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**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

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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

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## 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.~~

### Screen Analysis

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.

### Tempering

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%                            | 7.42%                            | 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%                  |
| <b>Total</b>         | <b>100.04%</b>         | <b>100.02%</b>                        | <b>99.98%</b>                    | <b>100.03%</b>                   | <b>100.01%</b>         |

## 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

pottery 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 satis-

factory 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 ( $\text{SiO}_2$ ). 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-out 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:

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

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



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  $4\frac{1}{2}$ " x  $4\frac{1}{2}$ " 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.

| Loca-<br>tion                 | 500           |             | 1000          |             | 1500          |             | 2000          |             | 3000          |             | 4000          |             |
|-------------------------------|---------------|-------------|---------------|-------------|---------------|-------------|---------------|-------------|---------------|-------------|---------------|-------------|
|                               | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> |
| 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       |
| <u>Avg.</u><br>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<br>Finished<br>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

FORMING PRESSURES IN LBS. PER SQ. IN.

| <u>Loca-<br/>tion</u>            | 500           |             | 1000          |             | 1500          |             | 2000          |             | 3000          |             | 4000          |             |
|----------------------------------|---------------|-------------|---------------|-------------|---------------|-------------|---------------|-------------|---------------|-------------|---------------|-------------|
| <u>Block</u>                     | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> |
| 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       |
| <u>Avg.<br/>A-D</u>              | 1.679         | 36.19       | 1.735         | 34.17       | 1.759         | 33.52       | 1.789         | 32.16       | 1.816         | 30.72       | 1.849         | 29.42       |
| <u>Block<br/>Thick-<br/>ness</u> | 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.

| Loca-<br>tion                 | 500           |             | 1000          |             | 1500          |             | 2000          |             | 3000          |             | 4000          |             |
|-------------------------------|---------------|-------------|---------------|-------------|---------------|-------------|---------------|-------------|---------------|-------------|---------------|-------------|
|                               | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> |
| 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       |
| <u>Avg.</u><br>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<br>Finished<br>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

FORMING PRESSURES IN LBS. PER SQ. IN.

| Loca-<br>tion           | 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.<br>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<br>Thick-<br>ness | 10.38" |       | 10.25" |       | 9.88"  |       | 9.46"  |       | 9.64"  |       | 9.56"  |       |

TABLE C

Mix:

Cheltenham 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.

| Loca-<br>tion                 | 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.<br>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<br>Finished<br>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

| Loca-<br>tion                     | 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                                 | 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.<br>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<br>Thick-<br>ness<br>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.

| Loca-<br>tion                 | 500           |             | 1000          |             | 1500          |             | 2000          |             | 3000          |             | 4000          |             |
|-------------------------------|---------------|-------------|---------------|-------------|---------------|-------------|---------------|-------------|---------------|-------------|---------------|-------------|
|                               | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> |
| 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.<br>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<br>Finished<br>Block | 10-5/16"      |             | 10-3/4"       |             | 10-5/16"      |             | 10-9/32"      |             | 10-1/32"      |             | 9-15/16"      |             |

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TABLE D-1

Mix:  
Same as given in Table D

HORIZONTAL VARIATION IN APPARENT POROSITY AND BULK DENSITY

FORMING PRESSURES IN LBS. PER SQ. IN.

| Loca-<br>tion                                | 500           |             | 1000          |             | 1500          |             | 2000          |             | 3000          |             | 4000          |             |
|--|---------------|-------------|---------------|-------------|---------------|-------------|---------------|-------------|---------------|-------------|---------------|-------------|
| <u>Block</u>                                 | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> |
| 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       |
| <u>Avg.</u><br>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       |
| <u>Block</u><br><u>Thick-</u><br><u>Ness</u> | 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.

| Loca-<br>tion                 | 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 |
| <u>Avg.</u><br>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<br>Finished<br>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.

| Loca-<br>tion                                | 500           | 1000        | 1500          | 2000        | 3000          | 4000        |               |             |               |             |         |       |
|--|---------------|-------------|---------------|-------------|---------------|-------------|---------------|-------------|---------------|-------------|---------|-------|
| <u>Block</u>                                 | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> | <u>Sp.Gr.</u> | <u>Por.</u> |         |       |
| 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 |
| <u>Avg.</u>                                  |               |             |               |             |               |             |               |             |               |             |         |       |
| 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 |
| <u>Block</u><br><u>Thick-</u><br><u>ness</u> |               |             |               |             |               |             |               |             |               |             |         |       |
|  | 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                      | APP.<br>POR. | AVG.<br>APP.<br>POR. | APP.<br>POR. | AVG.<br>APP.<br>POR. | APP.<br>POR. | AVG.<br>APP.<br>POR. | APP.<br>POR. | AVG.<br>APP.<br>POR. | APP.<br>POR. | AVG.<br>APP.<br>POR. | APP.<br>POR. | AVG.<br>APP.<br>POR. |
|----------------------------|--------------|----------------------|--------------|----------------------|--------------|----------------------|--------------|----------------------|--------------|----------------------|--------------|----------------------|
|                            | 1-I-1        | 2-I-1                | 3-I-1        | 4-I-1                | 5-I-1        | 6-I-1                |              |                      |              |                      |              |                      |
| 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                | 28.39        | 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.<br>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.<br>POR. | AVG.<br>APP.<br>POR. | APP.<br>POR. | AVG.<br>APP.<br>POR. | APP.<br>POR. | AVG.<br>APP.<br>POR. | APP.<br>POR. | AVG.<br>APP.<br>POR. | APP.<br>POR. | AVG.<br>APP.<br>POR. | APP.<br>POR. | AVG.<br>APP.<br>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                | 21.10        | 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.<br>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.<br>POR. | AVG.<br>APP.<br>POR. | APP.<br>POR. | AVG.<br>APP.<br>POR. | APP.<br>POR. | AVG.<br>APP.<br>POR. | APP.<br>POR. | AVG.<br>APP.<br>POR. | APP.<br>POR. | AVG.<br>APP.<br>POR. | APP.<br>POR. | AVG.<br>APP.<br>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.<br>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                      | 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-IV-1    | 2-IV-1         | 3-IV-1    | 4-IV-1         | 5-IV-1    | 6-IV-1         | 7-IV-1    |                |           |                |           |                |           |                |
| 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.<br>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                       | App. Por.      |           | App. Por.      |           | App. Por.      |           | App. Por.      |           | 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. | App. Por. |
|                             | 1-V-1          |           | 2-V-1          |           | 3-V-1          |           | 4-V-1          |           | 5-V-1          |           | 6-V-1          |           |
| 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.<br>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.<br>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   | I       |          |          | I        |          | Bulk Sp. Gr. | Avg. Bulk Sp. Gr. | Porosity | Avg. Porosity |
|---------|---------|----------|----------|----------|----------|--------------|-------------------|----------|---------------|
|         | Dry Wt. | Sat. Wt. | Sus. Wt. | Sat. Wt. | Sus. Wt. |              |                   |          |               |
| 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. -<br>Wt. Sus. | Wt. Sat. -<br>Wt. Dry | Bulk<br>Sp. Gr. | Avg. Bulk<br>Sp. Gr. | Porosity | Average<br>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

| <u>Mix III</u> | Wt. Dry | Wt. Sat. | Wt. Sus. | Wt. Sat.<br>Wt. Sus. | Wt. Sat.<br>Wt. Dry | Bulk<br>Sp. Gr. | Avg. Bulk<br>Sp. Gr. | Porosity | Average<br>Porosity |
|----------------|---------|----------|----------|----------------------|---------------------|-----------------|----------------------|----------|---------------------|
| 5-3-1X         | 1771    | 1908     | 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      | 438                  | 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.<br>Wt. Sus. | Wt. Sat.<br>Wt. Dry | Bulk<br>Sp. Gr. | Avg. Bulk<br>Sp. Gr. | Porosity | Average<br>Porosity |
| 5-4-1X   | 1715    | 1843     | 1189     | 654                  | 128                 | 2.132)          | 2.1315               | 19.61)   | 19.79               |
| 5-4-1  | 1798    | 1932     | 1246     | 686                  | 134                 | 2.130)          |                      | 19.50)   |                     |
| 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)          | 2.142                | 19.00)   | 19.03               |
| 6-4-1  | 1680    | 1801     | 1166     | 635                  | 121                 | 2.144)          |                      | 19.05)   |                     |
| 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)          | 2.119                | 20.30)   | 20.12               |
| 8-4-1  | 1427    | 1536     | 991      | 545                  | 109                 | 2.130)          |                      | 20.00)   |                     |
| 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)          | 2.107                | 21.40)   | 20.39               |
| 9-4-1  | 1295    | 1400     | 899      | 501                  | 105                 | 2.100)          |                      | 20.92)   |                     |
| 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)          | 2.083                | 21.22)   | 21.46               |
| 10-4-1   | 1108    | 1200     | 769      | 431                  | 92                  | 2.094)          |                      | 21.32)   |                     |
| 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.<br>Wt. Sus. | Wt. Sat.<br>Wt. Dry | Bulk<br>Sp. Gr. | Average<br>Bulk Sp.<br>Gravity | Porosity | Average<br>Porosity |
|---------|---------|----------|----------|----------------------|---------------------|-----------------|--------------------------------|----------|---------------------|
| 5-5-1X  | 1868    | 2015     | 1293     | 722                  | 147                 | 2.110)          | 2.122                          | 20.37)   | 20.09               |
| 5-5-1   | 2144    | 2307     | 1486     | 821                  | 163                 | 2.140)          |                                | 19.81)   |                     |
| 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)          | 2.133                          | 19.20)   | 18.96               |
| 8-5-1   | 1462    | 1565     | 1012     | 553                  | 103                 | 2.144)          |                                | 18.61)   |                     |
| 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)          | 2.127                          | 19.58)   | 19.70               |
| 9-5-1   | 1468    | 1580     | 1019     | 561                  | 112                 | 2.123)          |                                | 19.95)   |                     |
| 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)          | 2.098                          | 20.73)   | 20.52               |
| 10-5-1  | 1369    | 1479     | 949      | 530                  | 110                 | 2.092)          |                                | 20.78)   |                     |
| 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)          | 2.074                          | 21.42)   | 21.78               |
| 12-5-1  | 1121    | 1217     | 777      | 440                  | 96                  | 2.071)          |                                | 21.80)   |                     |
| 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    | 1.908   | 1.908        | 26.30             | 26.67    |                  |
| 5-6-2X  | 1850    | 1272     | 2062     | 790      | 212      | 1.905    |         |              |                   |          |                  |
| 5-6-2   | 1815    | 1251     | 2023     | 772      | 208      | 1.910    |         |              |                   |          |                  |
| 6-6-1X  | 1650    | 1136     | 1839     | 703      | 189      | 1.904    | 1.917   | 1.917        | 26.92             | 27.23    |                  |
| 6-6-1   | 1903    | 1323     | 2123     | 800      | 220      | 1.940    |         |              |                   |          |                  |
| 6-6-2X  | 1851    | 1281     | 2068     | 787      | 217      | 1.925    |         |              |                   |          |                  |
| 6-6-2   | 1666    | 1144     | 1858     | 714      | 192      | 1.900    |         |              |                   |          |                  |
| 8-6-1X  | 2003    | 2241     | 1387     | 854      | 238      | 1.923    | 1.918   | 1.918        | 27.80             | 27.15    |                  |
| 8-6-1   | 1418    | 981      | 1582     | 601      | 164      | 1.916    |         |              |                   |          |                  |
| 8-6-2X  | 1657    | 1148     | 1851     | 703      | 194      | 1.910    |         |              |                   |          |                  |
| 8-6-2   | 1737    | 1196     | 1927     | 731      | 190      | 1.925    |         |              |                   |          |                  |
| 9-6-1X  | 1784    | 1238     | 1981     | 743      | 197      | 1.956    | 1.931   | 1.931        | 26.23             | 27.06    |                  |
| 9-6-1   | 1631    | 1130     | 1821     | 691      | 190      | 1.926    |         |              |                   |          |                  |
| 9-6-2X  | 1818    | 2021     | 1256     | 765      | 203      | 1.932    |         |              |                   |          |                  |
| 9-6-2   | 1602    | 1795     | 1111     | 684      | 193      | 1.910    |         |              |                   |          |                  |
| 10-6-1X | 1776    | 1228     | 1969     | 741      | 193      | 1.942    | 1.943   | 1.943        | 26.05             | 26.18    |                  |
| 10-6-1  | 1627    | 1125     | 1804     | 679      | 177      | 1.948    |         |              |                   |          |                  |
| 10-6-2X | 1894    | 1309     | 2104     | 795      | 210      | 1.939    |         |              |                   |          |                  |
| 12-6-1X | 1237    | 856      | 1368     | 512      | 131      | 1.964    | 1.969   | 1.969        | 25.60             | 25.66    |                  |
| 12-6-1  | 1570    | 1090     | 1736     | 646      | 166      | 1.975    |         |              |                   |          |                  |
| 14-6-1X | 1138    | 786      | 1261     | 475      | 123      | 1.945    | 1.943   | 1.943        | 26.10             | 26.00    |                  |
| 14-6-1  | 1370    | 947      | 1518     | 571      | 148      | 1.948    |         |              |                   |          |                  |
| 14-6-2  | 1175    | 811      | 1303     | 492      | 128      | 1.938    |         |              |                   |          |                  |

MIX I

TABLE O<sub>1</sub>MODULUS OF RUPTURE OF BRICK WITH VARIABLE WATER CONTENT

|        | Weight Wet | Thickness<br>When Formed | Weight Dry | Thickness<br>Dry | Breadth | Load in<br>lbs. | Line<br>Pressure | $d^2$ | $bd^2$ | Modulus of<br>Rupture<br>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                     | 2753       | 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<sub>2</sub>  
MODULUS OF RUPTURE OF BRICK WITH VARIABLE WATER CONTENT

Mix II

|        | Weight Wet | Thickness<br>When Formed | Weight Dry | Thickness<br>Dry | Breadth | Load in<br>lbs. | Line<br>Pressure | $a^2$ | $bd^2$ | Modulus of<br>Rupture<br>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 03

MODULUS OF RUPTURE OF BRICK WITH VARIABLE WATER CONTENTMix III

|        | Weight Wet | Thickness<br>When Formed | Weight Dry | Thickness<br>Dry | Breadth | Load in<br>lbs. | Line Pressure | $d^2$ | $bd^2$ | Modulus of<br>Rupture<br>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<sub>4</sub>

Mix IV

MODULUS OF RUPTURE OF BRICK WITH VARIABLE WATER CONTENT

|        | Weight Wet | Thickness<br>When Formed | Weight Dry | Thickness<br>Dry | Breadth | Load in<br>lbs. | Line<br>Pressure | $p^2$ | $bd^2$ | Modulus of<br>Rupture<br>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 CONTENTMix V

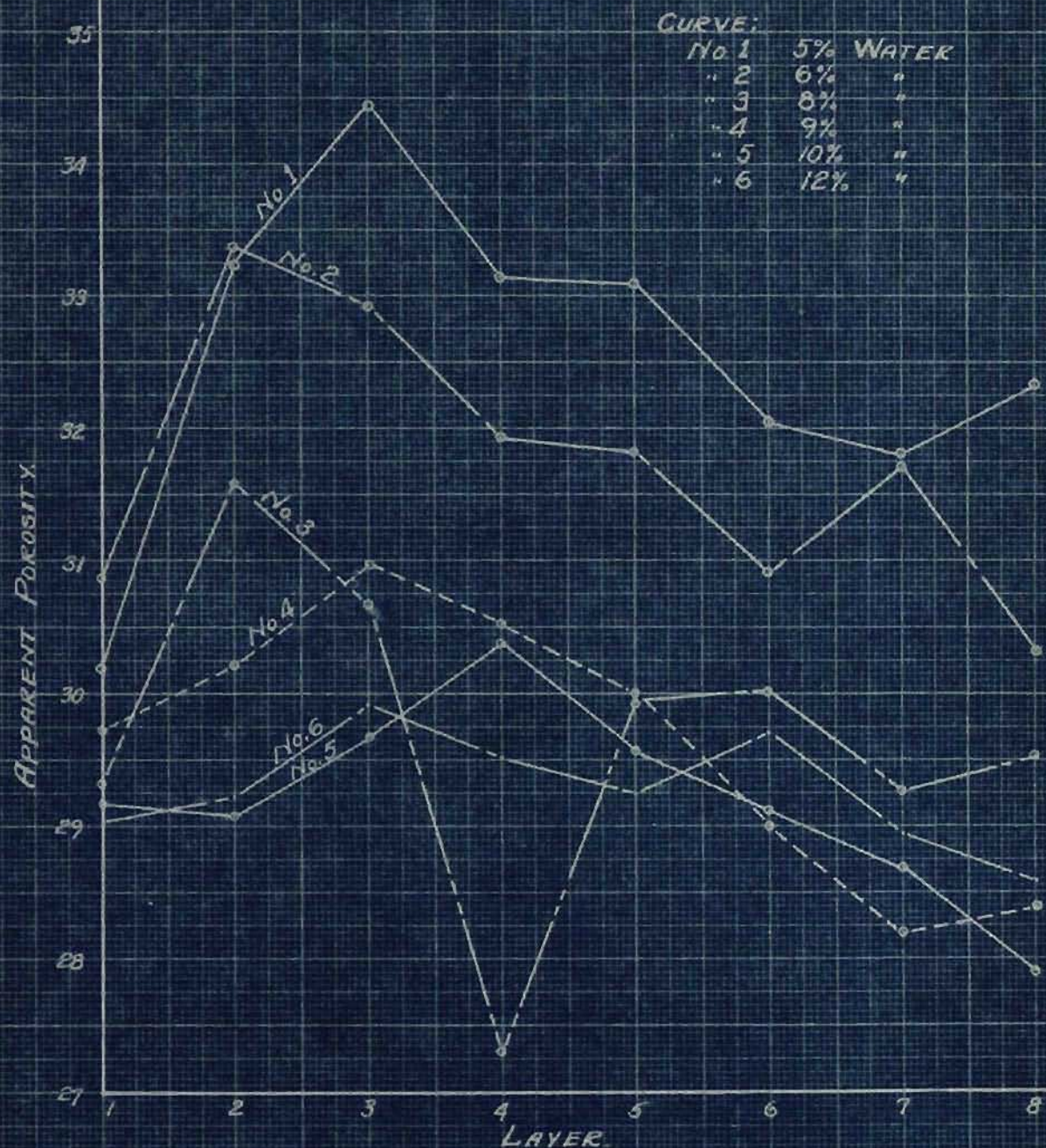
|        | Wt. Wet | Thickness<br>When<br>Formed | Wt. Dry | Thickness<br>Dry | Breadth | Load in<br>Lbs. | Line<br>Pressure | $d^2$ | $bd^2$ | Modulus of<br>Rupture<br>lbs. per sq.<br>in. | Average |
|--------|---------|-----------------------------|---------|------------------|---------|-----------------|------------------|-------|--------|--|---------|
| 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 0<sub>6</sub>

| MIX VI | MODULUS OF RUPTURE OF BRICK WITH VARIABLE WATER CONTENT |                                  |         |                       |         |                 |                  |       |        |  | Average |
|--------|---|----------------------------------|---------|-----------------------|---------|-----------------|------------------|-------|--------|--|---------|
|        | Wt. Wet   | Thick-<br>ness<br>When<br>Formed | Wt. Dry | Thick-<br>ness<br>Dry | Breadth | Load in<br>lbs. | Line<br>Pressure | $d^2$ | $bd^2$ | Modulus of<br>Rupture<br>lbs. per sq.<br>in. |         |
| 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  | 2.56                             | 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%.

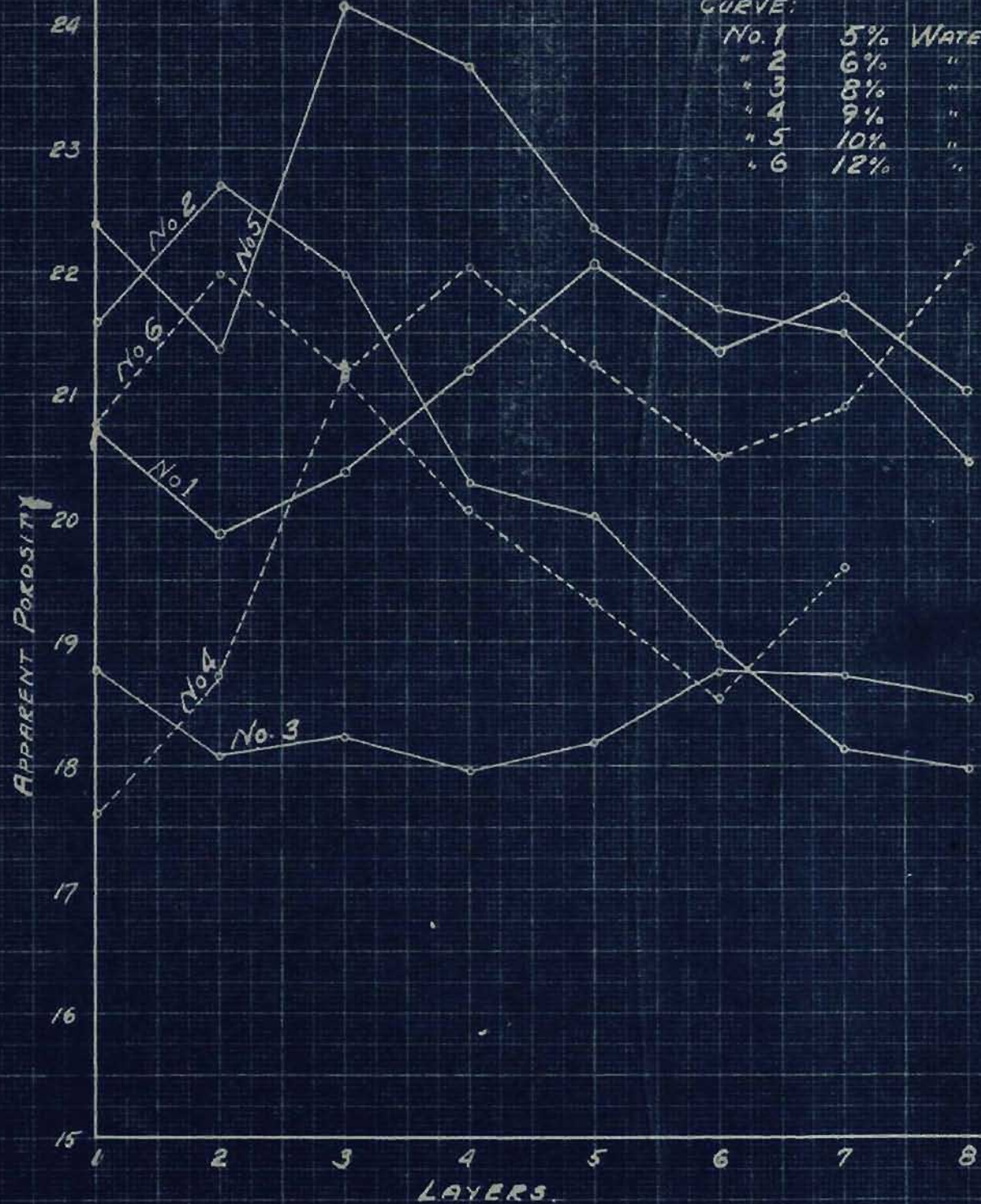


GRAPH P



Mix No. 2: 100% CHELTENHAM CLAY  
 DRY PANNED THRU 10 MESH  
 PRESSURE: 2000<sup>2</sup>/sq. in.  
 WATER CONTENT VARIED FROM 5% TO 12%

CURVE:  
 No. 1 5% WATER  
 " 2 6% "  
 " 3 8% "  
 " 4 9% "  
 " 5 10% "  
 " 6 12% "



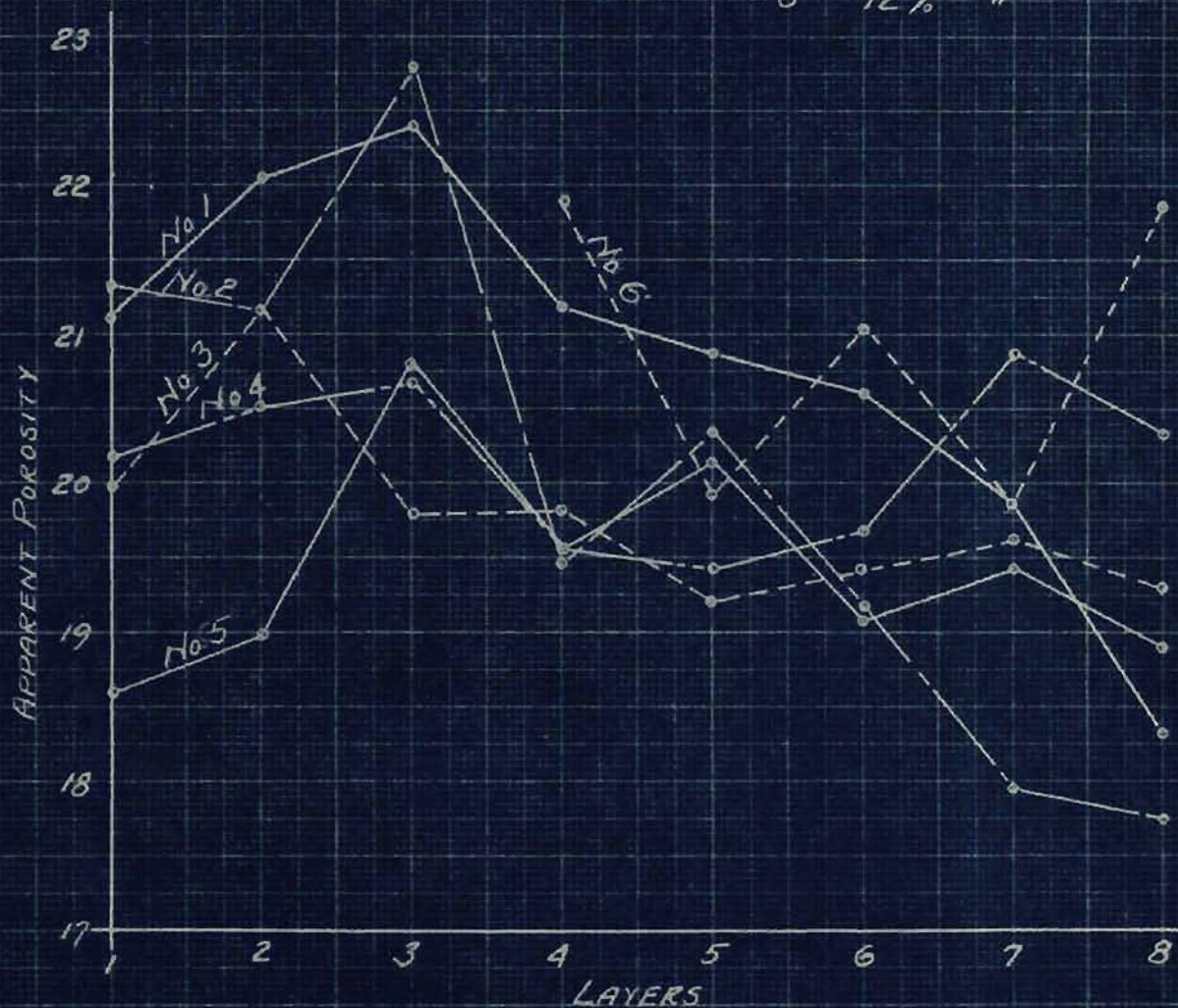
GRAPH Q

Mix No. 3:  $\frac{3}{4}$  CHELTENHAM CLAY;  $\frac{1}{4}$  ST LOUIS SURFACE CLAY.  
 DRY PANNED THRU 10 MESH  
 PRESSURE: 2000<sup>+</sup>/sq in.

WATER CONTENT VARIED FROM 5% TO 12%

CURVE:

|      |          |
|------|----------|
| No 1 | 5% WATER |
| " 2  | 6% "     |
| " 3  | 8% "     |
| " 4  | 9% "     |
| " 5  | 10% "    |
| " 6  | 12% "    |

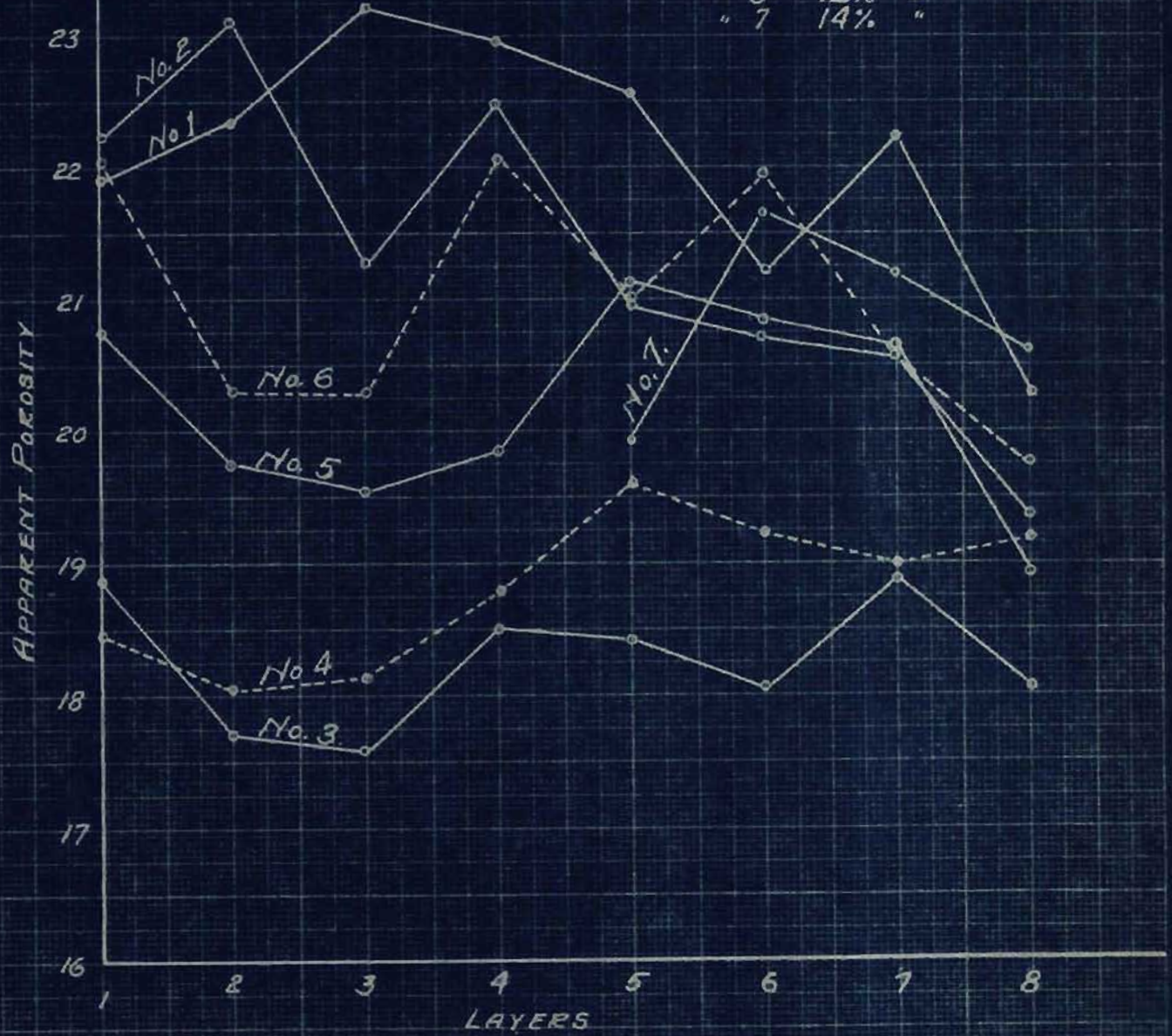


GRAPH R.

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% "

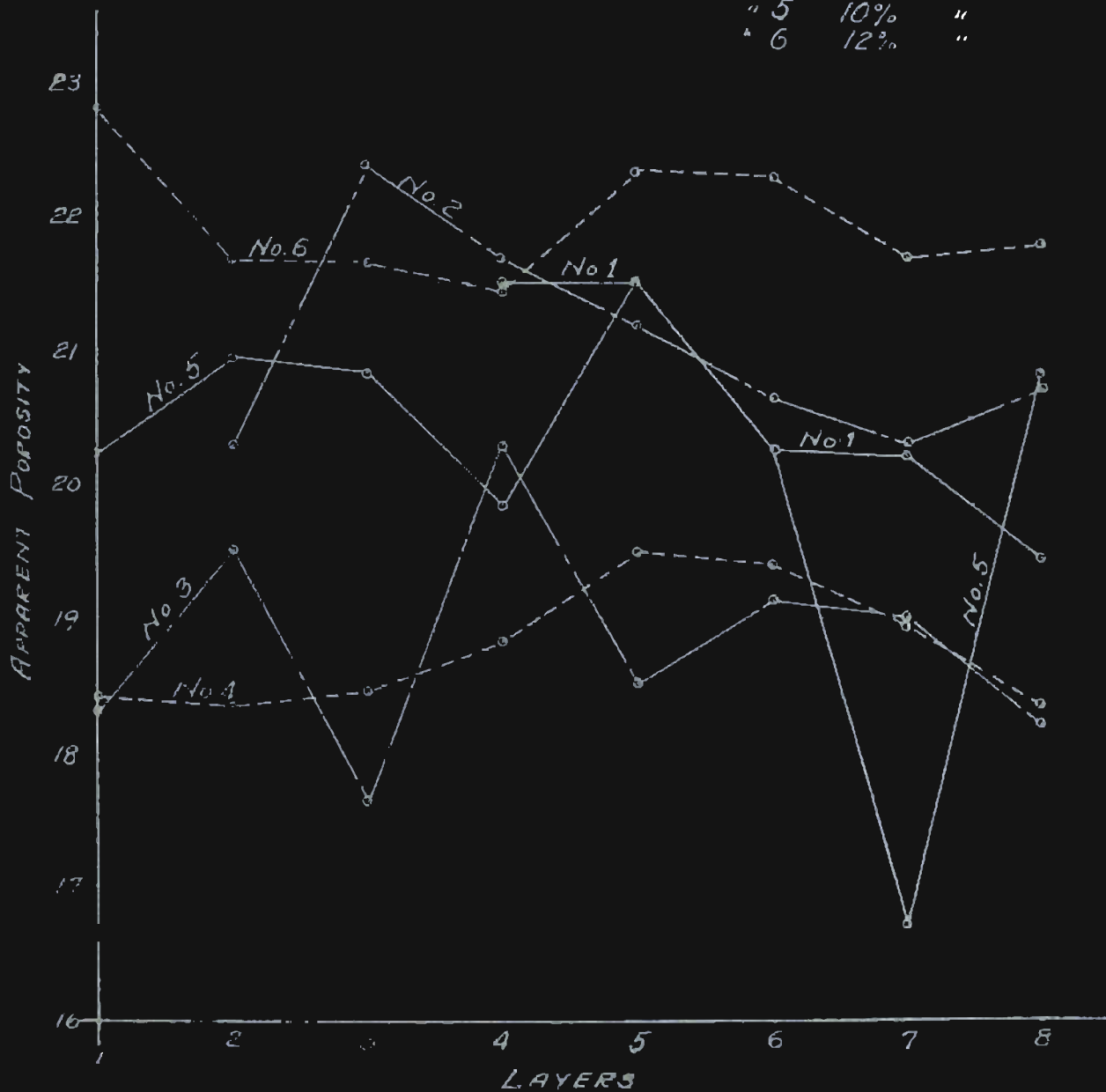


GRAPH 5

Mix No. 5 92% N. Mo. SEMI FLINT CLAY + 8% GROG  
 DRY PANNED THRU 8 MESH.  
 PRESSURE 2000<sup>2</sup>/sq. in.

WATER CONTENT VARIED FROM 5% TO 12%

CURVE:  
 No. 1. 5% WATER  
 " 2. 6% "  
 " 3. 8% "  
 " 4. 9% "  
 " 5. 10% "  
 " 6. 12% "



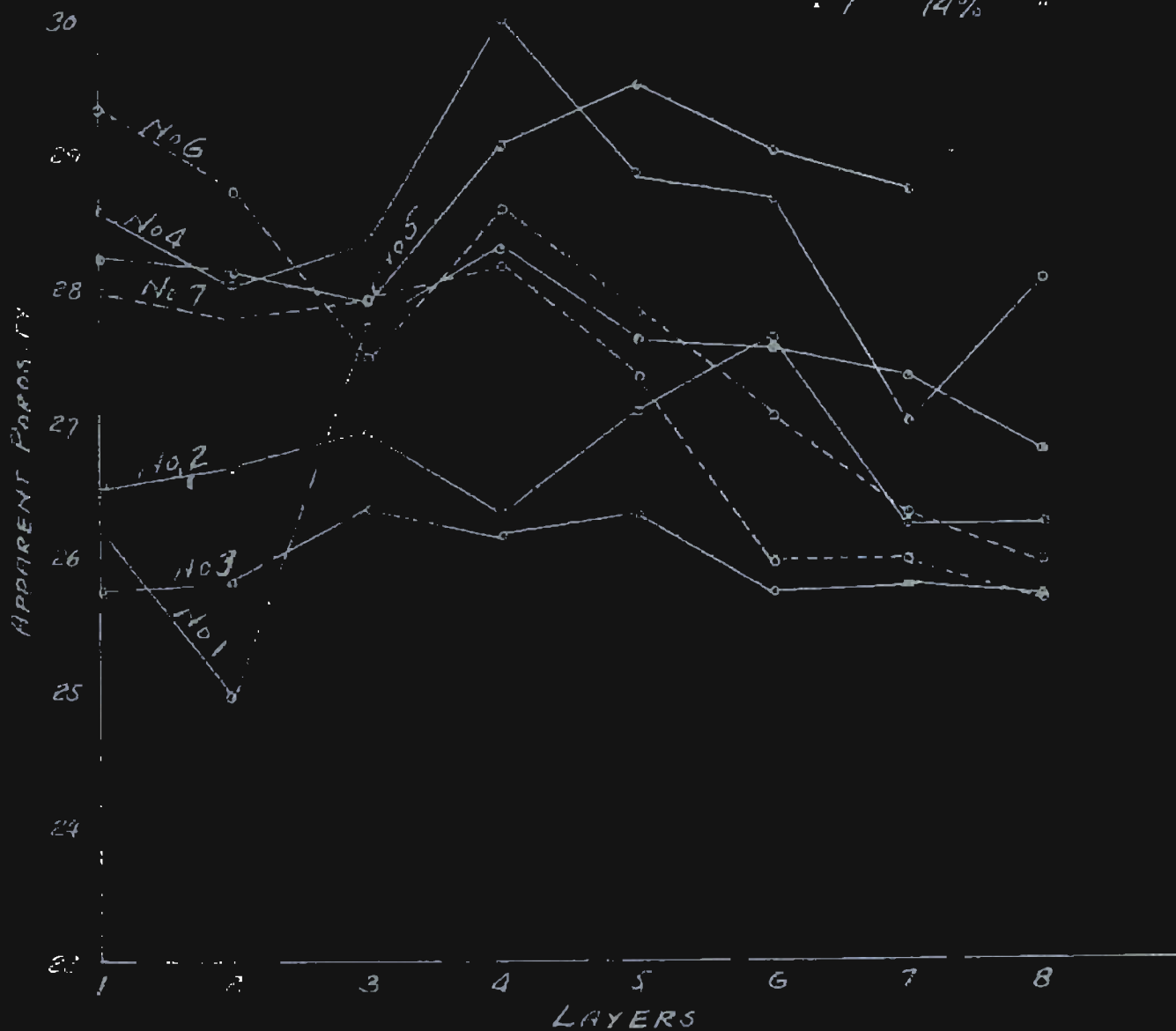
GRAPH T

75% NO. F INT 25% CHELTENHAM CLAY  
 DRY PANNED THRU 8 MESH  
 PRESSURE 2000<sup>2</sup>/sq in

WATER CONTENT VARIED FROM 5% TO 14%

CURVE:

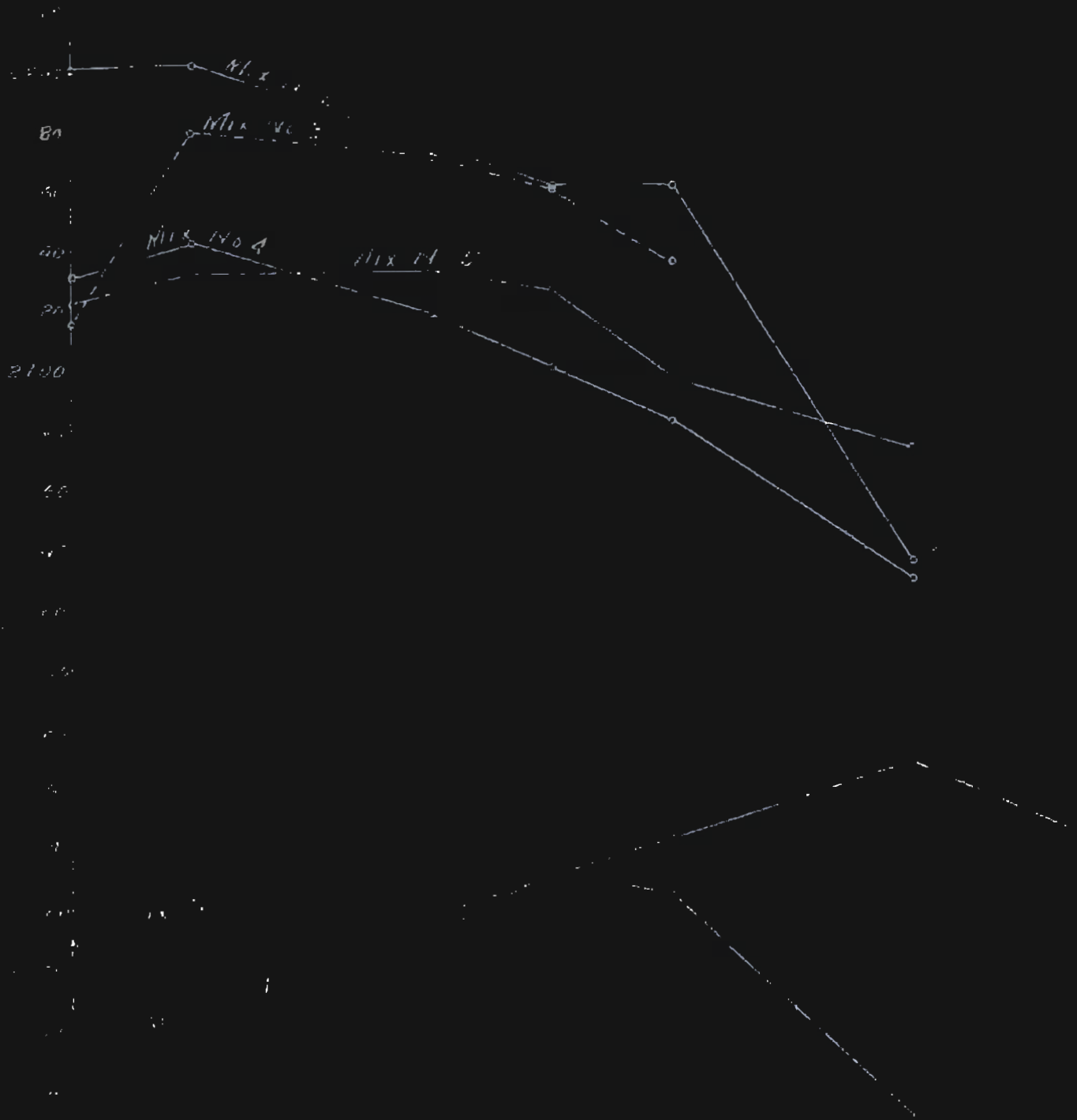
|      |          |
|------|----------|
| No 1 | 5% WATER |
| " 2  | 6% "     |
| " 3  | 8% "     |
| " 4  | 9% "     |
| " 5  | 10% "    |
| " 6  | 12% "    |
| " 7  | 14% "    |



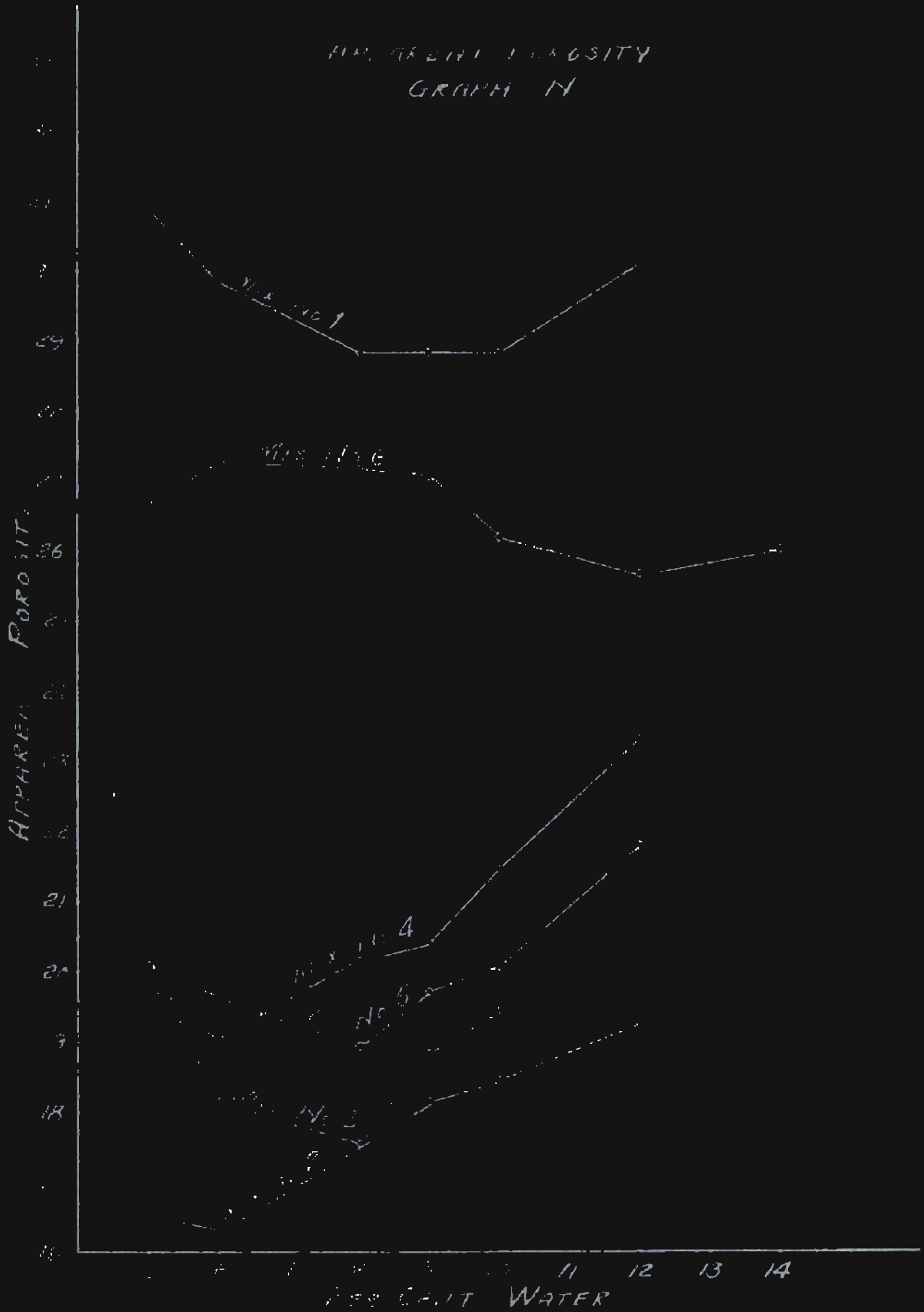
GRAPH V

BULK SPECIFIC GRAVITY

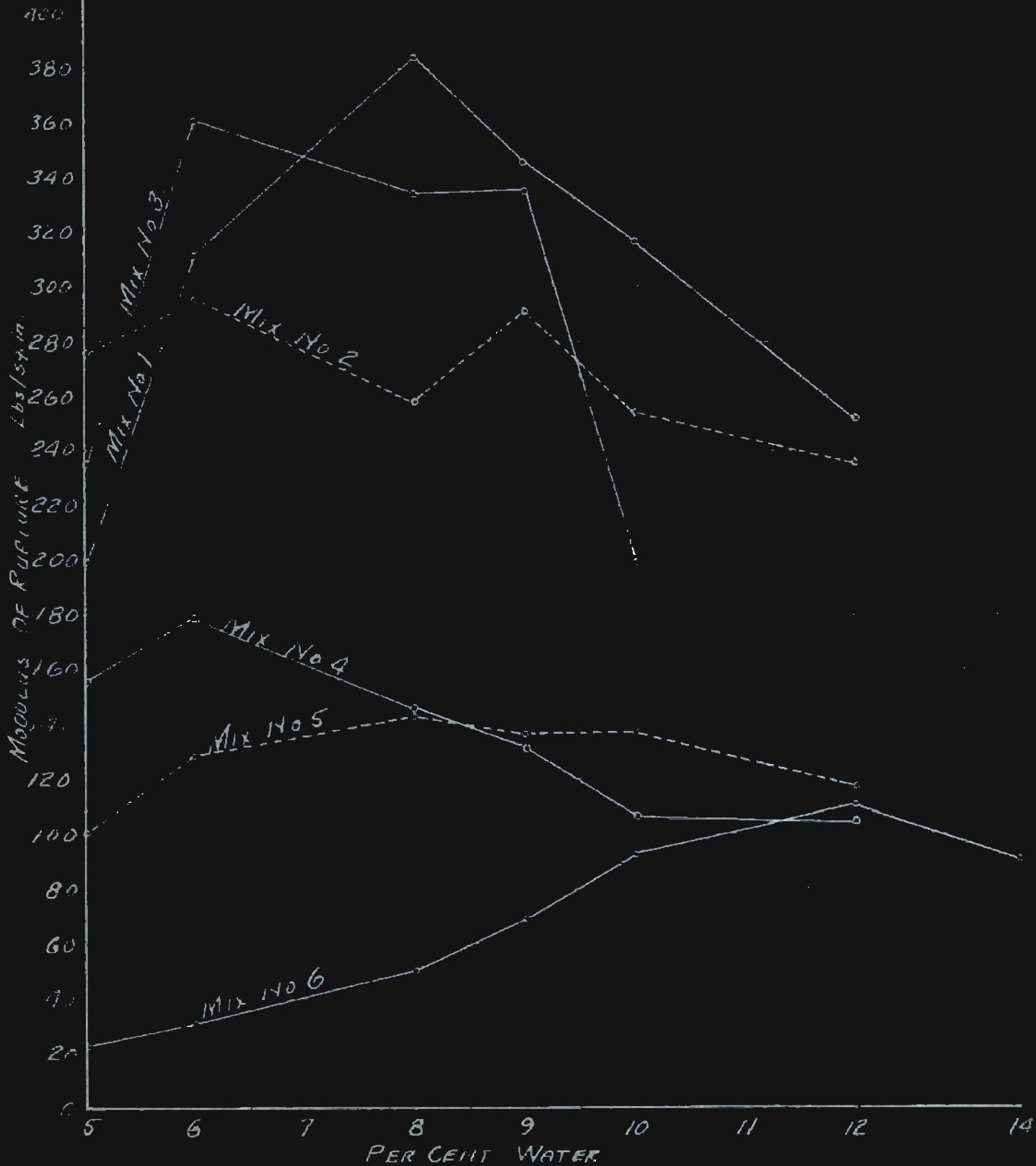
GRAPH M



APPARENT DENSITY  
GRAPH IV



MODULUS OF RUPTURE  
GRAPH O.

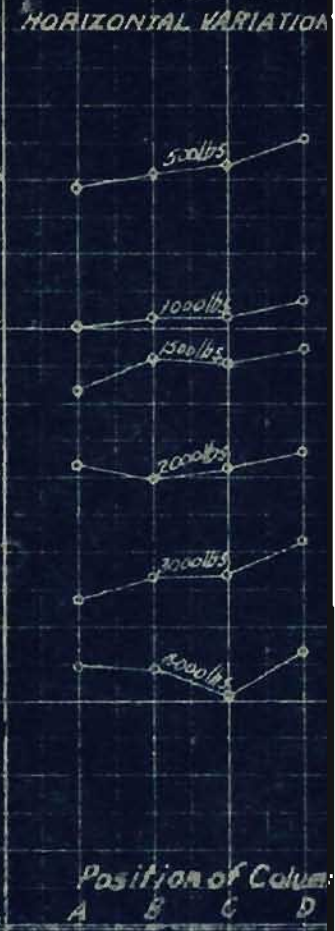
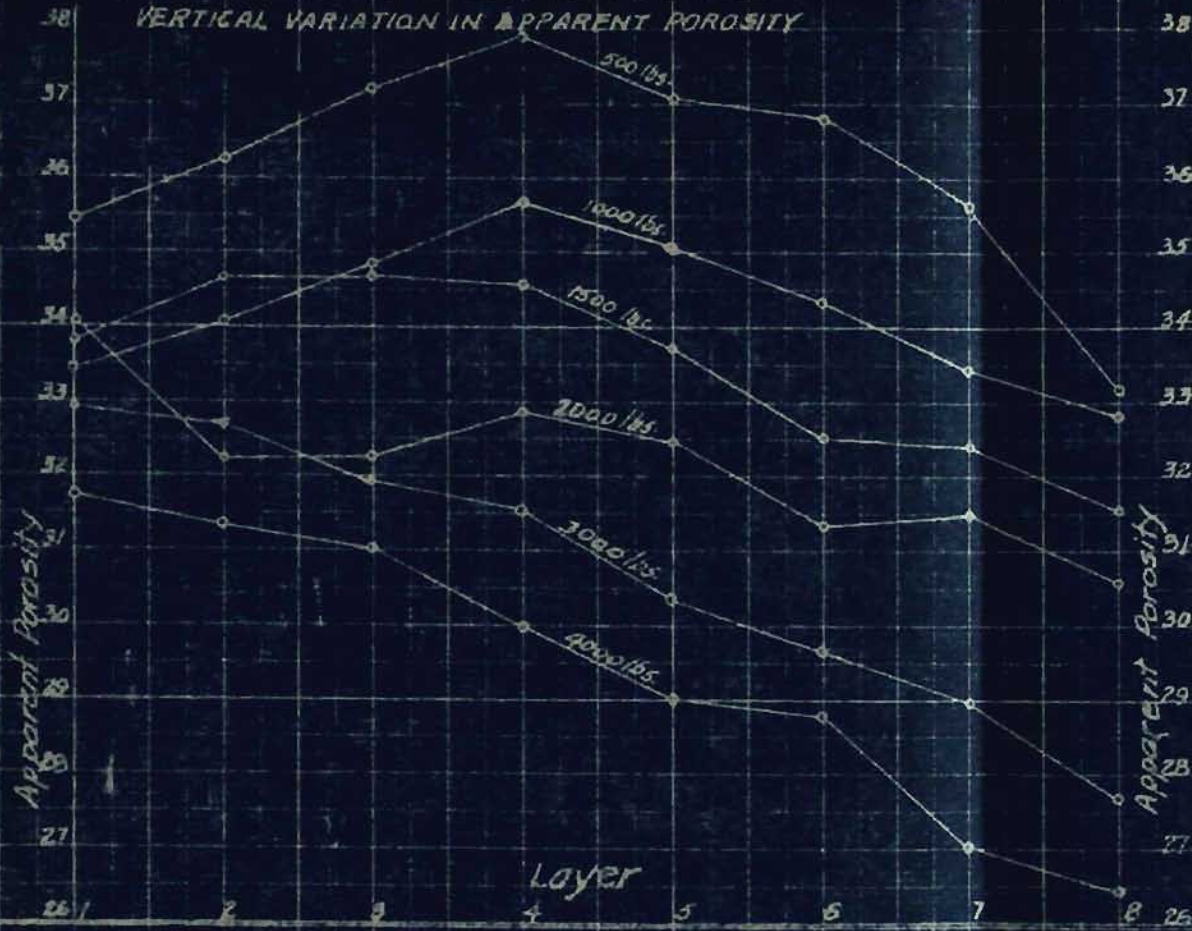




ST. LOUIS SURFACE CLAY DRY PANNEU THRU 10 MESH  
 VERTICAL VARIATION IN APPARENT POROSITY

PLOT A

PLOT AI  
 HORIZONTAL VARIATION



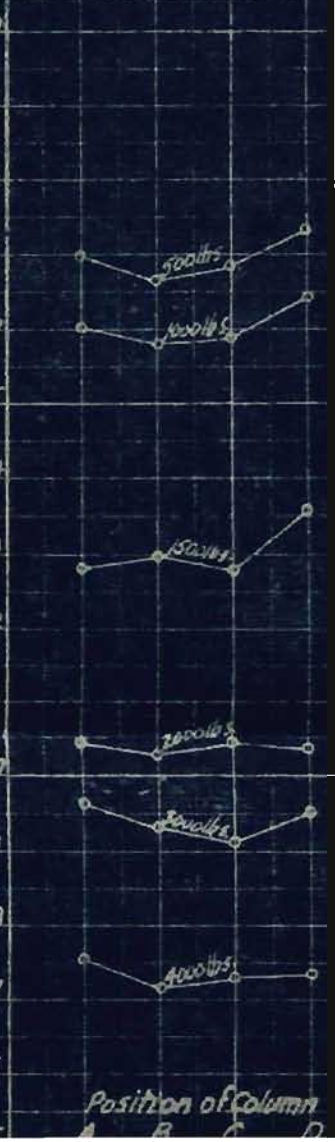
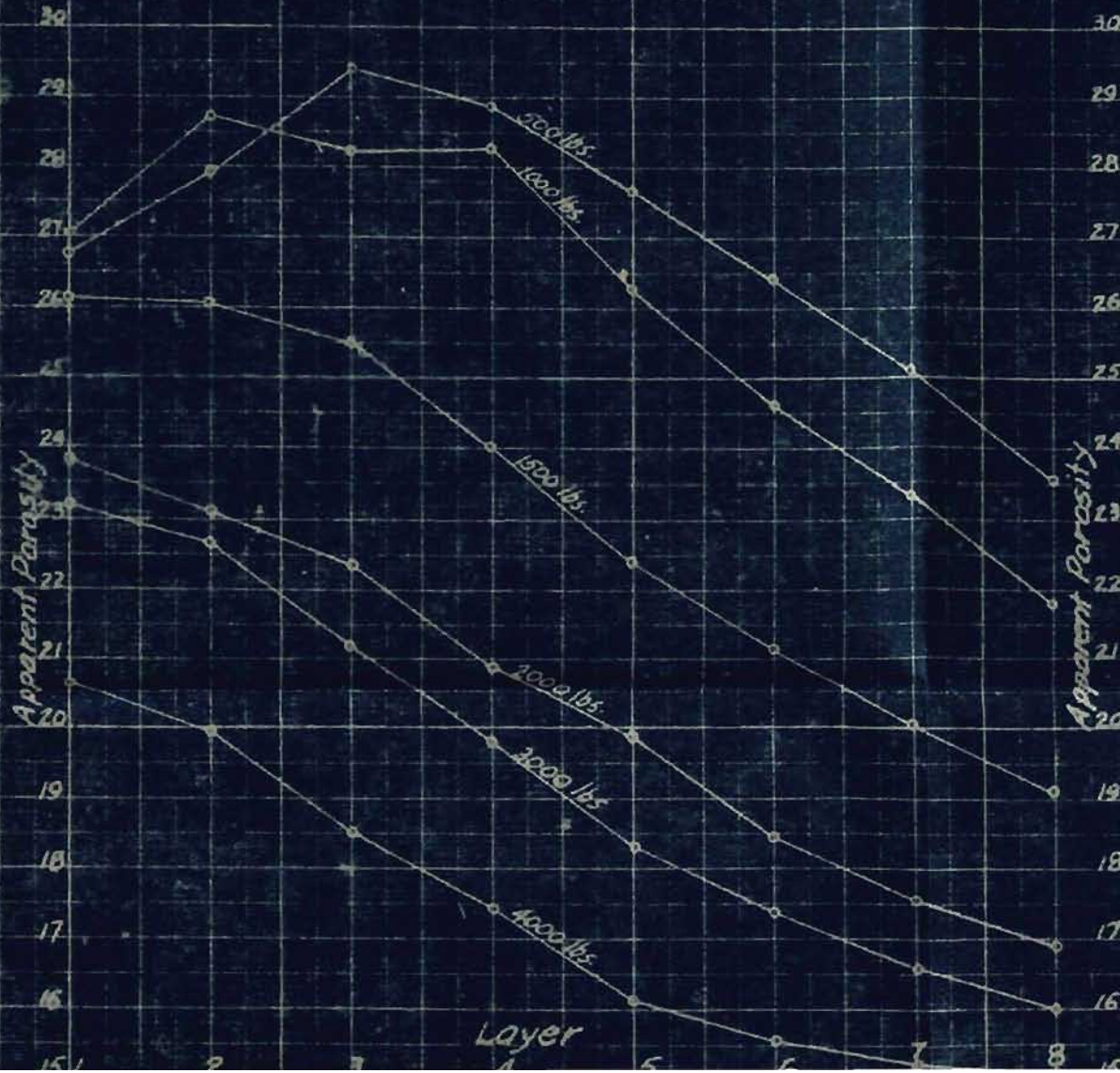
CHELTENHAM CLAY 8.51% } DRY PANNEU THRU 10 MESH  
 ST. LOUIS SURFACE CLAY 19.3%

PLOT B

PLOT BI

VERTICAL VARIATION IN APPARENT POROSITY

HORIZONTAL VARIATION



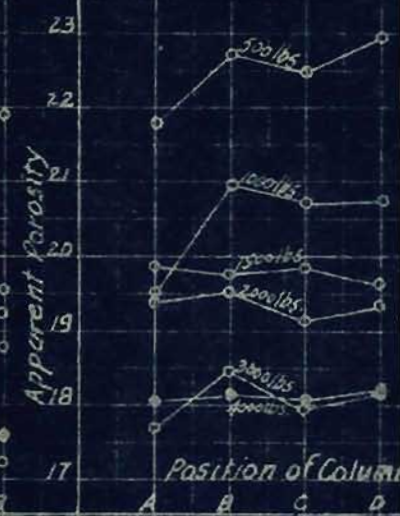
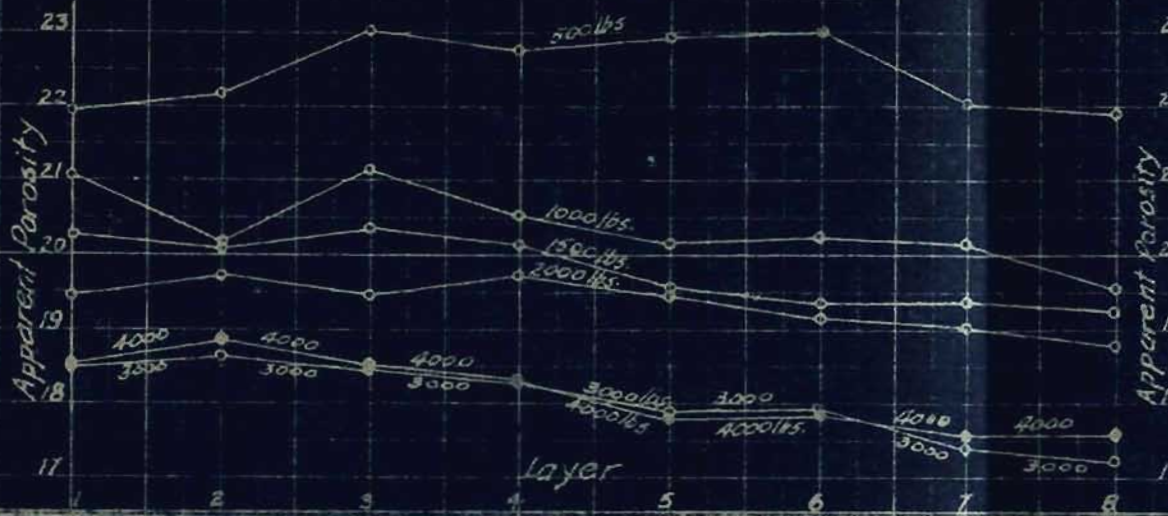
CHEL TENHAM CLAY 92% } DRY PANNED THRU 8 MESH  
 FIRE BRICK GROG 8%

PLOT C

PLOT CI

VERTICAL VARIATION IN APPARENT POROSITY

HORIZONTAL VARIATION



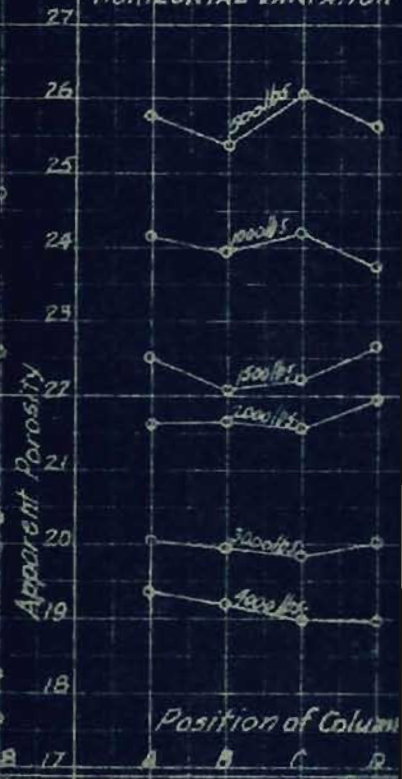
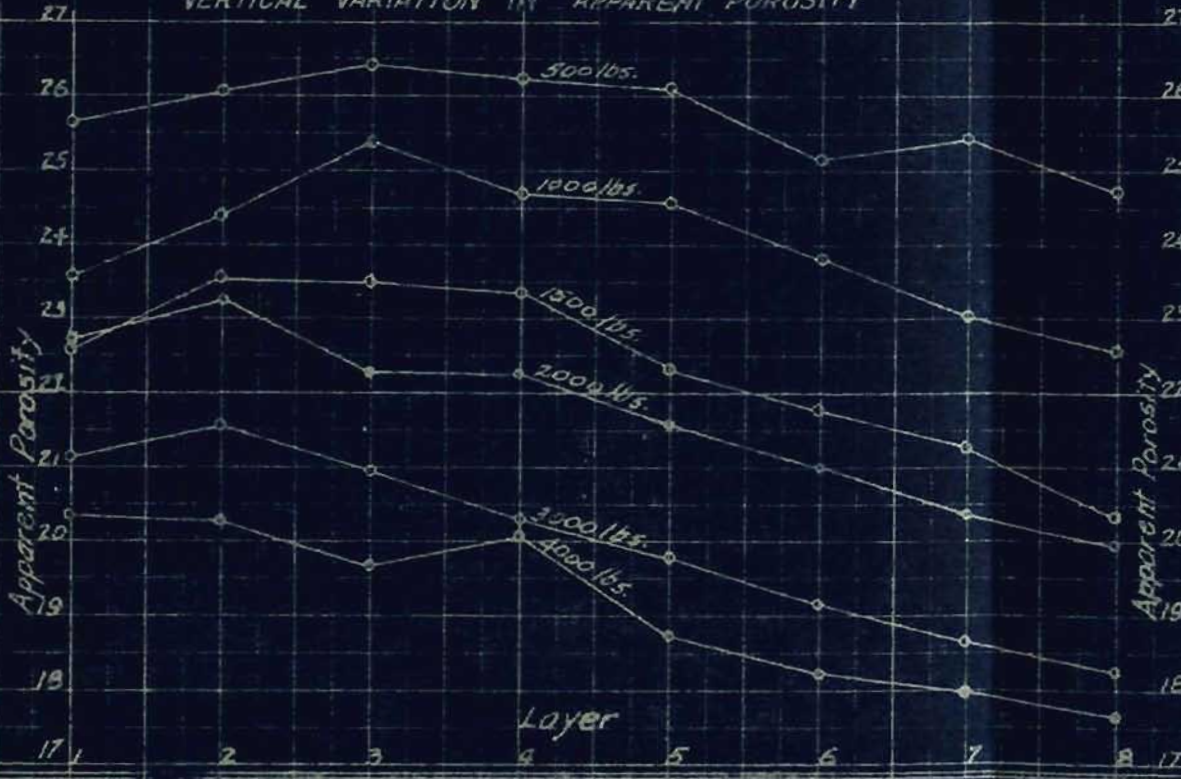
NORTH MISSOURI SEMI FLINT CLAY 92% } DRY PANNED THRU 8 MESH  
 FIRE BRICK GROG 8%

PLOT D

PLOT DI

VERTICAL VARIATION IN APPARENT POROSITY

HORIZONTAL VARIATION



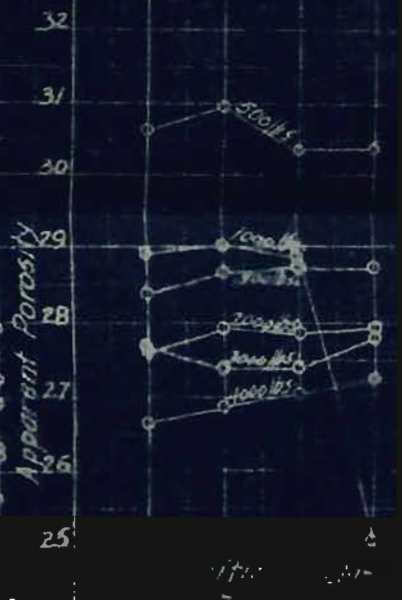
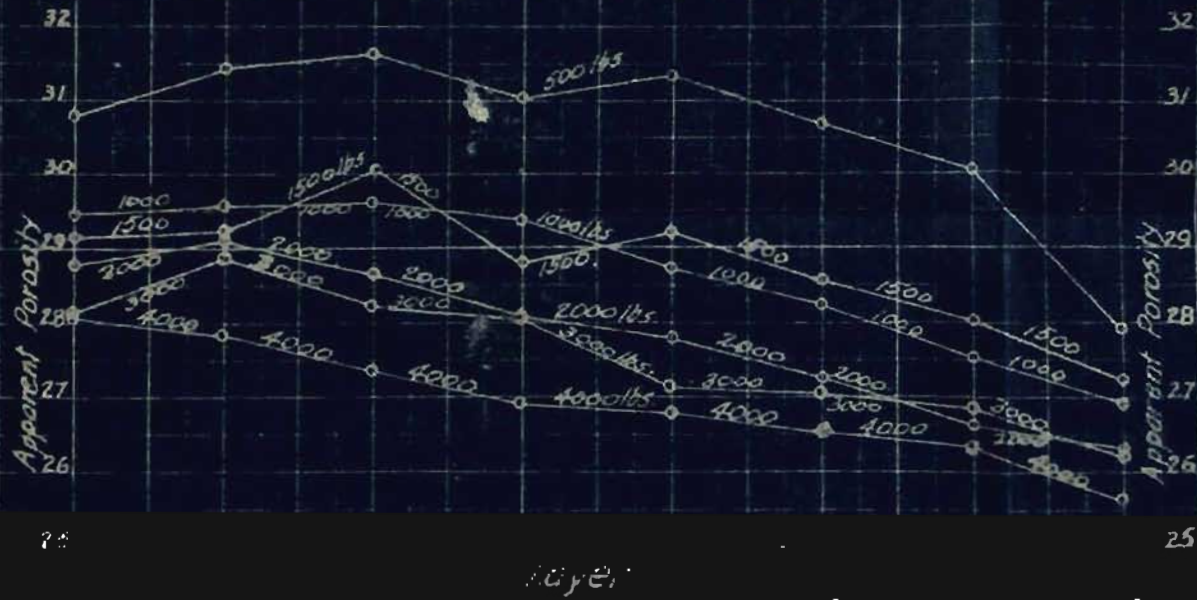
CHEL TENHAM CLAY 25% } DRY PANNED THRU 8 MESH  
 No. 1 MISSOURI FLINT CLAY 75%

PLOT E

PLOT EI

VERTICAL VARIATION IN APPARENT POROSITY

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 plotted 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 contain-

ing 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<sub>1</sub>, O<sub>2</sub>, O<sub>3</sub>, O<sub>4</sub>, O<sub>5</sub>, O<sub>6</sub>, 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<sub>1</sub>, O<sub>2</sub>, O<sub>3</sub>, O<sub>4</sub>, O<sub>5</sub>, O<sub>6</sub>.

In table O<sub>1</sub> will be found the data obtained on the 4<sup>th</sup> 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.

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