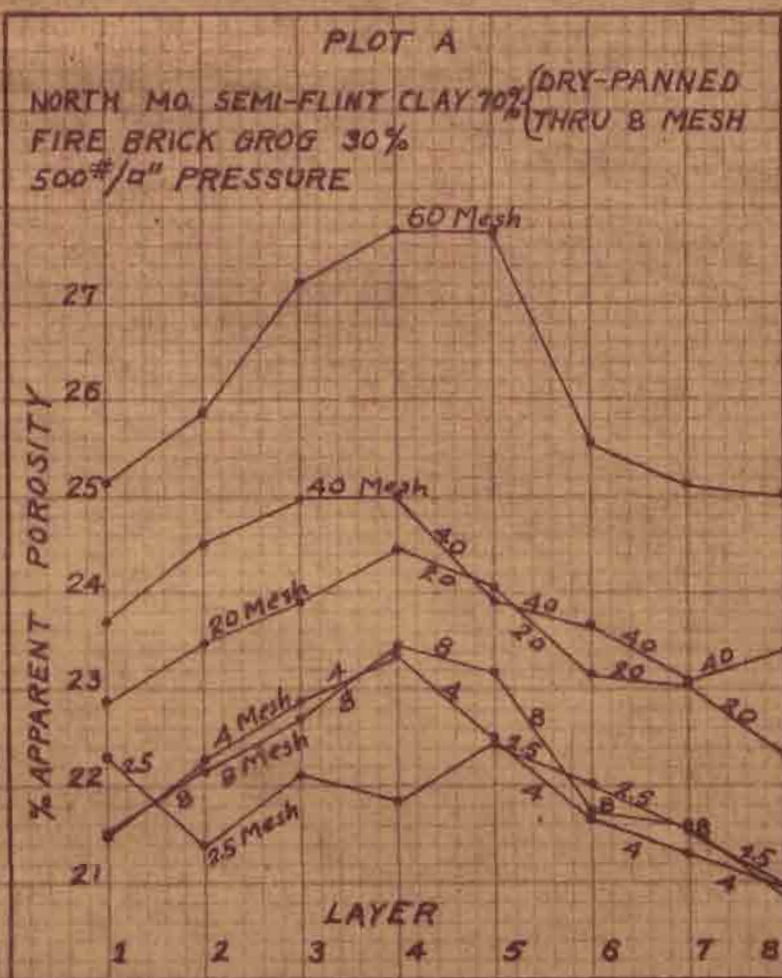
Block	Dry	Sat	Sus	Sat-Sus	Sat-Dry	% Por		Aver Por
13-1	166.0	180.0	114.5	65.5	14.0	21.37		21.66
13-2	138.5	150.0	96.0	54.0	11.5	21.30		21.94
13-3	217.0	236.0	150.0	86.0	19.0	22.09		22.00
13-4	180.5	198.0	125.0	73.0	17.5	23.97		22.67
13-5	189.0	206.0	130.5	75.5	17.0	22.52		22.03
13-6	177.5	193.5	123.0	70.5	16.0	22.70		22.00
13-7	227.5	246.5	157.5	89.0	19.0	21.35		21.20
13-8	213.0	231.0	147.5	83.5	18.0	21.56		21.54
13-1x	197.5	214.5	137.0	77.5	17.0	21.94		
13-2x	155.0	169.0	107.0	62.0	14.0	22.58		
13-3x	224.5	244.0	155.0	89.0	19.5	21.91		
13-4x	131.0	142.0	90.5	51.5	11.0	21.36		
13-5x	178.5	194.0	122.0	72.0	15.5	21.52		
13-6x	196.5	213.0	135.5	77.5	16.5	21.29		
13-7x	219.0	237.0	151.5	85.5	18.0	21.05		
13-8x	218.5	237.0	151.0	86.0	18.5	21.51		
14-1	183.5	205.0	127.0	78.0	22.0	28.21	(out)	23.94
14-2	169.0	186.5	117.5	69.0	17.5	25.36		24.74
14-3	189.5	209.5	132.0	77.5	20.0	25.81		25.48
14-4	196.0	217.5	135.5	82.0	21.5	26.22		26.22
14-5	200.0	221.0	138.5	82.5	21.0	25.46		25.88
14-6	207.0	228.5	144.0	84.5	21.5	25.44		24.77
14-7	179.0	196.0	123.5	72.5	17.0	23.45		23.52
14-8	176.0	193.0	122.0	71.0	17.0	23.94		23.45
14-1x	233.5	256.0	162.0	94.0	22.5	23.94		
14-2x	209.0	229.5	144.5	85.0	20.5	24.12		
14-3x	213.0	235.0	147.5	87.5	22.0	25.14		
14-4x	189.0	209.0	130.5	68.5	20.0	29.20	(out)	
14-5x	237.5	262.0	165.0	97.0	25.5	26.29		
14-6x	241.5	265.0	167.5	97.5	23.5	24.10		
14-7x	243.0	266.0	168.5	97.5	23.0	23.59		
14-8x	245.0	267.5	169.5	98.0	22.5	22.96		
14'-1	244.0	266.5	169.5	97.0	22.5	23.19		23.05
14'-2	229.5	251.5	160.0	91.5	22.0	21.04	(out)	23.97
14'-3	200.5	221.0	140.0	81.0	20.5	25.31		25.36
14'-4	194.0	214.0	135.0	79.0	20.0	25.31		25.30
14'-5	211.0	231.5	147.0	84.5	20.5	24.25		24.49
14'-6	220.0	241.5	153.0	88.5	21.5	24.39		24.07
14'-7	217.5	237.5	152.0	85.5	20.0	23.39		23.38
14'-8	215.5	235.5	150.5	85.0	20.0	23.54		23.18
14'-1x	226.0	246.5	157.0	89.5	20.5	22.91	Aver	23.50
14'2x	240.5	263.5	167.5	96.0	23.0	23.97	of	24.36
14'-3x	233.0	257.0	162.5	94.5	24.0	25.40	14	25.42
14'-4x	233.5	257.5	162.5	95.0	24.0	25.28	&	25.76
14'-5x	237.5	261.0	166.0	95.0	23.5	24.72	14'	25.19
14'-6x	242.0	265.0	168.5	96.5	23.0	23.83		24.47
14'-7x	232.0	253.5	161.5	92.0	21.5	23.38		23.54
14'-8x	218.5	238.0	152.5	85.5	19.5	22.81		23.32

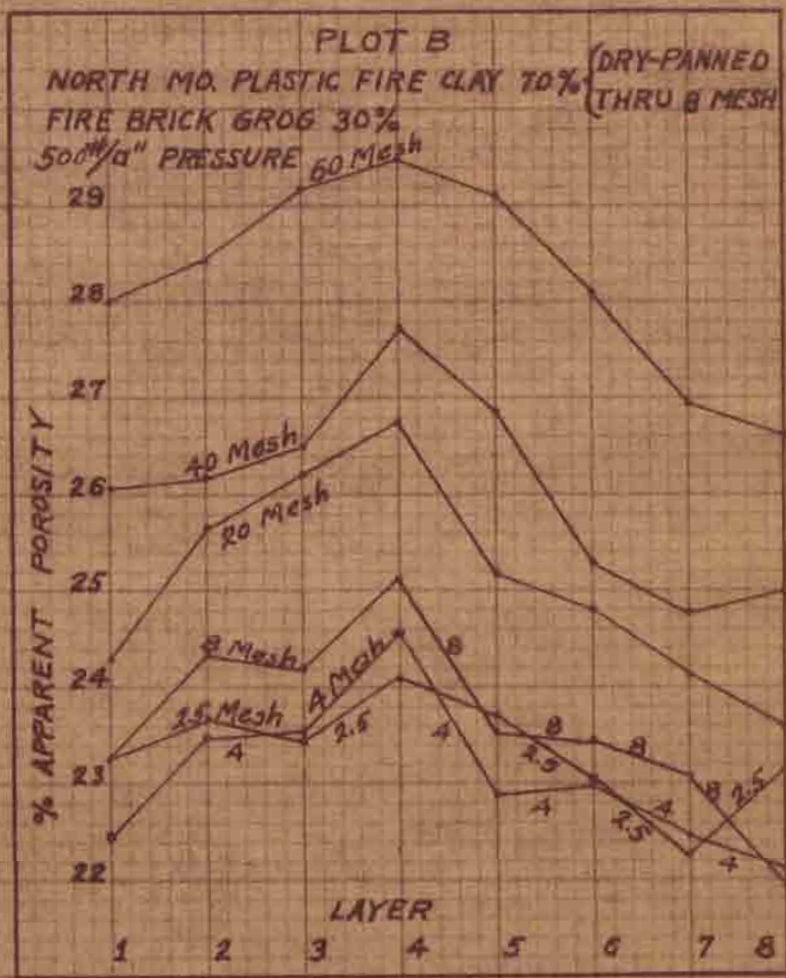
Block	Dry	Sat	Sus	Sat-Sus	Sat-Dry	% Por	Aver Por
15-1	255.5	278.0	172.0	106.0	22.5	21.23	21.84
15-2	249.5	272.5	171.5	101.0	23.0	22.77	22.56
15-3	200.0	220.5	139.0	81.5	20.5	25.15	(out)23.91
15-4	200.5	223.5	140.0	83.5	20.0	23.95	23.90
15-5	243.0	266.0	168.5	97.5	23.0	23.59	23.59
15-6	217.0	237.0	148.0	89.0	20.0	22.47	22.61
15-7	215.5	235.0	149.0	86.0	19.5	22.67	22.48
15-8	215.5	234.5	148.5	86.0	19.0	22.09	22.31
15-1x	247.5	269.5	171.5	98.0	22.0	22.45	
15-2x	236.5	157.5	163.5	95.0	21.0	22.34	
15-3x	229.0	251.0	159.0	92.0	22.0	23.91	
15-4x	220.5	242.0	152.5	89.5	21.5	24.02	
15-5x	148.5	163.0	104.0	59.0	14.5	24.58 (out)	
15-6x	210.0	229.0	145.5	83.5	19.0	22.75	
15-7x	199.5	217.0	138.5	78.5	17.5	22.29	
15-8x	186.5	203.5	128.0	75.5	17.0	22.52	
16-1	214.0	234.0	148.5	85.5	20.0	23.39	23.42
16-2	202.0	221.5	140.5	81.0	19.5	24.08	24.26
16-3	204.0	224.5	142.0	82.5	20.5	24.85	24.04
16-4	208.0	230.0	139.5	90.5	22.0	24.31	(out)26.36
16-5	182.5	200.5	126.5	74.0	18.0	24.33	25.12
16-6	174.0	191.5	121.0	70.5	17.5	24.82	25.09
16-7	211.0	231.0	146.5	84.5	20.0	23.67	23.46
16-8	205.0	223.5	142.5	81.0	18.5	22.84	22.61
16-1x	182.0	199.0	126.5	72.5	17.0	23.45	
16-2x	163.0	179.0	113.5	65.5	16.0	24.43	
16.3x	138.5	152.5	97.0	55.5	14.0	25.23	
16-4x	134.0	148.5	93.5	55.0	14.5	26.36	
16-5x	169.5	187.5	118.0	69.5	18.0	25.90	
16-6x	169.0	186.5	117.5	69.0	17.5	25.36	
16-7x	177.5	194.0	123.0	71.0	16.5	23.24	
16-8x	192.0	209.0	133.0	76.0	17.0	22.37	
17-1	210.0	232.5	146.0	86.5	22.5	26.01	25.20
17-2	199.5	223.0	139.0	84.0	23.5	27.98	(out)25.49
17-3	192.0	213.0	132.5	80.5	21.0	26.09	26.66
17-4	208.0	232.5	144.5	88.0	24.5	27.84	28.87
17-5	200.5	225.5	139.5	86.0	25.0	29.07	28.55
17-6	203.0	224.5	141.0	83.5	21.5	25.75	26.57
17-7	178.5	197.0	123.0	74.0	18.5	25.00	25.94
17-8	184.0	201.5	127.5	74.0	17.5	22.65	25.04
17-1x	197.5	217.0	137.0	80.0	19.5	24.38	
17-2x	186.0	200.5	129.0	76.5	19.5	25.49	
17-3x	201.5	224.5	140.0	84.5	23.0	27.22	
17-4x	202.0	228.0	141.0	87.0	26.0	29.89	
17-5x	185.0	207.0	128.5	78.5	22.0	28.03	
17-6x	190.5	213.0	132.5	80.5	22.5	27.39	
17-7x	192.5	214.0	134.0	80.0	21.5	26.88	
17-8x	169.5	188.0	118.0	70.0	18.5	26.43	

Block	Dry	Sat	Sus	Sat-Sus	Sat-Dry	% Por	Aver Por
18-1	219.0	241.0	152.5	88.5	22.0	24.86	25.66
18-2	214.5	237.0	149.0	88.0	22.5	25.57	25.61
18-3	218.0	243.0	151.0	92.5	25.5	27.57	27.08
18-4	215.5	244.0	150.5	93.5	28.5	30.48	30.95
18-5	193.0	217.5	134.5	83.0	24.5	29.52	28.05
18-6	192.0	214.5	133.5	81.0	22.5	27.78	27.64
18-7	200.5	220.5	139.0	81.5	20.0	24.54	25.43
18-8	206.5	226.0	143.0	83.0	19.5	23.49	25.01
18-1x	229.5	254.5	160.0	94.5	25.0	26.46	
18-2x	236.0	262.0	164.5	97.5	25.0	25.64	
18-3x	208.5	231.5	145.0	86.5	23.0	26.59	
18-4x	216.5	246.5	151.0	95.5	30.0	31.41	
18-5x	188.5	209.5	130.5	79.0	21.0	26.58	
18-6x	189.0	211.0	131.0	80.0	22.0	27.50	
18-7x	231.0	256.0	161.0	95.0	25.0	26.32	
18-8x	221.0	245.0	154.5	90.5	24.0	26.52	
19-1	290.0	316.5	201.5	115.5	26.5	23.04	23.27
19-2	271.0	296.0	198.0	98.0	25.0	25.51 (out)	23.71
19-3	254.5	278.0	176.0	102.0	23.5	23.04	23.45
19-4	283.5	310.5	196.5	114.0	27.0	23.68	24.13
19-5	271.5	297.5	187.0	110.5	26.0	23.53	23.72
19-6	247.5	270.5	171.5	99.0	23.0	22.23	23.08
19-7	285.5	312.0	198.5	113.5	26.5	23.35	22.26
19-8	269.0	294.0	187.0	107.0	25.0	23.36	2314
19-1x	251.0	274.5	174.5	100	23.5	23.50	
19-2x	243.0	266.0	169.0	97.0	23.0	23.71	
19-3x	273.0	299.0	190.0	109.0	26.0	23.85	
19-4x	222.0	244.0	154.5	89.5	22.0	24.58	
19-5x	225.5	247.0	156.5	90.5	21.5	23.76	
19-6x	240.0	262.0	166.0	96.0	22.0	22.92	
19-7x	241.5	261.5	167.0	94.5	20.0	21.16	
19-8x	227.5	248.0	158.5	89.5	20.5	22.91	
20-1	261.0	284.0	181.0	103.0	23.0	22.33	22.45
20-2	266.5	291.0	185.0	106.0	24.5	23.11	23.50
20-3	262.0	287.0	181.5	105.5	25.0	23.70	23.55
20-4	272.0	299.0	188.5	110.5	27.0	24.43	24.59
20-5	242.5	165.0	168.0	97.0	22.5	23.20	22.90
20-6	234.5	261.5	166.0	95.5	22.0	23.04	22.99
20-7	243.5	265.5	168.5	97.0	22.0	22.68	22.45
20-8	226.5	247.0	157.0	90.0	20.5	22.78	22.13
20-1x	245.0	267.0	169.5	97.5	22.0	22.56	
20-2x	249.5	273.5	173.0	100.5	24.0	23.88	
20-3x	272.5	298.0	189.0	109.0	25.5	23.39	
20-4x	237.0	261.0	164.0	97.0	24.0	24.74	
20-5x	182.5	199.0	126.0	73.0	16.5	22.60	
20-6x	137.0	149.5	95.0	54.5	12.5	22.94	
20-7x	214.0	133.0	147.5	85.5	19.0	22.22	
20-8x	224.0	243.0	154.5	88.5	19.0	21.47	

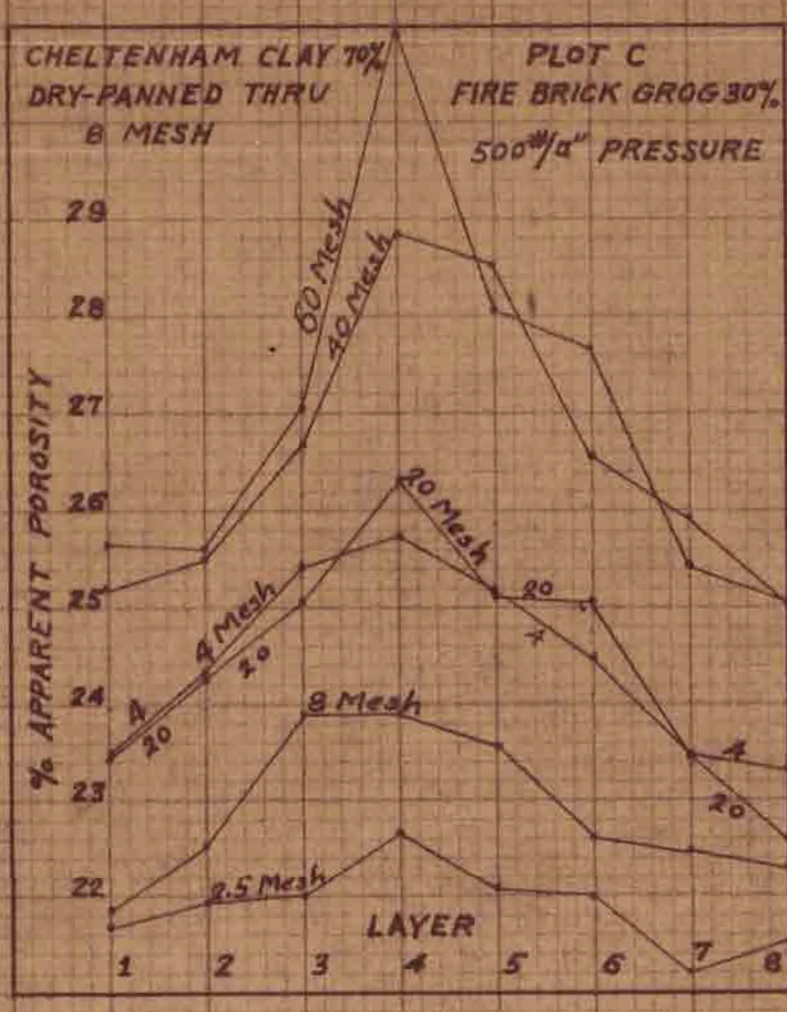
Block	Dry	Sat	Sus	Sat-Sus	Sat-Dry	% Por	Aver Por
21-1	286.0	312.0	198.0	114.0	27.0	23.68	23.27
21-2	169.0	186.0	117.0	69.0	17.0	24.64	24.34
21-3	293.5	322.0	204.0	118.0	28.5	24.15	24.20
21-4	290.5	320.5	200.5	120.5	30.0	25.00	25.13
21-5	199.5	219.0	138.0	81.0	19.5	24.07	23.55
21-6	214.0	234.0	148.0	86.0	20.0	23.26	23.45
21-7	214.5	234.0	148.5	85.5	19.5	22.81	23.08
21-8	242.5	263.5	168.0	95.5	21.0	21.99	21.95
21-1x	264.0	288.0	183.0	105.0	24.0	22.86	
21-2x	257.0	282.0	178.0	104.0	25.0	24.04	
21-3x	201.5	221.5	139.0	82.5	20.0	24.24	
21-4x	240.0	265.0	166.0	99.0	25.0	25.25	
21-5x	188.5	206.0	130.0	76.0	17.5	23.05	
21-6x	218.0	238.5	151.0	87.5	20.5	23.43	
21-7x	225.0	245.0	155.5	89.5	20.0	23.35	
21-8x	226.5	246.0	157.0	89.0	19.5	21.91	
22-1	278.0	305.0	194.0	111.0	27.0	24.33	24.30
22-2	270.0	298.5	187.5	111.0	28.5	25.68	25.65
22-3	270.5	300.5	188.0	112.5	30.0	26.67	26.23
22-4	259.5	288.5	180.5	108.0	29.0	26.85	26.75
22-5	251.5	278.0	174.0	104.0	26.5	25.48	25.18
22-6	267.0	284.5	194.5	110.0	27.5	25.00	24.81
22-7	267.5	284.0	194.0	110.0	26.5	24.90	24.12
22-8	254.5	279.0	176.0	103.0	24.5	23.79	23.60
22-1x	256.0	281.0	178.0	103.0	25.0	24.27	
22-2x	248.5	274.5	173.0	101.5	26.0	25.62	
22-3x	273.0	302.0	189.5	112.5	28.0	25.78	
22-4x	255.5	284.0	177.0	107.0	28.5	26.64	
22-5x	235.0	259.0	162.5	96.5	24.0	24.87	
22-6x	246.0	270.5	171.0	99.5	24.5	24.62	
22-7x	255.0	279.5	174.5	105.0	24.5	23.33	
22-8x	236.0	258.0	164.0	94.0	22.0	23.40	
23-1	171.0	189.0	118.5	70.5	18.0	25.53	26.06
23-2	195.0	215.0	135.0	80.0	20.0	25.00	(out) 26.19
23-3	199.0	221.0	138.0	83.0	22.0	26.51	26.51
23-4	206.5	231.0	143.5	87.5	24.5	28.00	27.76
23-5	192.5	214.5	133.5	81.0	22.0	27.16	26.84
23-6	183.0	202.0	126.0	75.0	19.0	25.33	25.28
23-7	197.5	217.5	137.0	80.5	20.0	24.85	24.78
23-8	189.5	209.0	131.0	78.0	19.5	25.00	25.00
23-1x	216.5	238.5	150.0	89.5	23.0	23.59	
23-2x	203.5	225.5	141.5	84.0	22.0	26.19	
23-3x	211.0	229.5	146.5	84.0	18.5	22.29	(out)
23-4x	218.5	245.0	150.5	94.5	26.0	27.51	
23-5x	198.0	220.0	137.0	83.0	22.0	26.51	
23-6x	131.5	145.0	91.5	53.5	13.5	25.23	
23-7x	219.0	241.0	152.0	89.0	22.0	24.74	
23-8x	226.0	249.0	157.0	92.0	23.0	25.00	

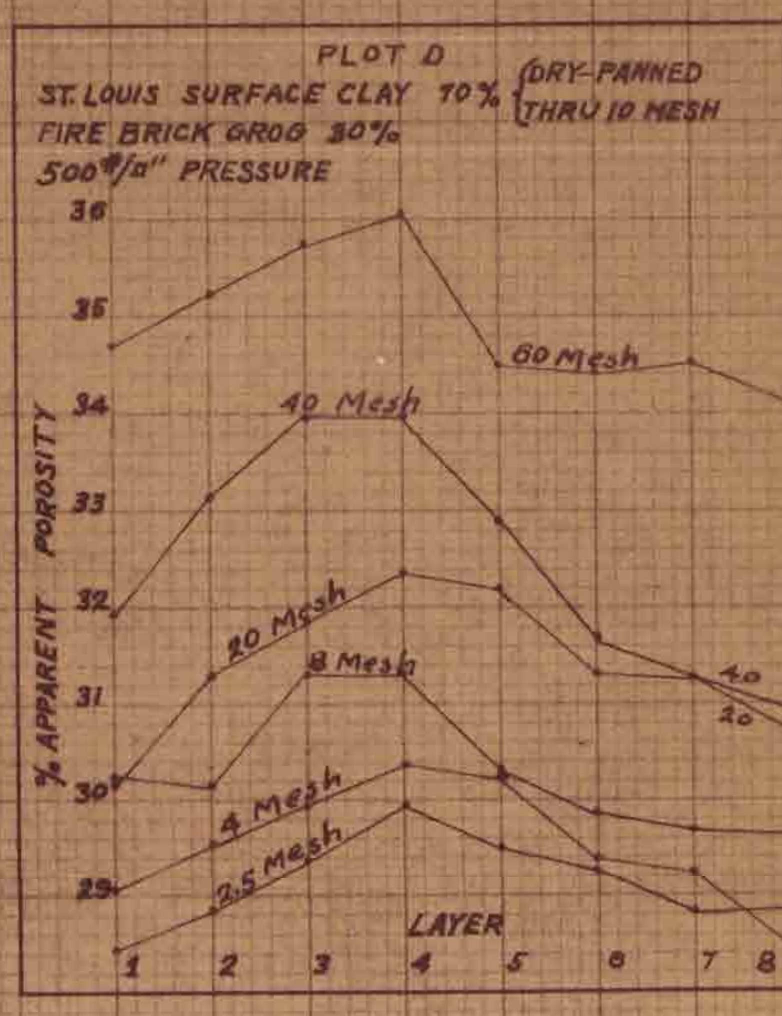
Block	Dry	Sat	Sus	Sat-Sus	Sat-Dry	% Por	Aver Por
24-1	104.0	116.0	72.5	43.5	12.0	27.59	28.00
24-2	207.5	232.5	144.0	88.5	25.0	28.25	28.45
24-3	213.5	240.5	148.0	92.5	27.0	29.19	29.19
24-4	193.0	217.5	134.0	83.5	24.5	29.34	29.47
24-5	180.5	203.0	125.0	78.0	22.5	28.85	29.12
24-6	178.0	200.5	123.5	77.0	22.5	29.22 (out)	28.09
24-7	189.0	210.0	131.0	79.0	21.0	26.58	26.95
2408	201.0	223.0	139.5	83.5	22.0	26.35	26.61
24-1x	208.0	233.0	145.0	88.0	25.0	28.41	
24-2x	208.0	233.5	144.5	89.0	25.5	28.65	
24-3x	172.0	195.0	119.0	76.0	23.0	30.26(out)	
24-4x	226.0	155.0	157.0	98.0	29.0	29.59	
24-5x	206.0	232.0	143.5	88.5	26.0	29.38	
24-6x	211.0	236.0	147.0	89.0	25.0	28.09	
24-7x	217.5	242.5	151.0	91.5	25.0	27.32	
24-8x	211.0	234.5	147.0	87.5	23.5	26.86	





EFFECT OF GROG SIZE ON THE APPARENT POROSITY





DISCUSSION OF RESULTS

All curves obtained are based on Apparent Porosity, which gives all indications of being directly proportional to pressure transmission. The smaller the difference between the extremes of Porosity the more uniform pressure transmission throughout each block. The ideal curve would be a straight line where the porosity would be equal for all layers, which would indicate that the pressure had been equally distributed to each layer of the block. Such a curve would be obtained with water as the transferring medium, while clay would not give this ideal pressure transmission due to its heterogeneous arrangment of the grains.

It may be easily seen from the curves that the size of grog plays an important part in the degree of pressure transmission throughout a test block.

It would appear to be reasonable that there would be more pressure at the top and at the bottom than in the center of the block, which was found to be true in this investigation.

PLOT A

North Missouri Semi-Flint Clay 70% and Fire Brick Grog 30%

From this et of curves it was easily concluded that the larger the grog size the better the pressure transmission, i.e., approximating the ideal straight line of water.

The 2.5 mesh curve was a curve being nearest to a straight line, as discussed above. There was not a large difference between the extremes of porosities of this curve - the total difference being 1.4%

As the grog size decreased, which is illustrated by the

4 and 8 mesh curves, the difference in the extremes becomes greater. There is very little difference in the 4 and 8 mesh curves, the two being very nearly parallel to each other. The total difference between the extremes of these two curves being 2.5%

As the size of grog decreased to a greater extent, the contrast between the extremes becomes more evident, until the size of grog had been reduced to 60 mesh, where the largest difference in the extremes was discovered. It was 2.8%

In each of the six curves, with the exdeption of the 2.5 mesh curve, the highest porosity was obtained in the fourth layer. This is reasonable because the fourth layer is in the exact center of the block and theoretically receives the least amount of pressure due to unequal pressure transmission. When the pressure is less in the center of the block, a soft core and a "shelly" structure will result.

There are several proposed reasons for the unequal distribution of pressure throughout a piece of ware. Some of the more probable are as follows:

(1) It is apparent that the pressure exerted on the top and bottom of a clay column has been absorbed before reaching the center of the column because the pressure in the center is less than that on the ends.

This may be logically explained by the assumption that the pressure is lost in transmitting itself from one grain to another. From this reasoning it would be natural to expect that with a certain height of column there would be no pressure transmitted to the center.

From the previous deductions it would seem that to increase the number of grains would reduce the degree of pressure transmission towards the center. This is the exact condition which arises from the fine grinding of the grog and as our curves indicate, this theory is tenable.

(2) When large size grog is used, similarity is approached to that of an ideal medium of pressure transmission because there are fewer contacts between the grains, as explained above, and the grog cannot be compressed to any such degree as clay due to its mobilness caused by its dense structure.

All homogeneous materials transmit pressure equally in all directions. Large grog is a homogeneous mixture because of its vitrified structure due to the formation of a binding glass when fired, while fine grog, although bound within itself, is too finely disseminated to act as a single transmitting medium.

The curves in Plot A were studied with the above considerations in mind and were found to bear out the theories in a very remarkable manner.

The total difference in the high porosity between the 2.5 and 60 mesh amounted to 4.5%

So it may be concluded that course grinding gives the best pressure transmission with the North Missouri Semi-Flint Clay.

PLOT B

North Missouri Plastic Fire Clay 70% and Fire Brick Grog 30%

The curves in this graph were very similar to those in Plot A, with the 2.5 mesh again giving the best pressure transmission. As the grog size decreased, the porosity rose; with the maxium porosity in the fourth layer.

All the curves were slightly more jagged than the curves in Plot A. This maybe explained by the knowledge that the North Missouri Semi-Flint approached more nearly the characteristics of the grog, since it contained more grains of a flinty nature, which produced a more even pressure transmission.

The total variation between the highest porosities of the 2.5 and 60 mesh were 5.5%

PLOT C

Cheltenham Fire Clay 70% and Fire Brick Grog 30%

This clay gave the best and worst examples of pressure transmission. The 60 mesh curve made a very decided jump to a high porosity in the center of the block which was very undesirable. But the 2.5 mesh curve was more nearly a straight line than any of the curves obtained and gives the best pressure transmission of any of the clay mixes.

Due to some inexplainable cause, the 4 mesh curve fell into a much higher region than was expected. This was probably due to experimental error.

The total variation between the high porosities of the 2.5 and 60 mesh was 8.3% which was the largest difference obtained.

PLOT D

St. Louis Surface Clay 70% and Fire Brick Grog 30%

This plot gave the best set of curves of any obtained in the investigation.

Each curve was clearly defined and the curves followed each other in an orderly sequence from the lowest mesh (2.5) to the highest (60). This graph differes from the three previously discussed in possessing a much higher prosity throughout the entire set of blocks on this building brick mix.

From screen analyses previously made by the other investigators, it was found that this clay possessed an unsual amount of fines through 200 mesh - about 46%. Compared with the other clays this is an exceedingly high figure. This clay possesses a very large amount of free silica, which probably contributed a large portion of the fines.

It has been definitely proved that fine material has a more greater amount of surface than a large material, both being originally of the same volume, and this obviously increases the porosity of a product composed mainly of fines. This shows why the curves obtained from the building brick clay have such an exceedingly high porosity. The large amount of free silica in this clay seemed to have a positive effect on the pressure transmission because it had a somewhat similar effect as the grog itself.

Once more the 2.5 mesh gave the best pressure transmission curve with a variation of 1.5%

The total variation between the high porosities of the 2.5 and 60 mesh curves was 6.0%

This clay shows a greater respnse to any variations in the manipulations of its physical characteristics than any of the other clays. It is the only building brick mix in this investigation, the other three being fire brick mixes.

RESUME

From the above investigations it may be concluded that in every case the large grog gives a much better transmission than the fine grog.

The reason for selecting 500 pounds per square inch forming pressure was because it accentuated the different variations, i.e., grog size, used throughout this investigation.

It is suggested that the following topics be carried in future research:

(1) The grog size be made larger than 2.5 mesh

(2) Increase the forming pressure to 2000 pounds per square inch and increase the amount of grog to 50%

(3) The results obtained in this investigation be more practically proved by using the best mixtures, as decided from this study, by making standard 9 inch brick and testing them for:

a) Modulus of Rupture in both the green and in the fired state

b) Hot Load Test

c) Spalling Test