1930

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 mix ingredient, and the moisture content of the mix

George Ava Page

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 MIX INGREDIENT, AND THE MOISTURE CONTENT OF THE MIX

By

GEORGE A. PAGE

A

THESIS

submitted to the faculty of the

SCHOOL OF MINES AND METALLURGY OF THE UNIVERSITY OF MISSOURI

in partial fulfillment of the work required for the

Degree of

BACHELOR OF SCIENCE IN CERAMIC ENGINEERING

Rolla, Missouri

1930

Approved by ____________________
Professor of Ceramic Engineering

TABLE OF CONTENTS

INTRODUCTION

In the manufacture of dry press brick, the final grinding and tempering of the clay is usually done in a dry pan.

The next operation is forming the ware by means of applying pressure, either mechanical or hydraulic. The actual pressure that a brick is subjected to in a mechanical press has always been a question.

It is logical to assume that different degrees of pressure will impart different characteristics on the physical properties of the unfired brick. Since no two clay deposits are alike in physical properties, it is logical to assume that each clay will have a "critical forming pressure", so as to speak, that pressure that will impart the desired physical properties to the unfired brick.

The operation of tempering the dry press mix is largely a rule of thumb operation.

It is logical to assume that different amounts of water in a dry press mix will have a marked effect on the transmission of pressure throughout the mix. Also the water content may have some effect on the physical properties of the unfired brick.

The purpose of this investigation was to determine what effect would be imparted to the brick by varying the forming pressure and keeping the water content constant, and what effect would be imparted by varying the water content and keeping the forming pressure constant, on a series of typical dry press mixes.

METHOD OF INVESTIGATION

When a column of granular material, such as a dry press mix, is compressed, the actual pressure that is developed at various levels in the column is different. On the other hand, the compression of a column of water develops equal pressures at all levels. One of the causes of "shelly" brick is due in part to the unequal pressures to which the top, middle and bottom of the brick are subjected.

We could develop equal pressures in all parts of the brick if enough water were added to establish a hydraulic condition throughout, but such a water content is above the permissible limit in the dry pressing operation. Other factors that must affect the transmission of pressure, and thereby the equality of the pressure in all parts of the brick, are the shape of the grain, fineness of grain, and grading of the grain size. There must be an optimum combination of these grain characteristics, wetness of mix, moulding pressure, and time of application.

The fineness, shape and grading of the grains are established by methods of grinding, and the pressure is determined by the manipulation of the press.

A survey of the literature does not reveal any data bearing directly on these considerations. This is, therefore, a virgin field for research work.

MATERIALS USED

The materials selected for this investigation vary greatly in their raw physical properties, and so cover practically the entire plasticity range used in the dry press process of brick making.

The materials and mixes follow:

1. St. Louis Surface Clay 100%.
2. Cheltenham Clay 100%.
3. Cheltenham Clay 6/7 - St. Louis Surface Clay 1/7.
4. Cheltenham Clay 92% - Grog 8%.
5. North Missouri Semi-Flint 92% - Grog 8%.
6. Missouri Flint 75% - Cheltenham Clay 25%.

These mixes are representative of the important raw materials used in making building brick and fire brick.

METHODS OF MILLING AND SCREENING

Each of the mixes and the single clay were subjected to dry pan grinding in a three-foot convertible wet and dry pan running at a speed of 60 R.P.M. The screen plates used had openings 1/8 inch in width and 5 inches in length. Grinding in each case was continued until the entire sample passed through the openings in the screen plates.

Mixes 1 and 3 were screened through 10 mesh and Mixes 2, 4 and 5 through 8 mesh, using a Great Western

Manufacturing Company gyratory Riddle. In each case the tailings were returned to the dry pan and reground until the entire sample passed the screen indicated. ~~The dry pan and the gyratory riddle are shown in Fig. 1 and Fig. 2.~~

<u>Screen Analysis</u>

Each batch was quartered to secure a representative sample for screen analysis.

The sample on the screens indicated in Table I, was placed in a Tyler Rotap machine for twenty minutes.

The contents of each screen was weighed to the nearest one-hundredth of a gram and the percentage retained calculated. The results of these analyses are tabulated in Table I.

<u>Tempering</u>

The tempering was done in the small kneading machine shown in Fig. 3. The moisture content of each mix was determined and enough water was added by hand to bring the total moisture content up to seven per cent. After the water addition, the mixer was allowed to run five minutes in order to give even distribution. To give the mix further opportunity to become more evenly moistened, it was put into a covered container and aged for twenty-four hours before being formed.

TABLE I

SCREEN ANALYSES OF DRY PANNED MIXES

Tyler Standard Sieve	St.Louis Surface Clay	1/7 St.Louis Surface -6/7 Cheltenham	25% Cheltenham - 75% No. 1 Flint	92% North Mo. Semi-Flint 8% Grog	92% Cheltenham 8% Grog
On 8	0%	0%	0%	0%	0%
Thru 8 on 10	0%	0%	13.40%	10.73%	6.61%
Thru 10 " 14	11.33%	17.37%	13.04%	11.58%	14.58%
Thru 14 " 20	8.87%	9.59%	10.10%	9.24%	11.49%
Thru 20 " 28	10.48%	10.80%	12.40%	11.57%	13.20%
Thru 28 " 35	7.32%	7.61%	9.61%	8.90%	9.77%
Thru 35 " 48	5.40%	5.91%	8.43%	7.49%	8.02%
Thru 48 " 65	3.84%	4.94%	8.37%	6.61%	6.75%
Thru 65 " 100	3.39%	6.48%	9.83%	10.42%	9.96%
Thru 100 " 150	2.37%	8.59%	7.21%	8.12%	6.94%
Thru 150 " 200	1.04%	3.84%	2.29%	2.42%	2.80%
Thru 200	46.00%	24.53%	5.30%	12.95%	9.89%
Total	100.04%	100.02%	99.98%	100.03%	100.01%

Forming

The test blocks were formed in a hydraulic dry press obtained from the Hydraulic Press Manufacturing Company, of Mount Gilead, Ohio. The press is shown in Fig. 4.

The specifications of the press are as follows:

Maximum total pressure - 135 tons (equivalent to 6000 lbs. per sq. in.)
Mold box - 20" x 9-3/4" x 4-3/4"
Lower ram travel - 22 inches
Mold box travel - 1-1/4 inches.

The deep mold box on this press makes possible the forming of shapes up to 10 inches in depth. The rate of ram travel which is quite slow compared with a mechanical press, can be increased by using a lighter compression medium. A gauge in the line between the electric plunger pump and the compression cylinder of the dry press indicates the pressure being developed on the column of clay in the mold box at all times during compression. Manipulation of the valves makes it possible to hold any desired pressure any length of time.

When a mold box 16 inches deep is used, it requires 15 seconds interval between the time the ram starts to travel and the time pressure is recorded on the gauge. Approximately 1.7 seconds per 100 lbs. per sq. in. increase in pressure is required.

The mix was introduced into the mold box by hand; a two inch layer being put in and covered with a layer of potters flint to a depth of 1/16 inch. The lower ram was then depressed two inches and another layer added in the same manner until a column consisting of eight two-inch layers had been built up. Each layer was weighed previous to entering the mold box, so as to insure uniformity. The different clays took different amounts for the block. On an average, 4-1/2 lbs. were required for each layer.

Drying

The blocks were dried five days under the conditions of the room atmosphere. They were then cut up into the pieces, described below, and then dried completely at 235°F. In no case were any drying defects noticeable.

Tests for Pressure Distribution

Many proposals for determining the pressure developed at different levels in the blocks were considered. It was proposed to determine the density at various levels by measuring the depth of penetration of a vicat needle, but such a test was found unsatisfactory with grogged bodies and was discarded. It was proposed to build a special mold box having horizontal plungers at the various levels, each of the plungers to be connected to a separate pressure gauge. Such a mechanism would be capable of measuring the surface pressures only. It was proposed to insert copper tubes, horizontally, at various levels in the mix, and after compression, measure the extent of their collapse. By comparing the degree of collapse of the tubes at various levels in the mix, with a chart showing the collapse of similar tubes at various pressures, a measure of transmission of pressure could be obtained. Consideration of the variations in the tubes and the unknown effect the extent to which the presence of the mix would affect the collapse of the tube, offered serious objections to this procedure. Electrical resistivity methods, consisting of inserting carbon plates at various levels, and connecting them to a battery and rheostat; thus the variations in resistance to the current flowing through the plates, caused by the variations in pressure, could be measured by the amperage flowing through the circuit. There are serious mechanical difficulties with this procedure, and furthermore the presence of the plates will alter the character of the compression of the mix.

After careful consideration of all of the proposals, it was decided that the most practicable procedure would be to determine the bulk specific gravity and apparent porosity of samples of the compressed mix taken at different levels and locations. Theoretically the bulk specific gravity will increase and the apparent porosity decrease with increased pressure at any point in the block. An index of pressure developed could therefore be obtained by a determination of these properties at various locations and levels in the block, and in this way the transmission of pressure studied. Since there is an inverse ratio between the bulk specific gravity and the apparent porosity of the same sample, and since the apparent porosity is a larger figure and shows greater variation than the bulk specific gravity, the apparent porosities only were used in plotting the curves given below. However, the bulk specific gravities are given in the tables.

It was apparent that regular sized brick would not give enough variation in physical properties from top to bottom to enable us to properly study the effect of pressure transmission. This is where the deep mold box, capable of taking an uncompressed column of 20 inches of mix, proved to be desirable. In fact the slow application of pressure effected on the press did not give as large a variation in specific gravity and porosity in a 10 inch block as was desirable, but certainly a more shallow form would have been wholly inadequate.

Accordingly an uncompressed column of 16 inches was taken in all cases and compressed to a form from 8 to 10 inches in thickness, depending on the nature of the mix. Logically the question arose as to how satisfactory samples on which to determine the specific gravity and porosity were to be obtained from the various locations of the moulded block. Sawing them out was attempted but proved unsatisfactory. The scheme was developed of introducing the mix into the mold box in 8 separate layers, separating the layers by a sprinkling of finely ground potters flint (SiO_2). The layers were two inches thick before compression and approximately 4-1/2 lbs. of clay were used in each layer, depending on the bulkiness of the clay. Care was taken to see that all layers of one block contained equal amounts by weight of the mix. The bonding power of the flint was so low, compared with the clay, that the layers could be lifted from one another by the hand, giving a clean-cut separation in each case. These layers were then placed on a cushion of sand and cut by striking a butcher knife, placed on their surface, with a hammer. The samples taken were approximately 1" x 1" x 1". Four specimens were taken from each layer, viz., one from a corner (A), one from the middle of an end (B), one from the middle of the side (C), and one from the central position of the layer (D). There is no reason to believe that the sprinkling of flint interfered with the transmission of pressure, and it not only served the purpose of separating the block into the layers, as described, but it also left lines or markings along the sides of the block allowing the direction and degree of the flow of the grains to be observed.

The bulk specific gravity and apparent porosity of the 1" x 1" x 1" samples (4 from each layer) were obtained by placing the sample in a small marked beaker and covering it with kerosene, after the dry weight had been determined. The samples in the beakers were then placed in a sealed container and subjected to a reduced pressure of 26 inches of mercury for two hours. They were then removed and the suspended weight in kerosene, and the saturated weight recorded. The following formulae were used:

$$\text{Bulk Specific Gravity} = \frac{\text{Weight Dry}}{\dfrac{\text{Weight Saturated} - \text{Weight Suspended}}{\text{Sp.Gr. of Kerosene}}}$$

$$\text{Apparent Porosity} = \frac{\text{Weight Saturated} - \text{Weight Dry}}{\text{Weight Saturated} - \text{Weight Suspended}}$$

METHOD OF INVESTIGATION TO STUDY THE EFFECT OF DIFFERENT WATER CONTENT ON THE DRY PRESS MIXES.

The next logical problem to study was the effect that variable water contents would impart to the unfired brick.

The materials used, method of milling and screening and screen analysis were the same as given before.

Tempering

The moisture content of each mix was adjusted so that brick were made from mixes containing 5, 6, 8, 9, 10, 12 and 14% of water. The clay and water were introduced into a small kneading machine and kneaded for fifteen minutes to insure even distribution of the water in the clay mass.

To allow the water to become more evenly distributed the mix was allowed to age in a closed container for twenty-four hours before being formed.

Forming

The forming was done on the press as described before. A two inch layer of clay was introduced at a time and a thin layer of potters flint was applied, and this was repeated until eight such layers were built up. The forming pressure was 2000 pounds per sq. in. One block was made of each water content. In addition to the block with the eight layers, there were formed two brick of each water content, which were 4 inches thick before being formed. These brick were weighed wet and weighed again when dry. Also the thickness was measured when wet and dry and broken on a cross breaking machine, which will be described later on in the report.

Drying

The blocks and brick were dried as described before.

TESTS FOR VARIOUS PHYSICAL PROPERTIES

The layers of the block were separated and the potters flint removed with a wire brush, then each layer was broken into two equal pieces. The size of the sections was approximately 4½" x 4½" x 1". These were weighed dry and then placed in an autoclave and immersed in kerosene and subjected to a reduced pressure of 26 inches of mercury for two hours.

They were then removed and weighed suspended in kerosene and saturated in kerosene and then the weight recorded.

From the data, the Apparent Porosity and Bulk Specific Gravity was determined.

Two bricks of each water content were broken on Riehle Universal Testing Machine, having a capacity of 50,000 pounds.

The span between the rounded knife edges was eight inches. It is well to note that the knife edges were not sharp but rounded. This will give approximately true transverse strength. The load was applied at the rate of .08 vertical inches per minute. The breadth and depth were measured and calculated as modulus of rupture in pounds per square inch.

The two halves of the broken brick were dried to constant weight and weighed dry and then immersed in an autoclave and subjected to a reduced pressure of 26 inches of mercury for two hours. They were then removed and weighed suspended in kerosene and saturated in kerosene, and weight recorded. From this data the apparent porosity and Bulk Specific Gravity were calculated.

TABLE - A

Mix:
St. Louis Surface Clay - Ground in Dry Pan Through 10 Mesh.

VERTICAL VARIATION IN APPARENT POROSITY AND BULK DENSITY

FORMING PRESSURE IN LBS. PER SQ. IN.

Location	500		1000		1500		2000		3000		4000	
	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.
1	1.705	35.44	1.755	33.42	1.745	33.80	1.748	34.05	1.760	32.92	1.790	31.71
2	1.680	36.26	1.740	34.07	1.730	34.64	1.770	32.23	1.765	32.68	1.800	31.35
3	1.655	37.21	1.720	34.85	1.728	34.67	1.755	32.27	1.780	31.95	1.815	31.03
4	1.630	37.89	1.700	35.66	1.733	34.59	1.778	32.87	1.818	31.55	1.830	29.99
5	1.660	37.08	1.710	35.07	1.753	33.72	1.790	32.46	1.820	30.36	1.858	29.01
6	1.660	36.80	1.728	34.35	1.783	32.51	1.818	31.35	1.843	29.68	1.870	28.80
7	1.720	35.64	1.748	33.43	1.790	32.41	1.813	31.49	1.860	28.97	1.905	27.02
8	1.720	33.17	1.770	32.81	1.813	31.53	1.833	30.61	1.883	27.68	1.923	26.45
Avg. 1-8	1.679	36.19	1.734	34.21	1.759	33.48	1.786	32.17	1.816	30.72	1.849	29.42
Depth of Finished Block	9.06"		8.90"		8.86"		8.66"		8.64"		8.24"	

TABLE A-1

Mix:
Same as given in Table A

HORIZONTAL VARIATION IN APPARENT POROSITY AND BULK DENSITY

Location	FORMING PRESSURES IN LBS. PER SQ. IN.											
	500		1000		1500		2000		3000		4000	
Block	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.
A	1.680	35.90	1.739	34.01	1.766	33.20	1.788	32.18	1.824	30.37	1.853	29.48
B	1.676	36.10	1.734	34.15	1.759	33.60	1.794	31.99	1.814	30.66	1.851	29.43
C	1.678	36.20	1.736	34.14	1.758	33.53	1.784	32.13	1.815	30.71	1.854	29.09
D	1.680	36.55	1.730	34.38	1.754	33.73	1.789	32.35	1.811	31.15	1.839	29.68
Avg. A-D	1.679	36.19	1.735	34.17	1.759	33.52	1.789	32.16	1.816	30.72	1.849	29.42
Block Thickness	9.06"		8.90"		8.86"		8.66"		8.64"		8.24"	

TABLE B

Mix:
Cheltenham Clay 85.7%)
St. Louis Surface Clay 14.3%) Ground in Dry Pan - Through 10 Mesh

VERTICAL VARIATION IN APPARENT POROSITY AND BULK DENSITY

FORMING PRESSURE IN LBS. PER SQ. IN.

Location	500		1000		1500		2000		3000		4000	
	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.
1	1.918	26.75	1.925	27.02	1.960	26.13	1.993	23.81	2.013	23.21	2.070	20.66
2	1.893	27.91	1.888	28.72	1.953	26.08	1.955	23.13	2.018	22.67	2.088	19.95
3	1.860	29.40	1.895	28.22	1.965	25.50	2.028	22.38	2.055	21.20	2.130	18.51
4	1.873	28.98	1.930	28.25	2.010	24.01	2.063	20.88	2.093	19.80	2.153	17.43
5	1.900	27.64	1.943	26.28	2.045	22.40	2.078	19.88	2.085	18.31	2.178	16.13
6	1.940	26.41	1.985	24.62	2.065	21.14	2.128	18.43	2.160	17.39	2.195	15.59
7	1.973	25.10	2.013	23.31	2.105	20.04	2.148	17.56	2.175	16.61	2.208	15.21
8	2.015	23.54	2.048	21.83	2.125	19.11	2.128	16.90	2.190	16.00	2.210	15.07
Avg. 1-8	1.922	26.97	1.953	26.03	2.029	23.05	2.065	20.37	2.099	19.40	2.154	17.32
Depth of Finished Block	10.38"		10.25"		9.88"		9.46"		9.64"		9.56"	

TABLE B-1

Mix:
Same as given in Table B.

HORIZONTAL VARIATION IN APPARENT POROSITY AND BULK DENSITY

Location	FORMING PRESSURES IN LBS. PER SQ. IN. 500		1000		1500		2000		3000		4000	
Block	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.
A	1.925	27.00	1.965	26.01	2.033	22.81	2.076	20.42	2.098	19.64	2.146	17.55
B	1.928	26.67	1.953	25.80	2.021	22.99	2.071	20.28	2.110	19.32	2.154	17.16
C	1.925	26.86	1.951	25.89	2.039	22.81	2.080	20.42	2.098	19.12	2.159	17.32
D	1.908	27.33	1.944	26.43	2.021	23.58	2.031	20.37	2.098	19.51	2.156	17.36
Avg. A-D	1.922	26.97	1.953	26.03	2.029	23.05	2.065	20.37	2.099	19.40	2.154	17.35
Block Thickness	10.38"		10.25"		9.88"		9.46"		9.64"		9.56"	

TABLE C

Mix:
Cheltenham Clay 92%) Ground in Dry Pan - Through 8 Mesh.
Fire Brick Grog 8%)

VERTICAL VARIATION IN APPARENT POROSITY AND BULK DENSITY

Location	FORMING PRESSURE IN LBS. PER SQ. IN.											
	500		1000		1500		2000		3000		4000	
	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.
1	2.046	21.96	2.100	21.07	2.105	20.29	2.115	19.47	2.170	18.50	2.16	18.52
2	2.045	22.20	2.073	20.16	2.102	20.10	2.128	19.71	2.185	18.63	2.15	18.86
3	2.012	23.03	2.075	21.16	2.100	20.34	2.085	19.46	2.183	18.43	2.16	18.51
4	2.020	22.80	2.090	20.51	2.112	20.14	2.128	19.72	2.185	18.30	2.17	18.26
5	2.030	22.94	2.095	20.13	2.105	19.58	2.130	19.44	2.175	17.89	2.18	17.81
6	2.030	23.00	2.083	21.25	2.125	19.36	2.135	19.18	2.170	17.92	2.18	17.84
7	2.056	22.07	2.097	20.18	2.125	19.39	2.145	19.01	2.183	17.41	2.19	17.58
8	2.035	21.91	2.125	19.54	2.127	19.23	2.140	18.80	2.183	17.22	2.18	17.58
Avg. 1-8	2.034	22.49	2.092	20.50	2.113	19.80	2.126	19.35	2.179	18.04	2.17	18.12
Depth of Finished Block	8-7/16"		8-3/16"		7-14/16"		8-3/16"		8-7/16"		8-7/16"	

TABLE C-1

Mix:
Same as given in Table C.

HORIZONTAL VARIATION IN APPARENT POROSITY AND BULK DENSITY

FORMING PRESSURES IN LBS. PER SQ. IN.

Location	500		1000		1500		2000		3000		4000	
Block	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.
A	2.043	21.80	2.098	19.51	2.113	19.87	2.130	19.38	2.182	17.70	2.170	18.07
B	2.032	22.71	2.088	20.96	2.113	19.78	2.133	19.52	2.168	18.49	2.175	18.14
C	2.032	22.48	2.091	20.70	2.111	19.84	2.133	19.17	2.187	17.93	2.178	18.07
D	2.028	22.96	2.091	20.73	2.112	19.64	2.105	19.3	2.17	18.14	2.165	18.22
Avg. A-D	2.034	22.49	2.092	20.48	2.112	19.78	2.125	19.35	2.178	18.06	2.172	18.13
Block Thickness in in.	8-7/16"		8-3/16"		7-14/16"		8-3/16"		8-7/16"		8-7/16"	

TABLE D

Mix:
North Missouri Semi-Flint Clay 92%)
Fire Brick Grog 8%) Ground in Dry Pan - Through 8 Mesh.

VERTICAL VARIATION IN APPARENT POROSITY AND BULK DENSITY

FORMING PRESSURE IN LBS. PER SQ. IN.

Location	500		1000		1500		2000		3000		4000	
	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.
1	1.952	25.66	1.963	23.60	2.018	22.56	2.043	22.72	2.073	21.13	2.093	20.35
2	1.943	26.06	1.968	24.41	1.985	23.58	2.030	23.24	2.055	21.59	2.095	20.27
3	1.917	26.43	1.940	25.38	1.983	23.50	2.048	22.29	2.078	20.95	2.103	19.69
4	1.927	26.22	1.940	24.71	2.085	23.37	2.060	22.28	2.095	20.30	2.190	20.09
5	1.915	26.12	1.963	24.58	2.150	22.33	2.065	21.55	2.115	19.80	2.128	18.72
6	1.935	25.18	1.988	23.81	2.045	21.71	2.088	21.00	2.130	19.15	2.143	18.23
7	1.950	25.43	2.010	23.03	2.058	21.30	2.103	20.37	2.143	18.64	2.140	17.99
8	1.965	24.75	2.018	22.57	2.078	20.35	2.115	19.95	2.153	18.26	2.130	17.64
Avg. 1-8	1.938	25.73	1.974	24.01	2.050	22.34	2.069	21.68	2.105	19.98	2.128	19.12
Depth of Finished Block	10-5/16"		10-3/4"		10-5/16"		10-9/32"		10-1/32"		9-15/16"	

TABLE D-1

Mix:
Same as given in Table D

HORIZONTAL VARIATION IN APPARENT POROSITY AND BULK DENSITY

Location	FORMING PRESSURES IN LBS. PER SQ. IN. 500		1000		1500		2000		3000		4000	
Block	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.
A	1.931	25.70	1.971	24.17	2.030	22.51	2.074	21.63	2.103	20.06	2.135	19.35
B	1.950	25.36	1.983	23.92	2.065	22.08	2.070	21.67	2.108	19.96	2.126	19.20
C	1.933	26.04	1.971	24.20	2.057	22.22	2.071	21.58	2.106	19.85	2.125	18.98
D	1.937	25.63	1.967	23.76	2.047	22.66	2.060	21.95	2.104	20.03	2.123	18.97
Avg. A-D	1.938	25.71	1.973	24.01	2.050	22.37	2.069	21.71	2.105	19.98	2.128	19.13
Block Thick-Ness	10-5/16"		10-3/4"		10-5/16"		10-9/32"		10-1/32"		9-15/16"	

TABLE E

Mix:
Cheltenham Clay 25%)
No. 1 Missouri Flint Clay 75%) Ground in Dry Pan - Through 8 Mesh.

VERTICAL VARIATION IN APPARENT POROSITY AND BULK DENSITY

FORMING PRESSURE IN LBS. PER. SQ. IN.

Location	500		1000		1500		2000		3000		4000	
	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.
1	1.807	30.78	1.828	29.15	1.840	29.44	1.858	28.80	1.833	28.15	1.850	28.10
2	1.805	31.42	1.825	29.25	1.833	29.59	1.858	29.11	1.840	28.88	1.863	27.87
3	1.795	31.61	1.820	30.07	1.837	29.63	1.873	28.66	1.848	28.22	1.870	27.36
4	1.785	31.02	1.818	28.82	1.848	29.34	1.888	28.11	1.850	28.04	1.883	26.92
5	1.780	31.34	1.835	29.21	1.858	28.71	1.895	27.80	1.868	27.18	1.885	26.79
6	1.803	30.69	1.855	28.58	1.883	28.25	1.910	27.26	1.880	27.02	1.903	26.55
7	1.813	30.03	1.860	28.02	1.900	27.53	1.928	26.62	1.890	26.83	1.915	26.32
8	1.840	27.92	1.875	27.25	1.885	26.91	1.928	26.31	1.908	26.22	1.925	25.68
Avg. 1-8	1.804	30.60	1.837	28.79	1.881	28.68	1.880	27.83	1.865	27.57	1.887	26.95
Depth of Finished Block	11-1/8"		10-3/4"		10-5/8"		10-7/16"		10-11/16"		10-3/4"	

TABLE E-1

Mix:
Same as given in Table E.

HORIZONTAL VARIATION IN APPARENT POROSITY AND BULK DENSITY

FORMING PRESSURES IN LBS. PER SQ. IN.

Location	500		1000		1500		2000		3000		4000	
Block	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.	Sp.Gr.	Por.
A	1.805	30.66	1.838	28.93	1.870	28.39	1.894	27.61	1.856	27.67	1.895	26.67
B	1.801	30.98	1.835	29.01	1.863	28.67	1.891	27.93	1.870	27.38	1.888	26.89
C	1.809	30.37	1.840	28.89	1.864	28.76	1.895	27.86	1.861	27.41	1.881	27.02
D	1.799	30.40	1.843	25.09	1.861	28.73	1.888	27.93	1.858	27.80	1.883	27.21
Avg. A-D	1.804	30.60	1.839	27.96	1.865	28.64	1.892	27.83	1.861	27.57	1.887	26.95
Block Thickness	11-1/8"		10-3/4"		10-5/8"		10-7/16"		10-11/16"		10-3/4"	

TABLE P-1

APPARENT POROSITY OF BLOCK WITH VARIABLE WATER CONTENT

Layer	1-I-1 App. Por.	1-I-1 Avg. App. Por.	2-I-1 App. Por.	2-I-1 Avg. App. Por.	3-I-1 App. Por.	3-I-1 Avg. App. Por.	4-I-1 App. Por.	4-I-1 Avg. App. Por.	5-I-1 App. Por.	5-I-1 Avg. App. Por.	6-I-1 App. Por.	6-I-1 Avg. App. Por.
1	33.33	30.18	31.17	30.86	29.82	29.32	29.51	29.73	29.27	29.17	.....	29.01
2	33.97	33.24	.....	33.37	31.47	31.58	30.00	30.22	29.21	29.07	29.57	29.22
3	33.84	34.45	12.55	32.92	29.81	30.41	30.92	30.97	.....	29.68	29.88	29.92
4	33.14	33.14	32.00	31.94	26.39	27.30	30.07	30.53	30.37	30.37	29.73	29.51
5	32.81	33.07	31.98	31.83	30.62	29.94	29.78	30.00	29.60	29.58	28.69	29.25
6	32.48	32.05	31.21	30.91	29.80	30.02	28.79	29.00	29.39	29.11	29.39	29.70
7	30.63	31.82	32.69	31.70	29.02	29.26	.....	28.19	28.68	28.68	28.84	28.94
8	.....	32.31	30.48	30.33	29.52	29.52	28.39	28.39	27.80	27.91	28.48	28.58
X												
1	27.02	.....	30.55	.....	28.82	.....	29.95	.....	29.08	.....	29.01	.....
2	32.51	.....	33.37	.....	31.69	.....	30.43	.....	28.93	.....	28.86	.....
3	35.05	.....	32.92	.....	31.00	.....	31.02	.....	29.68	.....	29.97	.....
4	33.14	.....	31.89	.....	28.21	.....	31.00	.....	.....	.....	29.30	.....
5	33.32	.....	31.67	.....	29.27	.....	30.21	.....	29.55	.....	29.81	.....
6	31.63	.....	30.61	.....	30.24	.....	29.20	.....	28.83	.....	30.00	.....
7	33.00	.....	30.71	.....	29.50	.....	28.19	.....	34.96	.....	29.05	.....
8	32.31	.....	30.18	.....	.....	.....	.....	.....	28.01	.....	28.67	.....
Total Avg. App. Porosity		32.53		31.73		29.63		29.63		29.20		29.27

TABLE Q-1

APPARENT POROSITY OF BLOCK WITH VARIABLE WATER CONTENT

Layer	App. Por.	Avg. App. Por.	App. Por.	Avg. App. Por.	App. Por.	Avg. App. Por.	App. Por.	Avg. App. Por.	App. Por.	Avg. App. Por.	App. Por.	Avg. App. Por.
	1-II-1		2-II-1		3-II-1		4-II-1		5-II-1		6-II-1	
1	22.39	22.39	21.57	21.59	18.92	18.75	17.61	17.61	20.00	20.69	.....	20.75
2	21.59	21.36	22.76	22.54	18.19	18.07	18.61	18.73	18.95	19.87	22.39	21.99
3	24.12	24.15	23.41	21.98	18.85	18.43	21.1o	21.13	21.23	20.38	20.33	21.18
4	23.41	23.61	19.34	20.29	17.16	17.94	19.59	20.06	21.20	21.40	22.65	22.03
5	21.79	22.39	16.92	20.00	18.31	18.17	19.98	19.32	21.47	22.05	21.90	21.24
6	.....	21.77	18.79	18.97	18.66	18.75	17.94	18.51	21.64	21.31	20.19	20.50
7	21.20	21.50	18.12	18.14	17.60	18.73	19.90	19.60	22.03	21.78	21.05	20.90
8	19.08	20.46	17.62	17.99	17.02	18.51	.....	.....	21.18	20.52	22.21	22.20
X												
1	.....	.....	21.62	.....	18.79	.....	.....	.....	21.38	.....	20.75	.....
2	21.13	.....	22.29	.....	17.95	.....	18.85	.....	20.80	.....	21.59	.....
3	24.18	.....	20.54	.....	18.10	.....	21.17	.....	19.53	.....	22.03	.....
4	23.80	.....	21.25	.....	18.71	.....	20.52	.....	21.61	.....	21.41	.....
5	23.00	.....	20.00	.....	17.93	.....	18.67	.....	22.57	.....	20.58	.....
6	21.77	.....	19.15	.....	18.84	.....	19.08	.....	20.98	.....	20.80	.....
7	21.81	.....	18.17	.....	19.85	.....	19.30	.....	21.52	.....	20.82	.....
8	20.00	.....	18.36	.....	20.00	.....	.....	.....	19.85	.....	22.20	.....
Total Avg. App.Porosity		22.20		20.19		18.42		19.28		21.00		21.35

TABLE R-1

APPARENT POROSITY OF BLOCK WITH VARIABLE WATER CONTENT

Layer	App. Por.	Avg. App. Por.	App. Por.	Avg. App. Por.	App. Por.	Avg. App. Por.	App. Por.	Avg. App. Por.	App. Por.	Avg. App. Por.	App. Por.	Avg. App. Por.
	1-III-1		2-III-1		3-III-1		4-III-1		5-III-1		6-III-1	
1	20.61	21.14	22.30	21.34	21.00	19.97	20.34	20.17	18.32	18.59	.....	.....
2	22.01	22.04	22.04	21.17	20.28	21.15	20.82	20.51	19.05	18.98	.....	.....
3	23.30	22.39	23.87	22.79	19.29	19.77	19.71	20.66	22.30	20.80	.....	.....
4	21.40	21.17	19.05	19.45	20.69	19.80	19.18	19.59	20.57	19.68	23.17	21.89
5	20.13	20.86	20.61	20.34	.....	19.20	18.93	19.42	20.15	20.15	20.27	19.91
6	20.19	20.61	19.00	19.17	19.14	19.43	19.59	19.69	18.90	19.07	20.94	21.54
7	20.00	19.85	28.64	17.94	19.37	19.61	19.70	20.86	19.52	19.43	20.00	20.90
8	18.26	18.33	17.76	17.76	19.37	19.28	20.37	20.34	.....	18.90	21.88	21.86
X												
1	21.67	.....	20.39	.....	18.94	.....	20.00	.....	18.86	.....	.....	.....
2	22.06	.....	20.30	.....	22.02	.....	20.21	.....	18.90	.....	.....	.....
3	21.49	.....	21.71	.....	20.25	.....	21.62	.....	19.30	.....	.....	.....
4	20.94	.....	19.85	.....	18.91	.....	20.00	.....	18.80	.....	20.62	.....
5	21.59	.....	20.06	.....	19.20	.....	19.90	.....	20.16	.....	19.55	.....
6	21.02	.....	19.34	.....	19.72	.....	19.79	.....	19.24	.....	22.14	.....
7	19.69	.....	17.94	.....	19.85	.....	22.02	.....	19.33	.....	21.80	.....
8	18.40	.....	.....	.....	19.18	.....	20.30	.....	18.90	.....	21.85	.....
Total Avg. App. Porosity		20.80		19.99		19.78		20.15		19.45		21.22

TABLE S-1

APPARENT POROSITY OF BLOCK WITH VARIABLE WATER CONTENT

Layer	1-IV-1 App. Por.	1-IV-1 Avg. App. Por.	2-IV-1 App. Por.	2-IV-1 Avg. App. Por.	3-IV-1 App. Por.	3-IV-1 Avg. App. Por.	4-IV-1 App. Por.	4-IV-1 Avg. App. Por.	5-IV-1 App. Por.	5-IV-1 Avg. App. Por.	6-IV-1 App. Por.	6-IV-1 Avg. App. Por.	7-IV-1 App. Por.	7-IV-1 Avg. App. Por.
1	20.30	21.90	23.08	22.27	18.75	18.88	18.16	18.47	20.33	20.75	22.02	22.02	.....	.....
2	23.90	22.35	22.94	23.13	17.27	17.70	18.18	18.07	20.16	19.75	20.81	20.32	.....	.....
3	23.24	23.23	21.41	21.27	17.14	17.57	17.57	18.16	19.82	19.53	20.31	20.31	.....	.....
4	23.90	22.98	22.43	22.49	17.98	18.50	18.70	18.80	19.36	19.84	20.81	22.08	.....	.....
5	22.22	22.54	20.89	20.95	17.81	18.42	20.27	19.60	20.50	21.13	21.02	21.00	20.24	19.93
6	20.34	21.22	21.00	20.70	17.99	18.04	18.95	19.24	20.27	20.85	21.90	21.95	22.13	21.68
7	21.73	22.43	21.03	20.57	18.78	18.89	18.93	19.02	20.17	20.65	21.02	20.51	21.44	21.22
8	20.00	20.48	19.30	19.36	18.00	18.06	19.40	19.27	18.64	18.90	20.95	19.77	20.63	20.63
X														
1	23.50	.....	21.46	.....	19.02	.....	18.78	.....	21.16	.....	25.41	.....	.....	.....
2	21.80	.....	23.31	.....	18.12	.....	17.96	.....	19.35	.....	19.84	.....	.....	.....
3	23.22	.....	21.13	.....	18.00	.....	18.76	.....	19.24	.....	20.32	.....	.....	.....
4	22.06	.....	22.54	.....	19.02	.....	18.90	.....	20.33	.....	23.35	.....	.....	.....
5	22.86	.....	21.00	.....	19.02	.....	18.93	.....	21.76	.....	20.98	.....	19.63	.....
6	22.10	.....	20.40	.....	18.08	.....	19.54	.....	21.44	.....	21.99	.....	21.22	.....
7	23.12	.....	20.12	.....	19.00	.....	19.11	.....	21.12	.....	20.00	.....	21.00	.....
8	20.95	.....	19.43	.....	18.12	.....	19.14	.....	19.15	.....	17.59	.....	.....	.....
Total Avg. App. Porosity		22.14		21.34		18.25		18.83		20.17		20.99		20.86

TABLE T-1

APPARENT POROSITY OF BLOCK WITH VARIABLE WATER CONTENT

Layer	1-V-1 App. Por.	1-V-1 Avg. App. Por.	2-V-1 App. Por.	2-V-1 Avg. App. Por.	3-V-1 App. Por.	3-V-1 Avg. App. Por.	4-V-1 App. Por.	4-V-1 Avg. App. Por.	5-V-1 App. Por.	5-V-1 Avg. App. Por.	6-V-1 App. Por.	6-V-1 Avg. App. Por.
1	.....	18.10	.....	.....	18.24	18.29	18.42	18.42	19.46	20.24	.....	22.78
2	.....	.....	20.28	20.28	20.53	19.49	19.09	18.34	21.97	20.92	21.90	21.65
3	.....	.....	21.39	22.36	18.15	17.64	18.80	18.45	21.40	20.82	21.82	21.64
4	21.32	21.50	.....	21.67	19.17	20.28	18.49	18.82	21.02	19.84	21.00	21.43
5	22.00	21.51	20.86	21.18	17.00	18.50	20.00	19.48	21.99	21.51	22.61	22.33
6	19.35	20.26	19.89	20.64	18.69	19.13	19.09	19.39	21.61	20.26	21.79	22.28
7	20.21	20.21	20.60	20.30	19.75	19.00	19.10	18.95	17.14	16.69	22.17	21.69
8	19.09	19.44	21.41	20.71	18.52	18.21	18.45	18.35	20.63	20.86	21.36	21.78
X												
1	18.10	.....	.....	.....	18.33	.....	.....	.....	21.01	.....	22.78	.....
2	.....	.....	.....	.....	18.45	.....	17.59	.....	19.84	.....	21.40	.....
3	.....	.....	23.34	.....	17.14	.....	18.10	.....	20.24	.....	21.46	.....
4	21.68	.....	21.67	.....	21.38	.....	19.15	.....	18.66	.....	22.46	.....
5	20.98	.....	21.50	.....	20.00	.....	18.96	.....	21.02	.....	22.05	.....
6	21.17	.....	21.39	.....	19.57	.....	19.69	.....	18.92	.....	22.77	.....
7	20.21	.....	20.00	.....	18.26	.....	18.80	.....	16.24	.....	21.21	.....
8	19.78	.....	20.00	.....	17.90	.....	18.25	.....	21.08	.....	22.21	.....
Total Avg. App. Porosity		20.17		21.02		18.82		18.77		20.14		21.95

TABLE V-1

APPARENT POROSITY OF BLOCK WITH VARIABLE WATER CONTENT

Layer	1-VI-1		2-VI-1		3-VI-1		4-VI-1		5-VI-1		6-VI-1		7-VI-1	
	App. Por.	Avg. App. Por.	App. Por.	Avg. App. Por.	App. Por.	Avg. App. Por.	App. Por.	Avg. App. Por.	App. Por.	Avg. App. Por.	App. Por.	Avg. App. Por.	App. Por.	Avg. App. Por.
1	28.38	26.19	27.04	26.44	25.59	25.75	29.38	28.56	28.10	28.22	29.71	29.33	27.42	27.99
2	25.92	24.96	26.80	26.62	26.02	25.81	29.63	28.01	(8.16)	28.10	28.82	28.70	27.00	27.75
3	27.88	27.73	27.05	26.92	26.61	26.35	27.21	28.35	28.18	27.87	27.59	27.49	27.61	27.91
4	28.78	28.30	25.78	26.30	25.91	26.14	29.79	30.00	28.20	29.01	28.78	28.59	28.17	28.18
5	28.21	27.61	26.95	27.08	26.80	26.30	29.01	28.82	29.48	29.51	27.80	27.80	27.01	27.34
6	27.82	27.54	28.59	27.60	26.10	25.74	29.74	28.68	29.59	29.00	26.57	27.06	26.30	25.96
7	27.44	27.35	26.30	26.24	25.52	25.77	25.80	27.00	29.42	28.73	25.82	26.38	26.12	25.97
8	26.52	26.78	26.81	26.25	25.56	25.71	28.42	28.09	.....	.....	25.90	25.99	26.22	25.72
X														
1	24.00	.....	25.84	.....	25.90	.....	27.75	.....	28.34	.....	28.96	.....	28.56	.....
2	24.00	.....	26.43	.....	25.61	.....	26.39	.....	28.10	.....	28.58	.....	28.48	.....
3	27.58	.....	26.78	.....	26.08	.....	29.50	.....	27.56	.....	27.39	.....	28.22	.....
4	27.81	.....	26.83	.....	26.38	.....	30.21	.....	29.81	.....	28.41	.....	28.19	.....
5	27.00	.....	27.20	.....	25.80	.....	28.62	.....	29.54	.....	27.80	.....	27.67	.....
6	27.26	.....	26.62	.....	25.37	.....	27.62	.....	28.41	.....	27.55	.....	25.61	.....
7	27.26	.....	26.18	.....	26.01	.....	28.21	.....	28.03	.....	26.95	.....	25.82	.....
8	27.04	.....	25.68	.....	25.86	.....	27.76	.....	.....	.....	26.08	.....	25.21	.....
Total Avg. App. Porosity		27.06		26.68		27.20		28.44		28.63		27.67		27.10

TABLE M-1

BULK SPECIFIC GRAVITY AND APPARENT POROSITY OF BRICK WITH VARIABLE WATER CONTENT

Mix I

	Wt. Dry	Wt. Sat.	Wt. Sus.	Wt. Sat. - Wt. Sus.	Wt. Sat. - Wt. Dry	Bulk Sp.Gr.	Avg. Bulk Sp.Gr.	Porosity	Avg. Porosity
5-1-1X	1346	1522	937	585	186	1.872)	1.873	31.80)	30.89
5-1-1	1392	1573	968	605	181	1.874)		29.98)	
6-1-1X	1262	1427	881	546	165	1.879)	1.880	30.20)	29.85
6-1-1	1472	1662	1026	636	190	1.881)		29.90)	
6-1-2X	1267	1430	883	547	163	1.880)		29.83)	
6-1-2	1398	1576	972	604	178	1.880)		29.50)	
8-1-1X	1360	1526	947	579	166	1.909)	1.911	28.70)	28.81
8-1-1	1231	1380	859	521	149	1.920)		28.64)	
8-1-2X	1262	1417	880	537	155	1.915)		28.82)	
8-1-2	1380	1552	962	590	172	1.900)		29.10)	
9-1-1X	1367	1530	953	577	163	1.945)	1.932	28.25)	28.82
9-1-1	1273	1431	886	545	160	1.920)		29.40)	
10-1-1X	1349	1512	937	575	163	1.920)	1.924	28.21)	28.03
10-1-1	1295	1449	899	550	154	1.918)		28.00)	
10-1-2X	1383	1545	960	585	162	1.950)		27.70)	
10-1-2	1444	1618	1002	616	174	1.909)		28.21)	
12-1-1X	1457	1650	1010	640	193	1.850)	1.850	30.10)	30.10

TABLE M-2

BULK SPECIFIC GRAVITY AND APPARENT POROSITY OF BRICK WITH VARIABLE WATER CONTENT

Mix II

	Wt. Dry	Wt. Sat.	Wt. Sus.	Wt. Sat.- Wt. Sus.	Wt. Sat.- Wt. Dry	Bulk Sp.Gr.	Avg. Bulk Sp.Gr.	Porosity	Average Porosity
5-2-1X	1519	1611	1050	561	92	2.200	2.200	16.38	16.51
5-2-2	1772	1879	1225	654	107	2.195		16.35	
5-2-2X	1589	1687	1098	589	98	2.195		16.65	
5-2-2	1507	1600	1043	557	93	2.210		16.68	
6-2-1X	1651	1748	1141	607	97	2.215	2.202	15.95	16.30
6-2-1	1543	1636	1067	569	93	2.205		16.32	
6-2-2X	1544	1640	1067	573	96	2.195		16.72	
6-2-2	1552	1647	1071	576	95	2.195		16.50	
9-2-1X	1221	1306	846	460	85	2.158	2.163	18.49	18.16
9-2-1	1323	1413	915	498	90	2.161		18.05	
9-2-2	1248	1332	865	467	84	2.175		17.95	
10-2-1X	1112	1189	769	420	77	2.155	2.162	18.35	18.47
10-2-1	1260	1348	876	472	88	2.170		18.60	
12-2-1X	1170	1259	774	485	89	1.964	2.036	18.35	19.28
12-2-1	1038	1119	719	400	81	2.109		20.20	

TABLE M-3

BULK SPECIFIC GRAVITY AND APPARENT POROSITY OF BRICK WITH VARIABLE WATER CONTENT

Mix III	Wt. Dry	Wt. Sat.	Wt. Sus.	Wt.Sat.-Wt.Sus.	Wt.Sat.-Wt.Dry	Bulk Sp.Gr.	Avg.Bulk Sp.Gr.	Porosity	Average Porosity
5-3-1X	1771	1906	1225	681	135	2.115	2.115	19.82	20.21
5-3-1	1803	1940	1248	692	137	2.200		19.80	
5-3-2X	1684	1818	1168	650	134	2.110		20.60	
5-3-2	1532	1656	1051	605	124	2.060		20.50	
6-3-1X	1685	1800	1171	629	115	2.180	2.180	18.30	18.15
6-3-1	1519	1622	1056	566	103	2.180		18.20	
6-3-2X	1694	1807	1174	633	103	2.190		16.25	
6-3-2	1578	1683	1094	589	105	2.180		17.85	
8-3-1X	1471	1565	1016	549	94	2.181	2.172	17.16	17.55
8-3-1	1506	1604	1041	563	98	2.178		17.39	
8-3-2X	1508	1608	1042	566	100	2.165		17.65	
8-3-2	1537	1641	1062	579	104	2.160		17.99	
9-3-1X	1396	1493	968	525	97	2.160	2.161	18.46	18.84
9-3-1	1377	1474	957	517	97	2.170		18.72	
9-3-2X	1430	1536	994	542	106	2.150		19.55	
9-3-2	1383	1480	960	520	97	2.165		18.65	
10-3-1X	1320	1418	915	503	98	2.135	2.137	19.43	19.44
10-3-1	1248	1340	866	474	92	2.145		19.43	
10-3-2X	1154	1239	800	439	85	2.140		19.37	
10-3-2	1154	1240	800	440	86	2.138		19.55	

TABLE M-4

BULK SPECIFIC GRAVITY AND APPARENT POROSITY OF BRICK WITH VARIABLE WATER CONTENT

Mix IV

	Wt.Dry	Wt.Sat.	Wt.Sus.	Wt.Sat.-Wt.Sus.	Wt.Sat.-Wt.Dry	Bulk Sp.Gr.	Avg.Bulk Sp.Gr.	Porosity	Average Porosity
5-4-1X	1715	1843	1189	654	128	2.132)		19.61)	
5-4-1	1798	1932	1246	686	134	2.130)	2.1315	19.50)	19.79
5-4-2X	1528	1646	1061	585	118	2.134)		20.20)	
5-4-2	1671	1798	1159	639	127	2.130)		19.85)	
6-4-1X	1609	1724	1118	606	115	2.152)		19.00)	
6-4-1	1680	1801	1166	635	121	2.144)	2.142	19.05)	19.03
6-4-2X	1767	1893	1225	668	126	2.142)		18.85)	
6-4-2	1605	1722	1113	609	117	2.141)		19.21)	
8-4-1X	1446	1559	1003	556	113	2.112)		20.30)	
8-4-1	1427	1536	991	545	109	2.130)	2.119	20.00)	20.12
8-4-2X	1546	1664	1074	590	118	2.118)		20.00)	
8-4-2	1426	1537	989	548	111	2.116)		20.20)	
9-4-1X	1273	1373	885	488	100	2.112)		21.40)	
9-4-1	1295	1400	899	501	105	2.100)	2.107	20.92)	20.39
9-4-2X	1386	1486	961	525	100	2.142)		19.05)	
9-4-2	1156	1247	802	445	91	2.073)		20.21)	
10-4-1X	1143	1238	792	446	95	2.087)		21.22)	
10-4-1	1108	1200	769	431	92	2.094)	2.083	21.32)	21.46
10-4-2X	1116	1211	774	437	95	2.078)		21.65)	
10-4-2	922	1000	639	361	78	2.074)		21.65)	
12-4-1X	921	1007	638	369	86	2.032)	2.030	23.30)	23.31
12-4-1	1008	1102	698	404	94	2.028)		23.31)	

TABLE M-5

BULK SPECIFIC GRAVITY AND APPARENT POROSITY OF BRICK WITH VARIABLE WATER CONTENT

Mix V	Wt. Dry	Wt. Sat.	Wt. Sus.	Wt. Sat. - Wt. Sus.	Wt. Sat. - Wt. Dry	Bulk Sp. Gr.	Average Bulk Sp. Gravity	Porosity	Average Porosity
5-5-1X	1868	2015	1293	722	147	2.110		20.37	
5-5-1	2144	2307	1486	821	163	2.140	2.122	19.81	20.09
5-5-2X	1949	2099	1352	747	150	2.121		20.10	
5-5-2	1960	2112	1356	756	152	2.120		20.10	
6-5-1X	1701	1827	1180	747	126	1.858	2.132	16.86	19.65
6-5-1	1807	1942	1253	689	135	2.132		19.65	
8-5-1X	1544	1656	1072	584	112	2.122		19.20	
8-5-1	1462	1565	1012	553	103	2.144	2.133	18.61	18.96
8-5-2X	1509	1618	1045	573	109	2.133		19.00	
8-5-2	1500	1608	1040	568	108	2.143		19.03	
9-5-1X	1419	1525	984	541	106	2.124		19.58	
9-5-1	1468	1580	1019	561	112	2.123	2.127	19.95	19.70
9-5-2X	1468	1579	1018	561	111	2.123		19.75	
9-5-2	1376	1478	956	522	102	2.140		19.55	
10-5-1X	1382	1493	958	535	111	2.070		20.73	
10-5-1	1369	1479	949	530	110	2.092	2.098	20.78	20.52
10-5-2X	1318	1421	914	507	103	2.112		20.30	
10-5-2	1349	1456	935	521	107	2.120		20.30	
12-5-1X	1129	1224	782	442	95	2.072		21.42	
12-5-1	1121	1217	777	440	96	2.071	2.074	21.80	21.78
12-5-2X	1136	1233	786	447	97	2.060		21.70	
12-5-2	1105	1199	766	433	94	2.096		21.70	

TABLE M-6

BULK SPECIFIC GRAVITY AND APPARENT POROSITY OF BRICK WITH VARIABLE WATER CONTENT

Mix VI	Wt. Dry	Wt. Sat.	Wt. Sus.	Wt. Sat. - Wt. Sus.	Wt. Sat. - Wt. Dry	Bulk Sp. Gr.	Avg. Bulk Sp. Gr.	Porosity	Average Porosity
5-6-1	1888	1297	2099	802	211	1.910)		26.30)	
5-6-2X	1850	1272	2062	790	212	1.905)	1.908	26.81)	26.67
5-6-2	1815	1251	2023	772	208	1.910)		26.92)	
6-6-1X	1650	1136	1839	703	189	1.904)		26.92)	
6-6-1	1903	1323	2123	800	220	1.940)		27.50)	
6-6-2X	1851	1281	2068	787	217	1.925)	1.917	27.60)	27.23
6-6-2	1666	1144	1858	714	192	1.900)		26.90)	
8-6-1X	2003	2241	1387	854	238	1.923)		27.80)	
8-6-1	1418	981	1582	601	164	1.916)		27.22)	
8-6-2X	1657	1148	1851	703	194	1.910)	1.918	27.61)	27.15
8-6-2	1737	1196	1927	731	190	1.925)		26.00)	
9-6-1X	1784	1238	1981	743	197	1.956)		26.23)	
9-6-1	1631	1130	1821	691	190	1.926)		27.48)	
9-6-2X	1818	2021	1256	765	203	1.932)	1.931	26.23)	27.06
9-6-2	1602	1795	1111	684	193	1.910)		28.30)	
10-6-1X	1776	1228	1969	741	193	1.942)		26.05)	
10-6-1	1627	1125	1804	679	177	1.948)	1.943	26.10)	26.18
10-6-2X	1894	1309	2104	795	210	1.939)		26.40)	
12-6-1X	1237	856	1368	512	131	1.964)	1.969	25.60)	25.66
12-6-1	1570	1090	1736	646	166	1.975)		25.73)	
14-6-1X	1138	786	1261	475	123	1.945)		26.10)	
14-6-1	1370	947	1518	571	148	1.948)	1.943	25.90)	26.00
14-6-2	1175	811	1303	492	128	1.938)		26.00)	

MIX I

TABLE O_1

MODULUS OF RUPTURE OF BRICK WITH VARIABLE WATER CONTENT

	Weight Wet	Thickness When Formed	Weight Dry	Thickness Dry	Breadth	Load in lbs.	Line Pressure	d^2	bd^2	Modulus of Rupture lbs. per sq. in.	Average
5-1-1	2949	1.95	2738	1.95	4.76	465	815	3.80	18.05	309.1)	299.3
5-1-1	2991	1.95	2773	1.95	4.75	430	815	3.84	18.20	289.5)	
6-1-1	2968	1.94	2733	1.93	4.74	410	815	3.73	17.85	276.1)	311.0
6-1-1	2888	1.90	2662	1.87	4.73	480	815	3.52	16.65	346.0)	
8-1-1	2870	1.80	2588	1.80	4.74	510	815	3.24	15.38	398.6)	384.4
8-1-2	2926	1.85	2640	1.83	4.72	490	815	3.35	15.85	370.2)	
9-1-1	2988	1.87	2661	1.83	4.72	430	815	3.35	15.85	333.0)	346.0
9-1-2	2907	1.85	2592	1.83	4.73	475	815	3.35	15.87	359.0)	
10-1-1	3013	1.86	2627	1.85	4.71	430	815	3.42	16.10	320.5)	317.0
10-1-2	3212	2.00	2806	1.97	4.72	465	815	3.78	17.80	313.5)	
12-1-1	2767		2344	1.79	4.67	305	815	3.21	14.50	252.5)	252.5

TABLE O_2

MODULUS OF RUPTURE OF BRICK WITH VARIABLE WATER CONTENT

Mix II

	Weight Wet	Thickness When Formed	Weight Dry	Thickness Dry	Breadth	Load in lbs.	Line Pressure	d^2	bd^2	Modulus of Rupture lbs. per sq. in.	Average
5-2-1	3537	2.04	3285	2.01	4.70	425	815	4.00	18.80	271.8	275.9
5-2-2	3334	1.90	3091	1.87	4.70	385	815	3.52	16.50	280.0	
6-2-1	3447	1.97	3193	1.96	4.70	475	815	3.84	18.01	316.9	295.4
6-2-2	3358	1.94	3095	1.88	4.69	375	815	3.52	16.50	273.0	
6-2-1	3154	1.83	2870	1.80	4.66	285	815	3.24	15.10	226.3	258.1
8-2-2	3155	1.84	2857	1.80	4.66	365	815	3.24	15.10	290.0	
9-2-1	2822	1.63	2540	1.58	4.63	260	815	2.50	11.60	269.0	291.4
9-2-2	2870	1.69	2584	1.65	4.64	330	815	2.73	12.65	313.8	
10-2-1	2649	1.57	2371	1.50	4.62	220	700	2.25	10.40	254.0	254.0
12-2-1	2505	1.53	2206	1.47	4.57	195	300	2.16	9.90	236.0	236.0

TABLE Φ_3

MODULUS OF RUPTURE OF BRICK WITH VARIABLE WATER CONTENT

Mix III

	Weight Wet	Thickness When Formed	Weight Dry	Thickness Dry	Breadth	Load in lbs.	Line Pressure	d^2	bd^2	Modulus of Rupture lbs.per sq.in.	Average
5-3-1	3798	2.26	3568	2.25	4.72	475	815	5.07	23.95	238.0	235.0
5-3-2	3410	2.05	3213	2.05	4.73	390	815	4.25	20.50	233.0	
6-3-1	3465	1.99	3207	1.98	4.70	555	815	3.93	18.50	359.2	361.7
6-3-2	3533	2.04	3267	2.00	4.70	570	815	4.00	18.80	364.2	
8-3-1	3251	1.89	2862	1.86	4.68	410	815	3.46	16.20	304.2	334.2
8-3-2	3349	1.94	3051	1.91	4.69	450	815	3.64	17.10	315.0	
9-3-1	3077	1.79	2777	1.79	4.66	415	815	3.20	14.95	333.0	335.2
9-3-2	3139	1.82	2830	1.80	4.66	425	815	3.24	15.10	337.5	
10-3-1	2863	1.69	2561	1.63	4.62	205	815	2.66	12.30	201.0	197.5
10-3-2	2584	1.54	2304	1.49	4.64	165	675	2.22	10.20	194.0	

TABLE O_4

Mix IV

MODULUS OF RUPTURE OF BRICK WITH VARIABLE WATER CONTENT

	Weight Wet	Thickness When Formed	Weight Dry	Thickness Dry	Breadth	Load in lbs.	Line Pressure	d^2	bd^2	Modulus of Rupture lbs. per sq. in.	Average
5-4-1	3783	2.21	3527	2.20	4.72	295	815	4.85	22.90	154.9)	155.2
5-4-2	3448	2.06	3211	2.02	4.73	250	815	4.08	19.30	155.5)	
6-4-1	3669	2.07	3293	2.03	4.73	275	815	4.13	19.50	169.0)	179.0
6-4-2	3654	2.12	3376	2.09	4.73	325	815	4.36	20.60	189.0)	
8-4-1	3160	1.83	2868	1.80	4.70	185	815	3.24	15.20	146.2)	146.1
8-4-2	3268	1.90	2976	1.87	4.70	200	815	3.50	16.48	146.0)	
9-4-1	2857	1.67	2573	1.65	4.69	125	815	2.72	12.80	117.2)	131.6
9-4-2	2830	1.64	2551	1.62	4.67	150	815	2.62	12.25	147.0)	
10-4-1	2530	1.52	2258	1.46	4.65	80	600	2.12	9.85	97.5)	106.2
10-4-2	2291	1.36	2039	1.34	4.63	80	600	1.79	8.34	115.0)	
12-4-1	2222	1.35	1939	1.37	4.57	75	100	1.88	8.65	104.0)	104.0

TABLE 05

MODULUS OF RUPTURE OF BRICK WITH VARIABLE WATER CONTENT

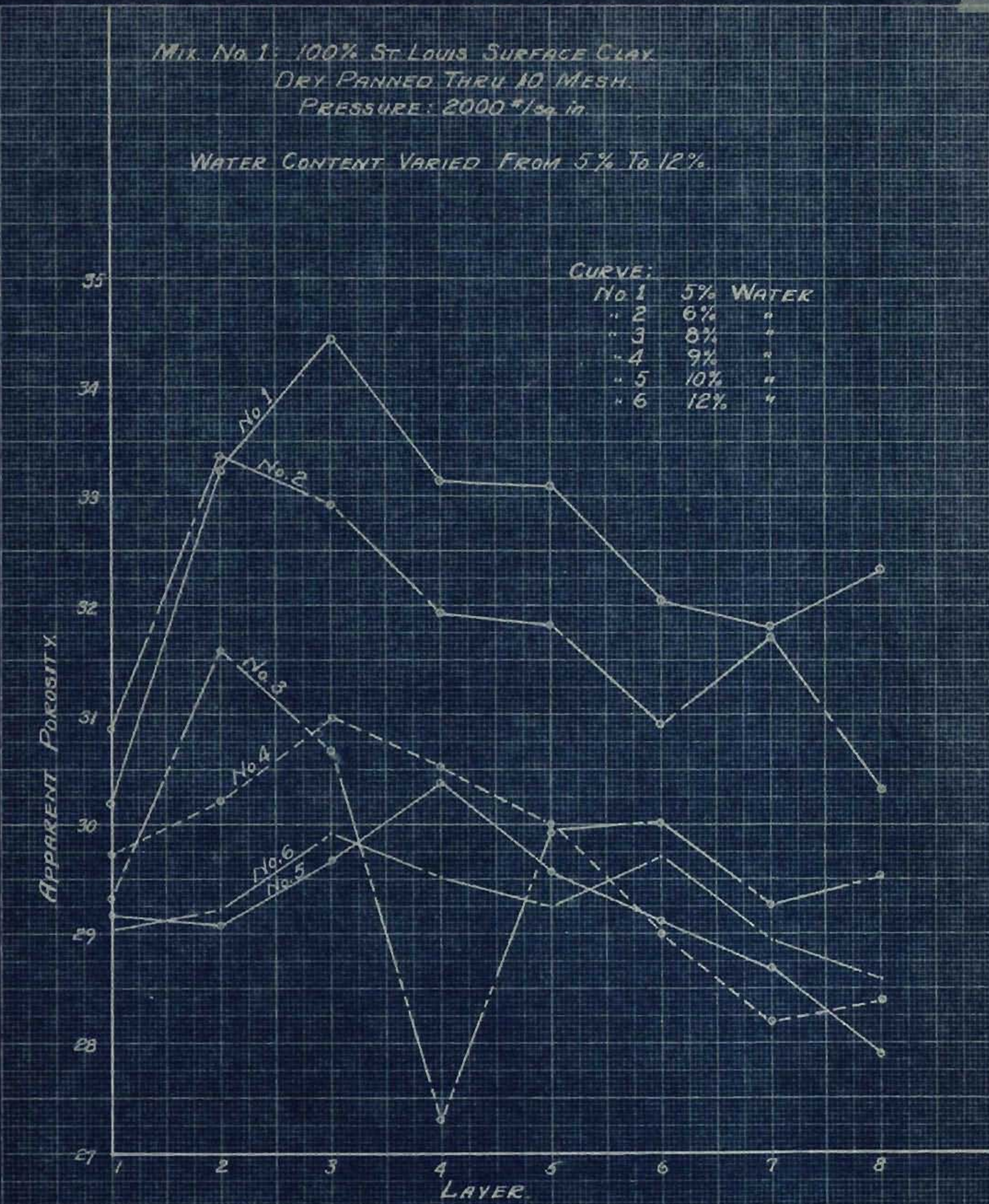
Mix V

	Wt. Wet	Thickness When Formed	Wt. Dry	Thickness Dry	Breadth	Load in Lbs.	Line Pressure	d^2	bd^2	Modulus of Rupture lbs. per sq. in.	Average
5-5-1	4273		4045	2.53	4.75	275	815	6.40	34.00	97.1	100.4
5-5-2	4157		3928	2.45	4.73	240	815	6.00	28.40	103.7	
6-5-1	3745		3509	2.18	4.74	255	815	4.75	22.50	135.7	128.3
6-5-2	3782		3543	2.20	4.73	235	815	4.84	22.80	120.9	
8-5-1	3300		3041	1.87	4.73	200	815	3.49	16.55	145.0	143.3
8-5-2	3267		3011	1.87	4.72	195	815	3.49	16.51	141.7	
9-5-1	3166		2889	1.81	4.70	165	815	3.28	15.40	128.5	136.2
9-5-2	3116		2846	1.79	4.70	180	815	3.20	15.00	144.0	
10-5-1	3047		2758	1.76	4.70	150	815	3.10	14.55	123.8	137.5
10-5-2	2970		2688	1.72	4.71	175	815	2.96	13.90	151.2	
12-5-1	2523		2252	1.47	4.67	95	675	2.16	10.01	114.0	117.5
12-5-2	2533		2258	1.46	4.65	100	675	2.13	9.90	121.1	

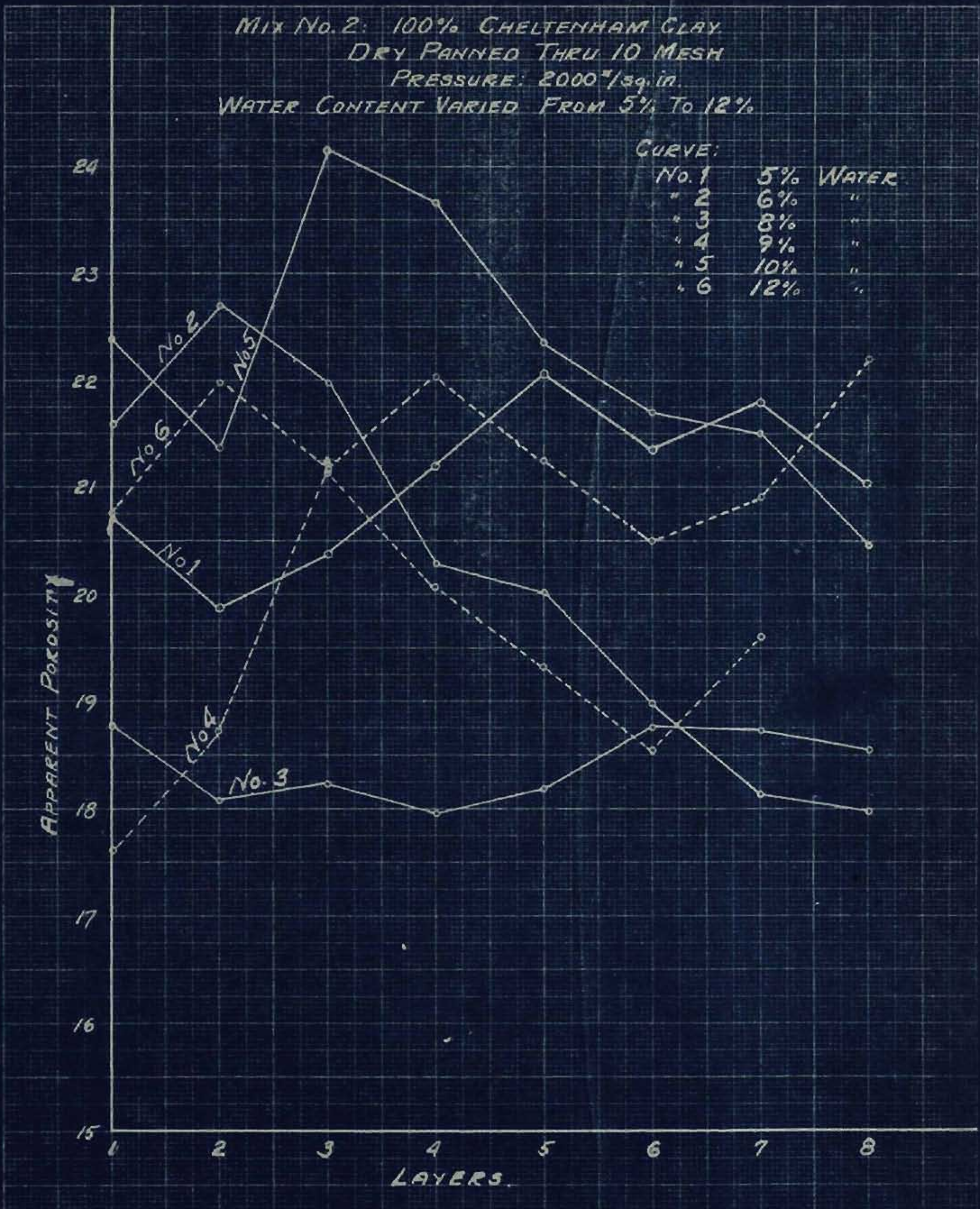
TABLE O_6

MODULUS OF RUPTURE OF BRICK WITH VARIABLE WATER CONTENT

MIX VI	Wt. Wet	Thick-ness When Formed	Wt. Dry	Thick-ness Dry	Breadth	Load in lbs.	Line Pressure	d^2	bd^2	Modulus of Rupture lbs. per sq. in.	Average
5-6-1	3838	2.54	3628	2.53	4.75	60	815	6.40	34.00	21.09	22.05
5-6-2	3887	2.58	3679	2.56	4.76	60	815	6.55	31.20	23.02	
6-6-1	3809	2.50	3574	2.48	4.75	70	815	6.15	29.20	28.80	30.60
6-6-2	3775	2.46	3537	2.46	4.75	78	815	6.05	28.78	32.50	
8-6-1	3824	2.43	3531	2.43	4.75	110	815	5.90	28.00	47.20	50.10
8-6-2	3757	2.39	3465	2.39	4.76	120	815	5.76	27.40	53.10	
9-6-1	3777	2.38	3447	2.36	4.75	150	815	5.51	26.20	68.60	69.70
9-6-2	3790	2.38	3455	2.36	4.76	155	815	5.51	26.25	70.80	
10-6-1	3744	2.35	3390	2.30	4.74	190	815	5.30	25.20	90.60	90.27
10-6-2	3767	2.35	3419	2.33	4.74	200	815	5.43	26.80	89.95	
12-6-1	3168	1.94	2818	1.89	4.73	160	815	3.57	16.85	114.10	110.50
12-6-2	3239	1.97	2885	1.95	4.74	160	815	3.80	18.05	107.00	
14-6-1	2863	1.77	2499	1.73	4.70	110	775	3.00	14.05	94.00	91.00
14-6-2	2576	1.59	2234	1.58	4.70	85	775	2.50	11.70	89.00	


Mix No. 1: 100% St. Louis Surface Clay.
Dry Panned Thru 10 Mesh.
Pressure: 2000 #/sq. in.
Water Content Varied From 5% To 12%.
Curve:
No. 1 5% Water
" 2 6% "
" 3 8% "
" 4 9% "
" 5 10% "
" 6 12% "
No. 1
No. 2
No. 3
No. 4
No. 5
No. 6
Apparent Porosity
35
34
33
32
31
30
29
28
27
1
2
3
4
5
6
7
8
Layer

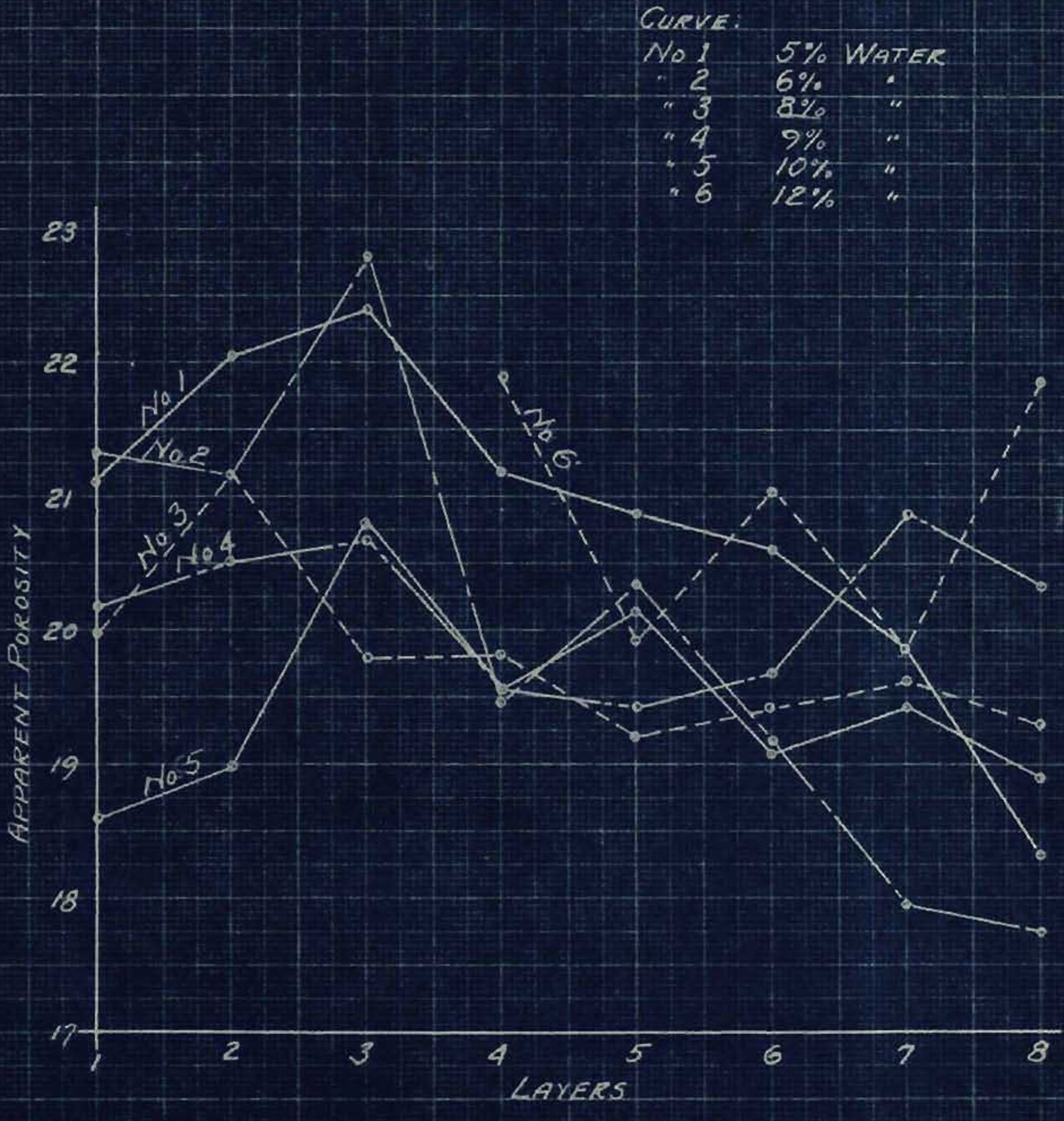
Graph P.


MIX NO. 2: 100% CHELTENHAM CLAY
DRY PANNED THRU 10 MESH
PRESSURE: 2000#/sq. in.
WATER CONTENT VARIED FROM 5% TO 12%
CURVE:
No. 1 5% WATER
" 2 6% "
" 3 8% "
" 4 9% "
" 5 10% "
" 6 12% "
No 2
No 5
No 6
No 1
No 4
No. 3
24
23
22
21
20
19
18
17
16
15
APPARENT POROSITY
1
2
3
4
5
6
7
8
LAYERS.

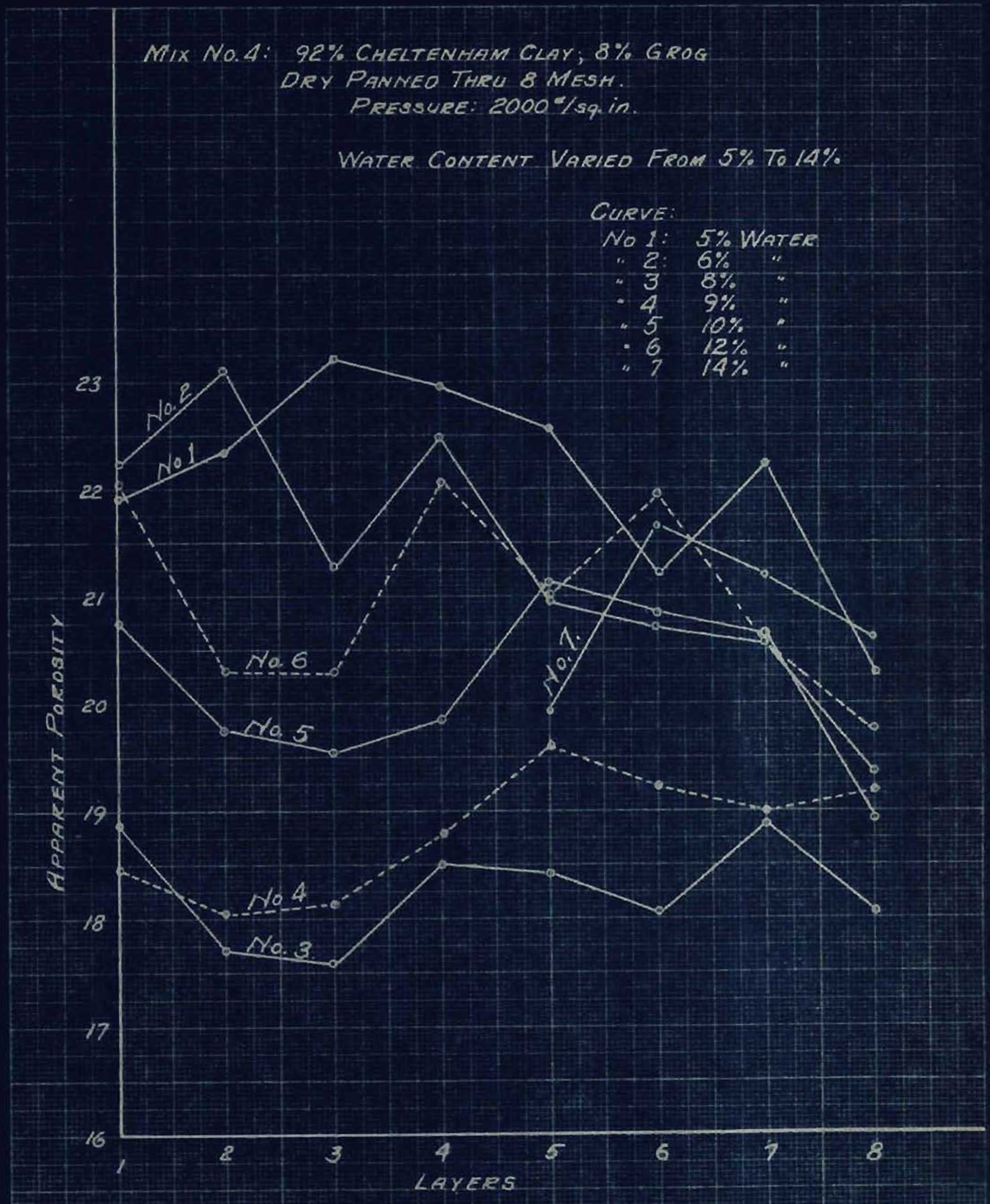
GRAPH Q

Mix No. 3: 6/7 Cheltenham Clay; 1/7 St Louis Surface Clay.
Dry Panned Thru 10 Mesh
Pressure: 2000#/sq in.

Water Content Varied From 5% To 12%



Graph R.

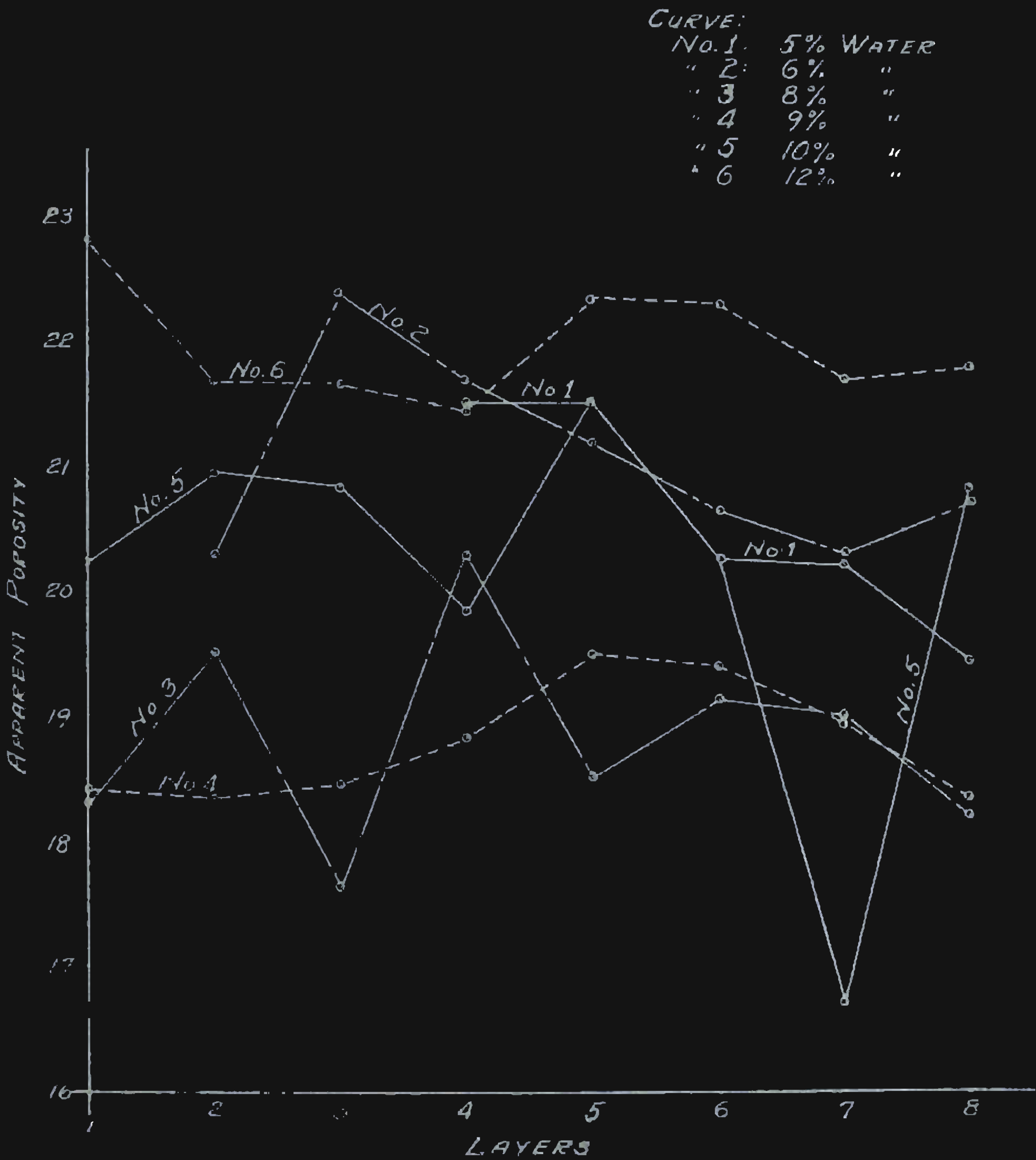


Mix No. 4: 92% Cheltenham Clay; 8% Grog
Dry Panned Thru 8 Mesh.
Pressure: 2000#/sq. in.
Water Content Varied From 5% To 14%.
Curve:
No 1: 5% Water
" 2: 6% "
" 3 8% "
" 4 9% "
" 5 10% "
" 6 12% "
" 7 14% "
No. 1
No. 2
No. 3
No. 4
No. 5
No. 6
No. 7
23
22
21
20
19
18
17
16
Apparent Porosity
1
2
3
4
5
6
7
8
Layers

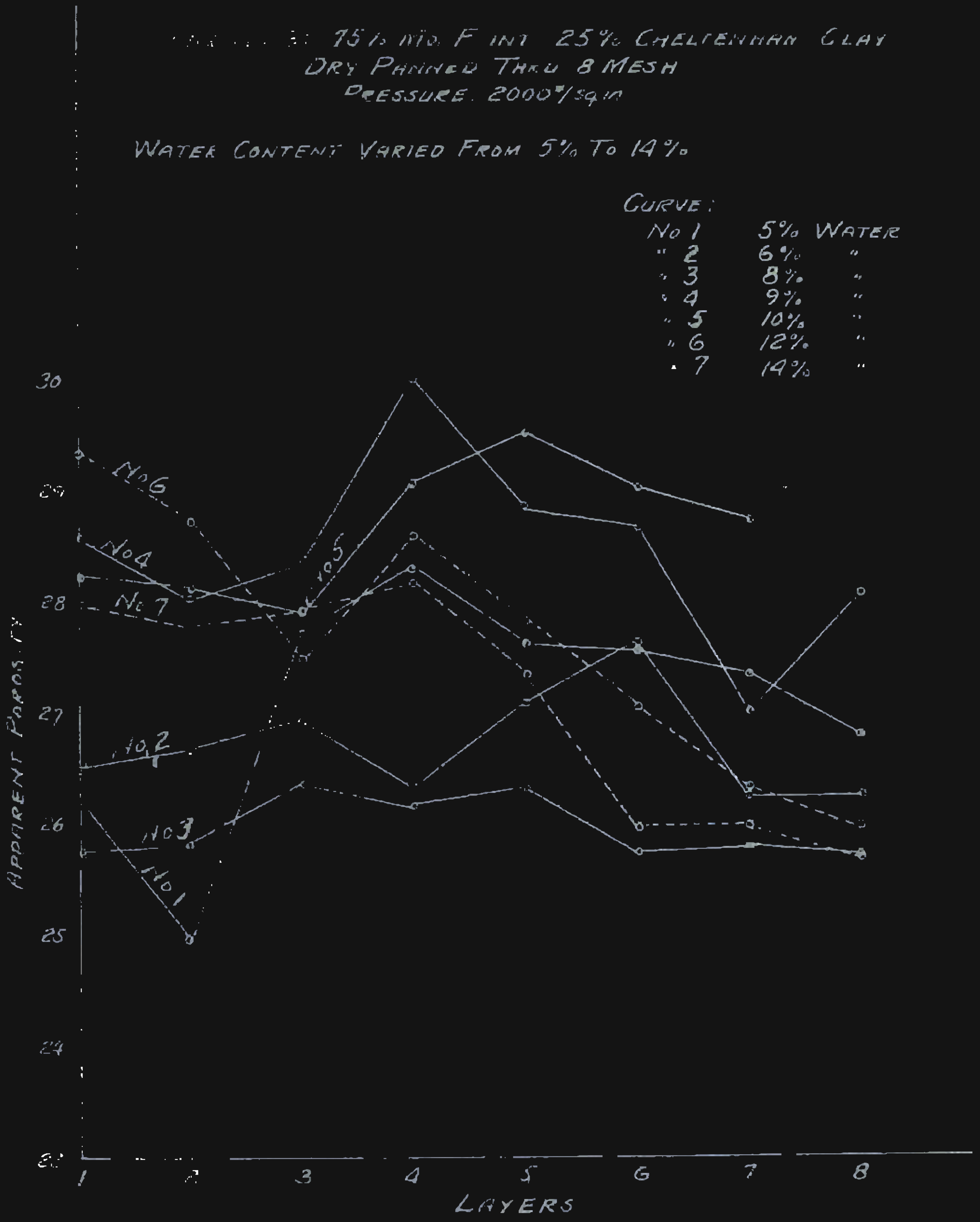
Graph 5

Mix No. 5 92% N. Mo. Semi Flint Clay + 8% Grog
Dry Panned Thru 8 Mesh.
Pressure 2000#/sq. in.

Water Content Varied From 5% To 12%



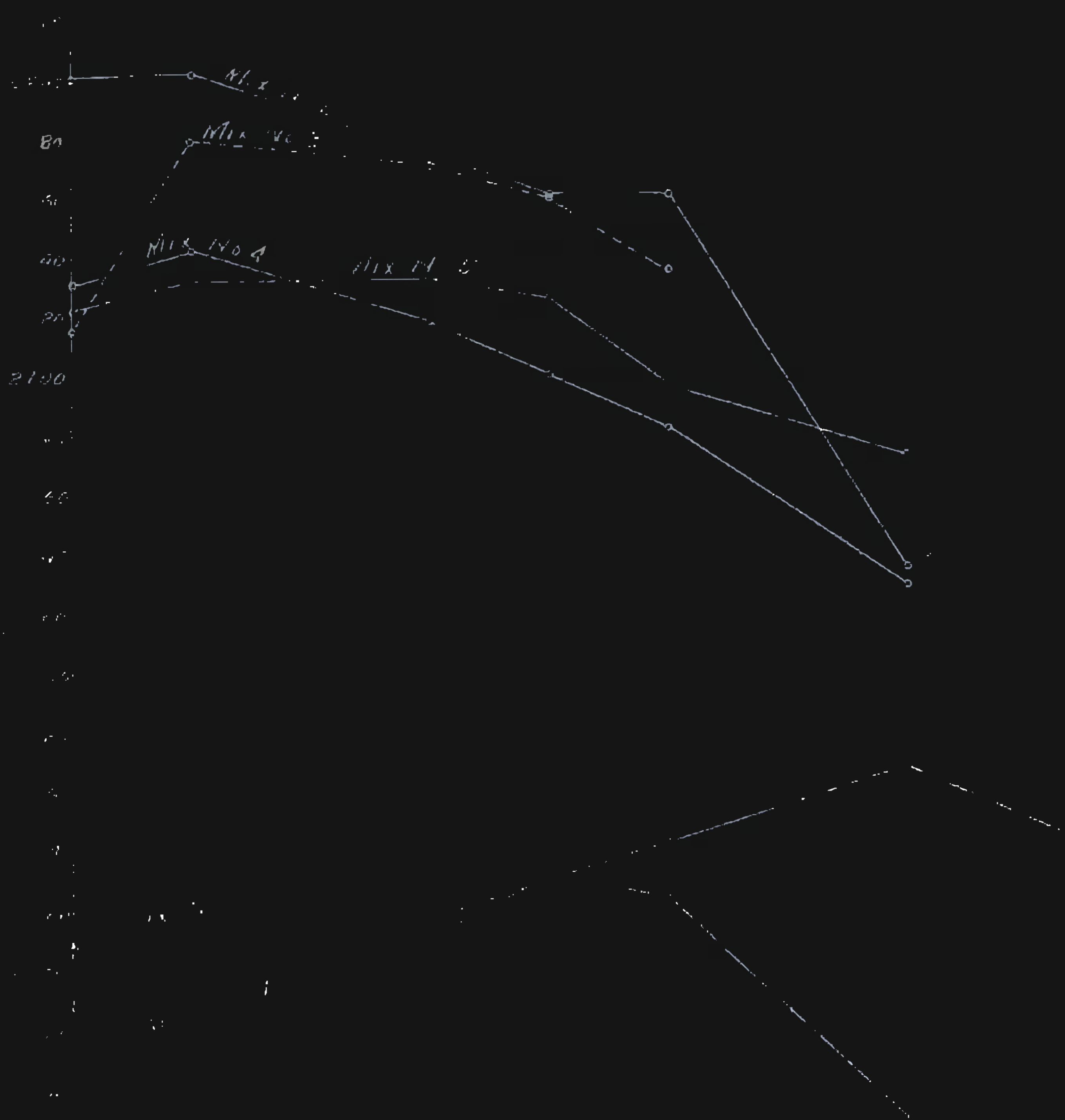
Graph T

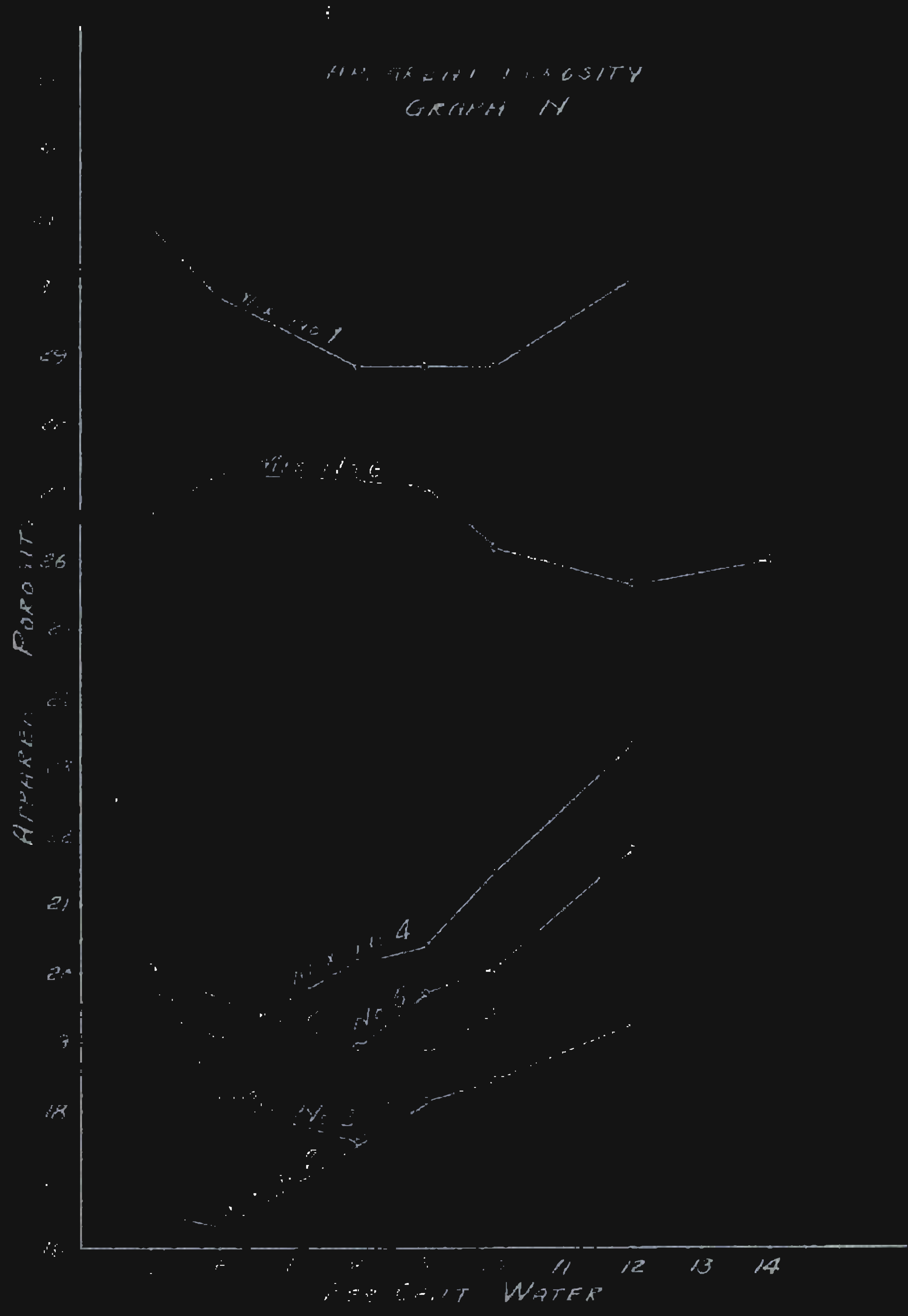

75% Mo. Flint 25% Cheltenham Clay
Dry Panned Thru 8 Mesh
Pressure 2000#/sq.in
Water Content Varied From 5% To 14%
Curve:
No 1 5% Water
" 2 6% "
" 3 8% "
" 4 9% "
" 5 10% "
" 6 12% "
" 7 14% "
No 1
No 2
No 3
No 4
No 5
No 6
No 7
Apparent Porosity
30
29
28
27
26
25
24
1 2 3 4 5 6 7 8
Layers

Graph V

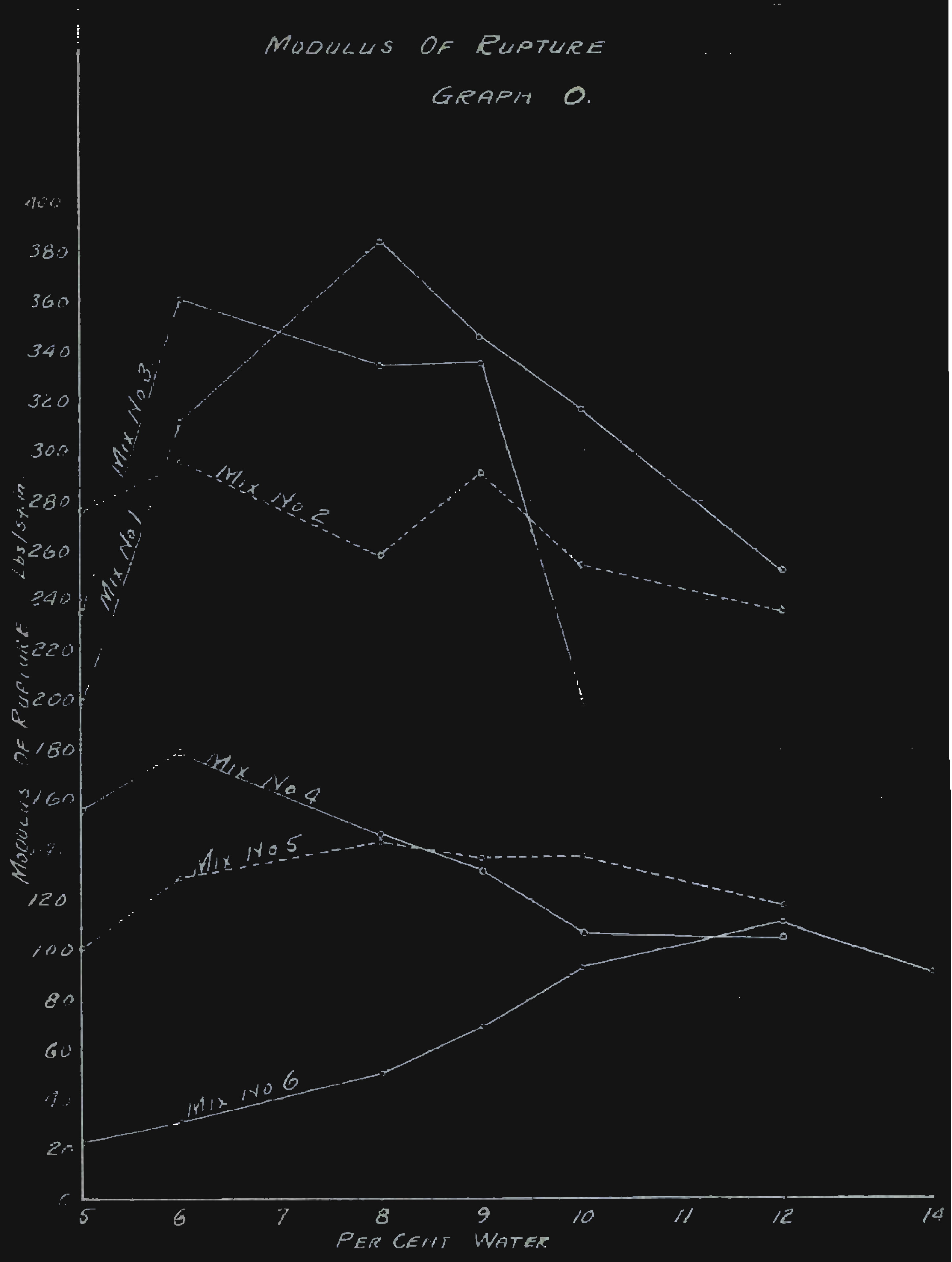
BULK SPECIFIC GRAVITY

GRAPH M

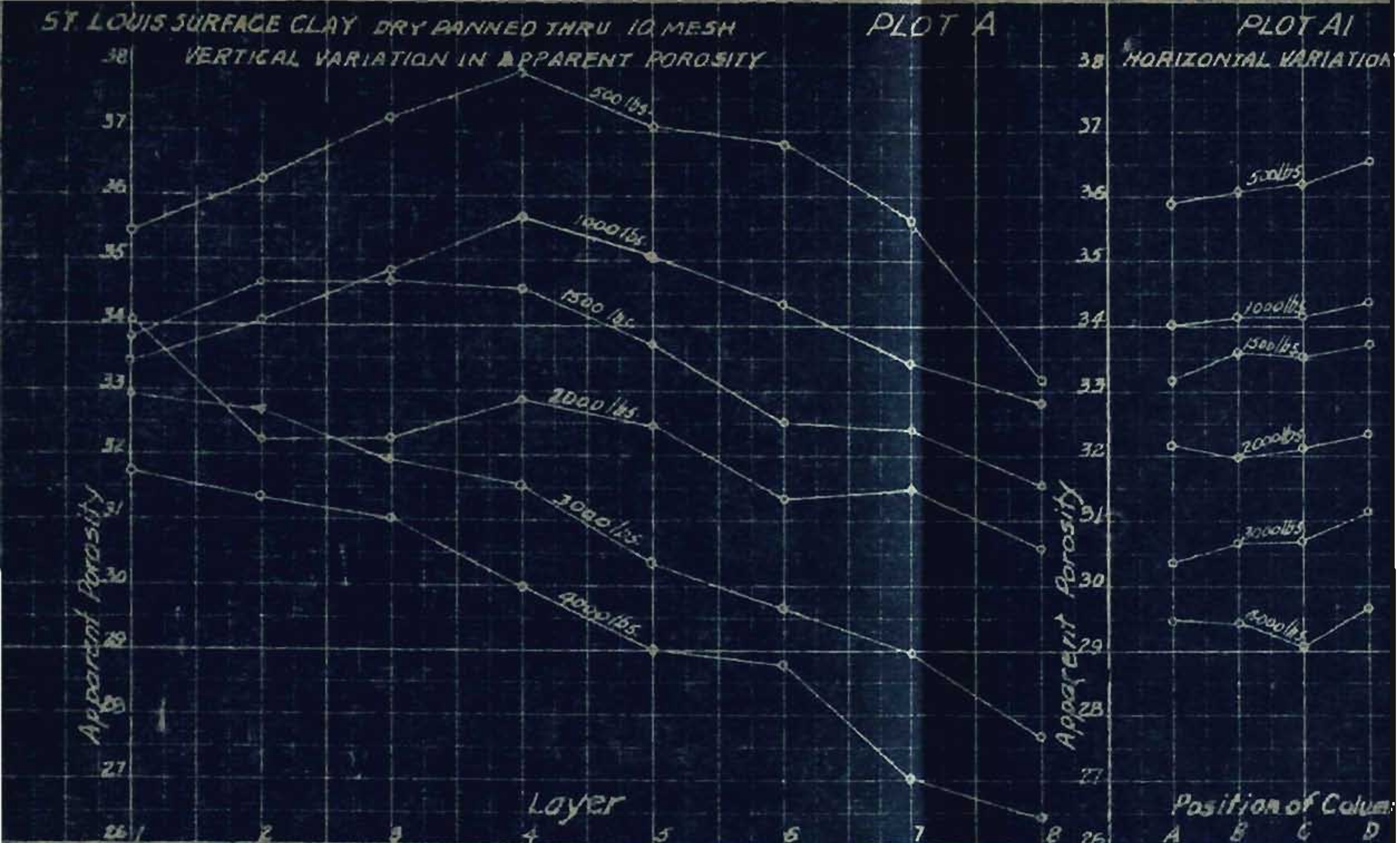


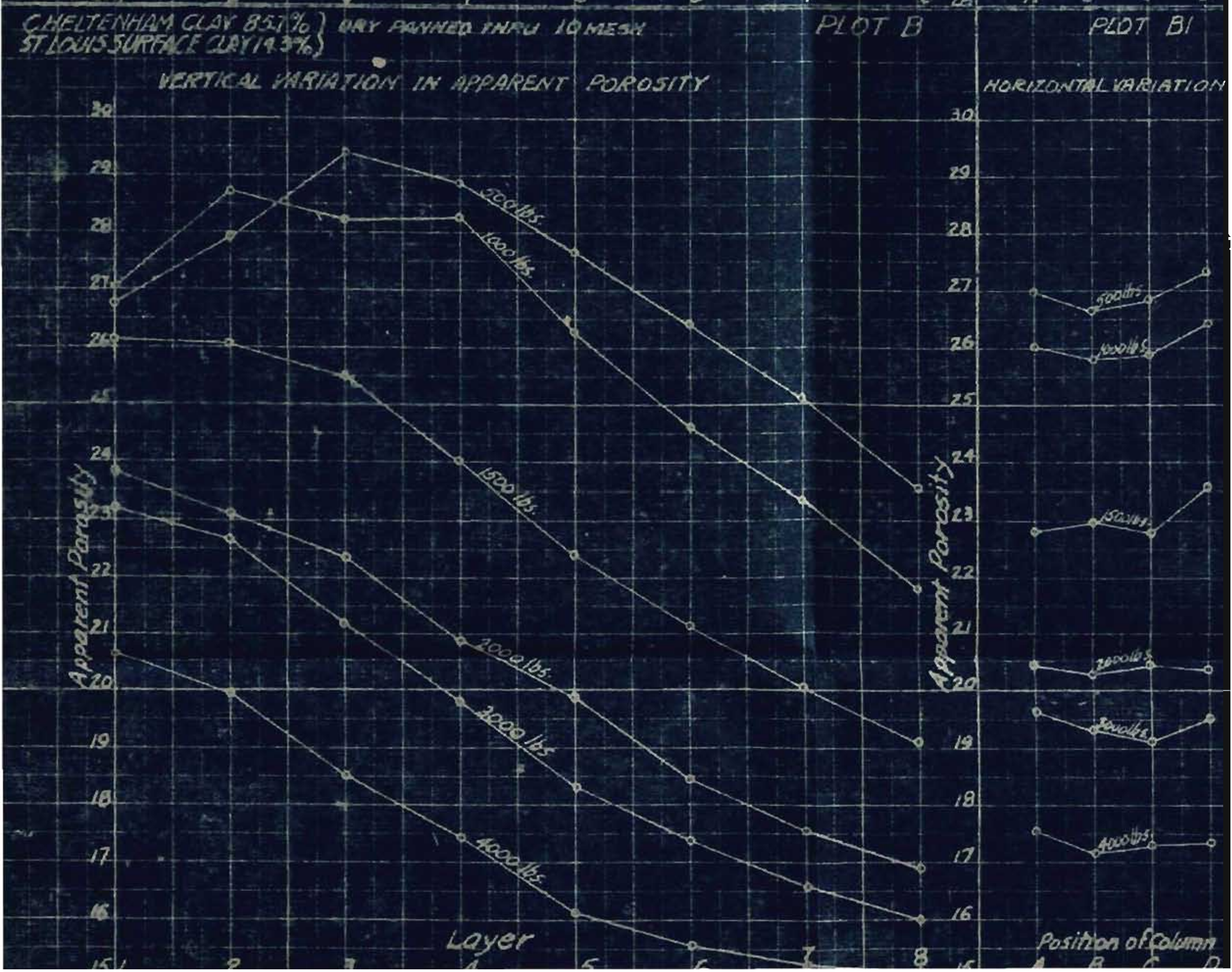


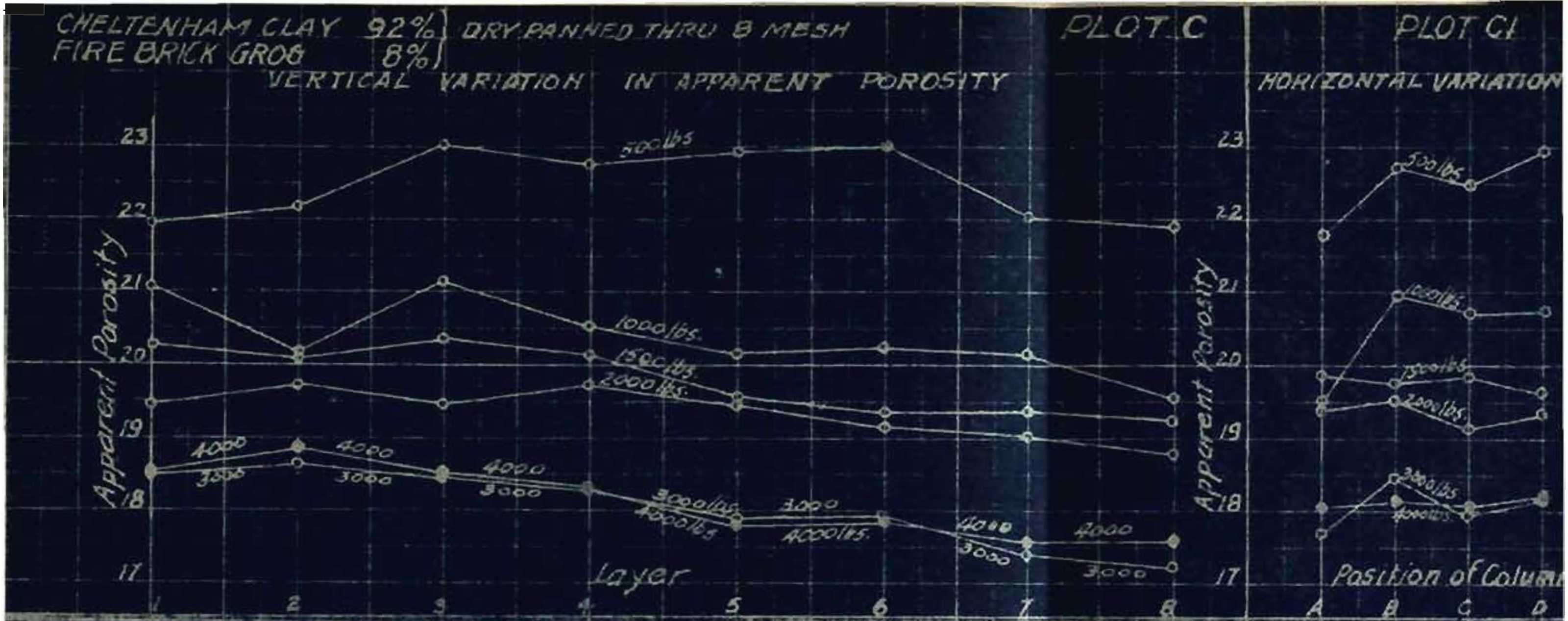
GRAPH N
26
21
18
4
12
13
14
WATER

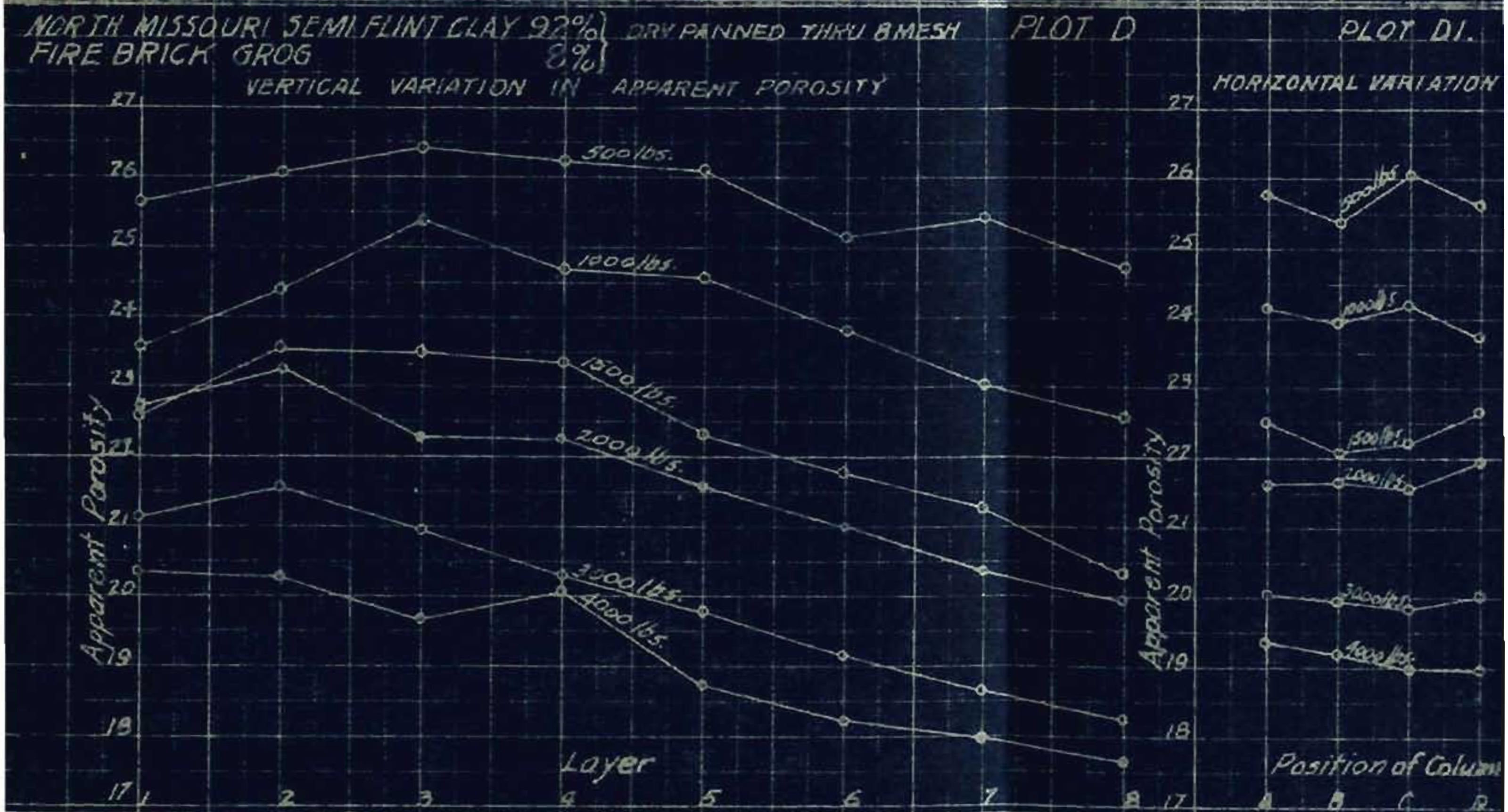


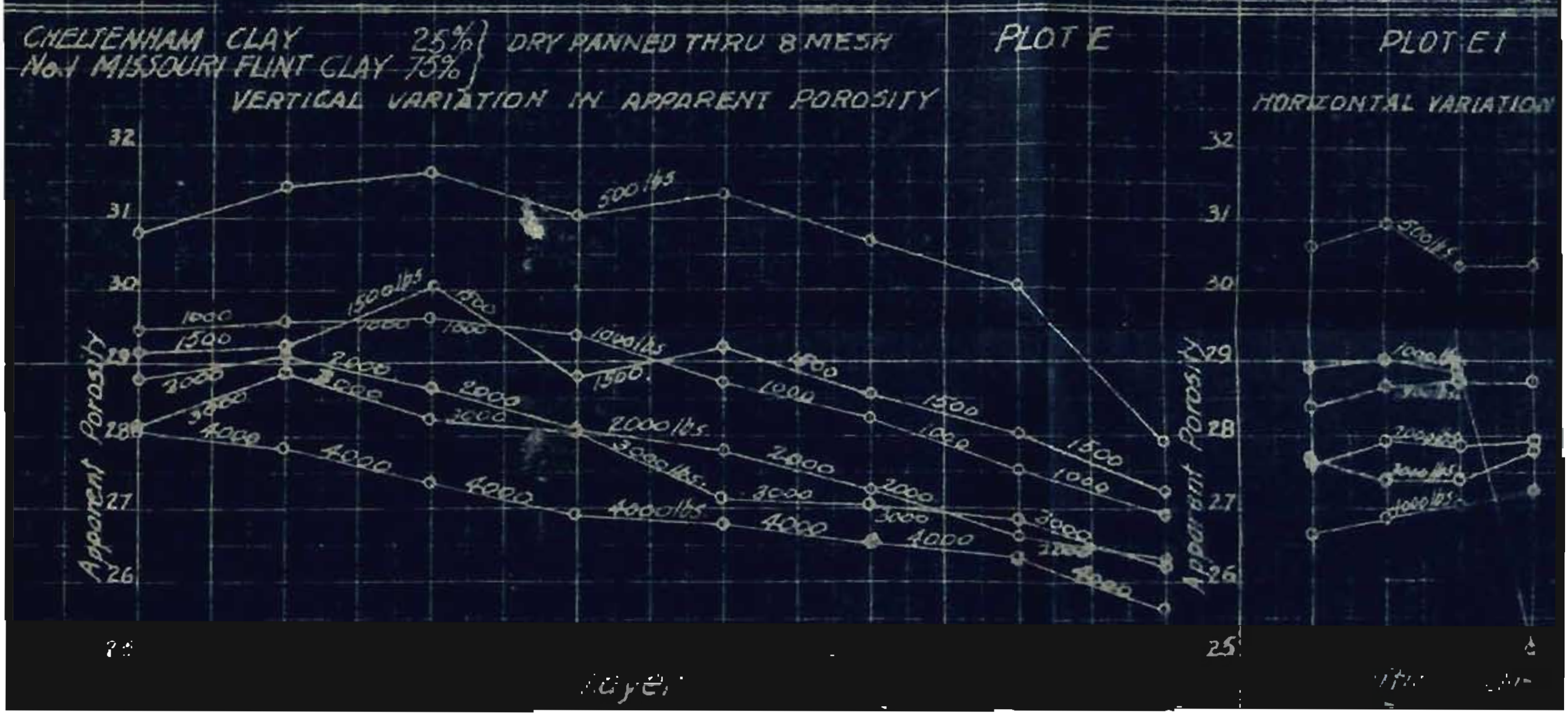
MODULUS OF RUPTURE
GRAPH O.
MODULUS OF RUPTURE Lbs/sq.in
400
380
360
340
320
300
280
260
240
220
200
180
160
120
100
80
60
20
Mix No 3
Mix No 1
Mix No 2
Mix No 4
Mix No 5
Mix No 6
5
6
7
8
9
10
11
12
14
PER CENT WATER


ST. LOUIS SURFACE CLAY DRY PANNED THRU 10 MESH
VERTICAL VARIATION IN APPARENT POROSITY
PLOT A
PLOT A1
HORIZONTAL VARIATION
500 lbs.
1000 lbs.
1500 lbs.
2000 lbs.
3000 lbs.
4000 lbs.
Apparent Porosity
Layer
Position of Column
A B C D


CHELTENHAM CLAY 85.7% ST. LOUIS SURFACE CLAY 14.3% DRY PANNED THRU 10 MESH
PLOT B
PLOT B1
VERTICAL VARIATION IN APPARENT POROSITY
HORIZONTAL VARIATION
500 lbs.
1000 lbs.
1500 lbs.
2000 lbs.
3000 lbs.
4000 lbs.
Apparent Porosity
Layer
Position of Column


CHELTENHAM CLAY 92%
FIRE BRICK GROG 8%
DRY PANNED THRU 8 MESH
PLOT C
VERTICAL VARIATION IN APPARENT POROSITY
Apparent Porosity
Layer
500 lbs
1000 lbs.
1500 lbs
2000 lbs.
3000 lbs.
4000 lbs.
PLOT C1
HORIZONTAL VARIATION
Position of Column
A B C D


NORTH MISSOURI SEMI FLINT CLAY 92%
FIRE BRICK GROG 8%
DRY PANNED THRU 8 MESH
PLOT D
VERTICAL VARIATION IN APPARENT POROSITY
Apparent Porosity
Layer
500 lbs.
1000 lbs.
1500 lbs.
2000 lbs.
3000 lbs.
4000 lbs.
PLOT D1.
HORIZONTAL VARIATION
Position of Column
A B C D


CHELTENHAM CLAY 25%
No. 1 MISSOURI FLINT CLAY 75%
DRY PANNED THRU 8 MESH
PLOT E
VERTICAL VARIATION IN APPARENT POROSITY
Apparent Porosity
500 lbs
1000 lbs
1500 lbs
2000 lbs.
3000 lbs.
4000 lbs.
PLOT E1
HORIZONTAL VARIATION

DISCUSSION OF RESULTS

Discussion of the Data on Vertical Variation of Porosity

(Tables and Graphs A, B, C, D and E.)

The curves and plots A, B, C, D, and E show the variation in the average porosity for each layer from the top to the bottom of the block. The average porosity of each layer is platted against the forming pressure, which varies from 500 to 4000 lbs. per square inch.

In all of the mixes and pressures, it will be noticed that the vertical variation in the porosity is large while this is not true of the horizontal variation in porosity. The amount of the variation differs from mix to mix.

From the plots and tables it may be seen that each mix transmits pressure in a different manner, so that the result will apply only to that typical mix. In the case of Cheltenham clay 92% and Grog 8%, with 2000 lbs. per sq. in. pressure (Plot C), the maximum porosity variation in the various layers from top to bottom is 1%. This would indicate almost perfect pressure transmission in all parts of the block.

When the pressure is to an extreme, either high or low, the result seems to be a very non-uniform block. When the pressure is low the block tends to have spongy parts, and when the pressure is high, the top layer is porous and the bottom layer very dense.

The actual porosities that are developed in this mix at the various pressures range from 22.5% at 500 lbs. pressure to 18% at 4000 lbs. pressure.

So, it may be seen that the porosity is not affected very greatly by the increased forming pressure.

In reference to Plot E, the best results were obtained with 2000 lbs. pressure. But the advantage over the higher pressure is not so marked. As in the preceding case, a pressure higher than 2000 lbs. has a very slight advantage and it may be doubtful in regard to the value. The greatest positive effect comes from increasing the pressure from 500 to 1000 pounds.

Next in the uniformity of porosity comes the mix of North Missouri Semi-flint and grog (Plot D). Unlike the above mixes, no one pressure has a marked advantage over any other in developing uniform porosity, although the tendency seems to be in the same direction, and unlike the Cheltenham mixes, there is a quite uniform and steady decrease in total porosity from 500 to and thru 4000 lbs. pressure, and there is a distinct advantage for the higher pressures in developing a low average porosity for the whole block.

The other two mixes (Plots A and B) are for building brick. They show quite different dry pressing characteristics from the fire brick mixes already discussed. The minimum average porosity for the whole block, in the case of the St. Louis Surface Clay (Plot A) is about 29.5%, compared with the figure of about 17.5% obtained with the North Missouri Semi-Flint and grog (Plot D), and with the Cheltenham-grog Mixes (Plot C). It seems that the pressure will have to be increased well above 4000 lbs. per sq. in. to obtain minimum porosity in mixes containing St. Louis Surface Clay. Between 1500 lbs. and 4000 lbs. compression, the porosity is reduced about 5% in the case of the Surface Clay (Plot A), and 7% in the case of the mixture of Cheltenham and Surface Clay (Plot B). As in the case of the fire brick mixes, the point of maximum porosity shifts from the intermediate layers at the low pressures to the top layers at the highest pressure, the porosities more nearly equalizing at the intermediate pressure. As in the other mixes, nothing is to be gained in the uniformity of porosity by increasing the pressure above 2000 lbs. per sq. in.

The uniformity of porosity, from top to bottom, is not developed at any pressure in mixes containing surface clays (Plots A and B) to the extent that it is in the fire brick mixes. The surface clay does not seem so conducive to pressure transmission as those mixes containing the non-plastics and grog. An explanation of this may be that some clays allow greater grain slippage than others.

An explanation for the shifting of the point of highest porosity from the intermediate layers at low pressures to the top layer at high pressures may be found in the movement of the mould box and the lower ram. As pressure is applied, the lower ram begins to travel upward, while the lower ram remains stationary. As the pressure increases, a compression of the lower layers cause enough friction on the walls of the mould box to cause it to be lifted and force the upper layers against the upper ram. This movement of the mould box is thru a distance of 1-1/4' and is completed when pressure around 2000 lbs per sq. in. have been exerted on the lower layers. This would mean that above 2000 lbs. the pressure was applied by the lower ram, which may, in part, be the reason that the curves above this pressure have a tendency to be smoother than those for the lower pressures. If the compression is stopped at 500 lbs. a dense upper and lower layer exist, the lower layer being denser, due to the lower ram traveling more, and a "shelly" core is about the third layer. As the pressure increases more and more pressure is transmitted to the core, and remove the shelly core at about 1500 to 2000 lbs., it being more completed in some cases than in others. If this condition is to be eliminated, a degree of compression greater than that effected with 1500 lbs. compression in these experiments is required.

DISCUSSION OF RESULT ON VARIABLE WATER CONTENT

Graphs, P, Q, R, S, T, V, M, O, and N, and Tables O_1, O_2, O_3, O_4, O_5, O_6, M-1, M-2, M-3, M-4, M-5, M-6, P-1, Q-1, R-1, S-1, T-1, and V-1.

In reference to Graph O and Tables O_1, O_2, O_3, O_4, O_5, O_6.

In table O_1 will be found the data obtained on the 4" brick before being formed. The designation 5-1-1 signifies that the mix contained 5% moisture, was made of Mix 1, and the final 1 designates which one of the two brick formed was used to obtain the data.

Graph O shows the relation of the per cent water content to the modulus of rupture in pounds per sq. in. for each of the six different mixes.

Graphs P, Q, R, S, T, and V show the relation of the Apparent Porosity to the layers for each mix and each different water content.

Tables P-1, Q-1, R-1, S-1, T-1, and V-1 show the calculated percentage of Apparent Porosity. 1-I-1 designates that the first 1 is the amount of water in the mix.

This is not the exact amount but 1 represents 5%, 2 represents 6%, 3 represents 8%, 4 represents 9%, 5 represents 10%, 6 represents 12% and 7 represents 14% water in the mix. The Roman numeral I represents the mix and the final 1 represents the layer. No. 1 layer is the top layer and 2 the second and so on down until layer 8. These apply to the large block formed only.

Graph M is the relation of the Bulk Specific Gravity to the per cent of water for each mix. This applies to the 4$ brick before being formed only.

Tables M-1, M-2, M-3, M-4, M-5, and M-6 contain the Bulk Specific Gravity data and porosity value for the brick only. The 5-1-1 designates that the brick has 5% water, batch No. 1 and Brick No. 1. The X designates the second half of the brick after being broken on the cross breaking machine.

Graph N is the relation of the Apparent Porosity to the per cent water for each of the six mixes. The data is in Tables M-1, M-2, M-3, M-4, M-5 and M-6.

In reference to Graph M, the general tendency is for the specific gravity to decrease as the water content increases, with the exception of Mix No. 1 and Mix No. 6. The specific gravity of Mix No. 6 increases up to 12% of water and decreases a little at 14% of water. This was the only mix that could be formed with 14% of water, the other mixes flowed at the air holes of the press when more than 12% of water was added to the mix. No. 1 Mix increased up to 9% of water and then a steady drop in sp. gr. thru 10 and 12% water. Mix No. 3 could not be formed above 10% water content.

In reference to Graph N, it will be noticed that again Mixes 1 and 6 act differently than the others. The Apparent Porosity of all the mixes with the exception of Mix 6 increases with the increase of the water content. The Porosity of Mix 6 decreases with an increase of water content above 8%. Mix No. 1 Porosity decreased from 5 to 8% and then increased slightly from 8% to 12% water content.

In reference to Graph O concerning the relation of the modulus of rupture to the per cent water content of the Mix, it may be seen that Mix No. 6 has a steady increase in strength up to 12% of water and then decreases when 14% water is added. If we may say that the green strength will be in proportion to the fired strength, which is an assumption, as no data can be obtained to support the statement, it would be good practice to add 12% of water to Mix 6 to obtain a brick with the maximum green strength and fired strength. This is a higher water content than is generally used in dry press work. Mix 5 strength increases very little from 5% of water up to 8%, and decreases a very little after 8%. From this result, it would look as though for maximum strength in Mix 4, 6% water would be the correct water content. No. 3 Mix should contain from 6 to 9% of water but the maximum strength is at 6%. No. 2 Mix is very irregular and it is hard to tell the exact range of water content to give the maximum strength. No. 1 Mix increases very much to 8% and then decreases very fast as the water content is increased.

In reference to Graph P, Q, R, S, T, and V, it will be noticed that Mix No. 1 does not resemble the other, the lower the water content, the higher the porosity. It is in general the reverse of this for the other mixes.

In general, these graphs follow closely the results in the other graphs.

CONCLUSIONS

It is apparent from the data that the forming pressure applied to the dry press mix is a very important factor in controlling the physical properties of the finished brick. This work should bring out the fact that most dry press manufacturers are not operating with as high a forming pressure as has been stated in literature and discussions, although it is a difficult problem to measure the actual pressure transmission in a mechanical dry press.

It is of interest to note that in most cases the higher the water content above 8%, the greater the percentage of apparent porosity, with the exception of the high flint mix.

From the data on the various water contents, with relation to the Modulus of Rupture, manufacturers may find some advantage in changing the water content of their dry press mix and thereby obtain an unfired brick of greater strength, that will make it possible to reduce the loss in handling in the green state.

It is suggested that the manufacturers of fire brick and face brick compare their mixes with the typical mixes used in this work and the result may be an improvement over present methods of manufacture.

Due consideration must be given to special conditions that prevailed, when application of these results is made to commercial practice.

ACKNOWLEDGMENTS

The writer wishes to acknowledge his appreciation to the Dry Press Committee of the National Brick Manufacturers Association for the privilege of working on these problems concerning the dry press process now being investigated by that Committee, and to F. F. Netzeband, a copartner in the work and to C. M. Dodd, under whom this research was carried out.