1930

The effect of occluded air in dry-press mixes

William Raymond Powell

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THE EFFECT OF OCCLUDED AIR IN DRY-PRESS MIXES

by

Wm. R. Powell

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

The effect of occluded air in clay mixes has recently become a subject of considerable importance especially since some of the defects occurring in dry-press ware, such as cracks and soft or granulated centers, have been either partially or wholly attributed to occluded air.

According to this theory, the defects are due to the entrapping of air among the clay grains before compression, which, when the pressure is released, has a tendency to expand and cause a rupture in the bond. Also granulated centers have been explained by the fact that the entrapped air may act as a cushion, thus preventing intimate contact of the clay grains.

Lovejoy is of the opinion that the granulated centers are more the result of pressure gradient than of occluded air.

The purpose of this investigation was to determine the effect of occluded air in dry-press mixes.

I. A. V. Bleinenger "Brick Check After Pressing" Brick and Clay Record, Vol. XLIIP. 753 (1913)
2. Ellis Lovejoy, "Granulated centers are a result of Pressure gradient rather than Occluded Air. T.A.C.S. Vol.7, P. 232-250 (1905)
A survey of the literature showed no definite data on the subject so it was proposed that a comparison of the physical properties of a block made in the regular way and a block made under vacuum should show the effect of air in the mix.

It was therefore proposed to run determinations on various clays, milled by various methods and varying the forming pressure, making one series of block by the regular method and the other series under vacuum. Since each of the series was made under identical conditions with the exception of vacuum treatment, conclusions may be drawn as to the effect of air in the mix during formation.

To every person who is familiar with the manufacture of clay products, particularly dry-press ware, it is a known fact that a certain amount of air is occluded in finely ground clay mixes which can be observed forcing out through the air holes in the die plate. Also the mix is known to contain a certain amount of moisture. So in producing a vacuum in the mold box as shown in Fig. 1, which contains the clay mix, it is apparent that there is a mixture of air and water vapor under reduced pressure which lowers the degree of vacuum obtainable and removes moisture from the clay mix at very low pressures.
According to Dalton's Law: The mass of a given vapor required to saturate a given space at a given temperature is the same whether the vapor is by itself or associated with vaporless gases; the total pressure of the air and water vapor in a mixture of the two is the sum of the partial pressures; and the maximum tension of a given vapor at a given temperature is the same whether it is by itself or associated with a vaporless gas, as air.

Thus assuming that the volume, pressure and temperature of the air and water vapor under atmospheric and reduced conditions follow the law of the ideal gas, it is possible to calculate the maximum degree of vacuum obtainable.

At room temperature (25 degrees C.) the vapor tension of saturated vapor is only 23 mm mercury. This pressure would be greatly reduced by the pump, the amount of reduction being dependent on the capacity of the pump.

It is therefore seen that the effect of water vapor pressure on the degree of vacuum is very slight (10 to 15 mm mercury) and may be neglected entirely while the removal of moisture which takes place at reduced pressures may cause error if the process is continued for a considerable length of time.
in view of the above facts it was proposed to obtain a moderate vacuum in as short a time as possible.

A water bottle partially filled with water was placed in the line between the vacuum pump and the mold-box so as to saturate the atmosphere and thus prevent removal of moisture from the charge. The water bottle also prevented water from being sucked back into the mold-box when the water supply was cut off.
CROSS SECTIONAL VIEW
SHOWING METHOD OF SEALING MOLD BOX TO PRODUCE VACCUUM

Fig. 1.
METHOD OF INVESTIGATION

Preliminary Study

In order to carry on the proposed investigation it was first necessary to obtain a vacuum in the mold-box and maintain it during pressure application. The following method was finally worked out and perfected so that a vacuum of 26 inches of mercury could be obtained in from 5 to 10 minutes.

Description of Apparatus: (See Fig. 1.)

A steel gasket plate 3/8 inches thick with rounded edges on the upper side was placed under the die plate of the movable lower ram. This steel plate cleared the edges of the mold-box by 1/16 inch so that a 3/32 inch rubber gasket placed between the die plate and this special gasket plate and extending 1/4 inch beyond it's edges was forced out against the sides of the mold-box forming a seal as the ram moved upward. The ram was then forced upward until the space in the mold-box was of the correct volume to receive the charge, and a 1/4 inch coating of paraffin was applied to the upper side of the lower die plate. Heat from the steam heated die plate caused the paraffin to melt and seal the bottom.
In order to obtain equal distribution of the effect of the vacuum, the upper die plate was modified in the following manner; a 1/8 inch by 1/8 inch horizontal groove was cut in the sides and ends 1/4 inch from its top surface. Holes 1/8 inch in diameter were drilled connecting the groove with all the air vents in the original plate. The die plate was then placed on the charge of clay, and on top of this was placed a 3/32 inch rubber gasket having two 1/4 inch holes which coincide with the air vents in the center of each end of the die plate and extending 1/4 inch over the edge. A 3/8 inch steel plate similar to the one used on the bottom ram but having two holes coinciding with the holes in the rubber gasket into which are fitted two 1/4 inch nipples, was placed on top of the rubber gasket and forced down into the mold-box. Melted paraffin was then poured over the top of the plate and around the gasket to seal any minute holes.

The nipples in the upper die plate were connected to a 1/4 inch water vacuum pump and a manometer by means of a rubber pressure tubing.

The small water pump used was found capable of producing a vacuum of 28.75 inches of mercury.
**PROCEDURE**

The various clays were milled and placed in a small mechanical mixer where the water content was adjusted to 7%. It was then aged for 24 hours in a covered container. After aging the clay mix was introduced into the mold-box in two-inch layers. The block consisted of 8 layers which were separated by thin layers of potters flint. Just enough flint was used to facilitate the separation of the layer after compression.

The pressure was then applied to the desired amount and held at the maximum pressure for 2 seconds.

The vacuum treated block was formed under the same conditions except that the mold-box was sealed as described under apparatus and the full vacuum obtained before compression and maintained throughout the compression stroke.

Attention is called here to the fact that the floating mold-box on the press was blocked up to prevent breaking of the top seal when making vacuum treated block.

The blocks were dried for 24 hours at 235 degrees F. in a Westinghouse Electric drier each layer

---

**FIG. 2. Test Block.**

1. Layers
2. Potters
3. Flint
4. Potters
5. Flint
6. Potters
7. Flint
8. Layers
trimmed and weighed dry. They were then put into kerosene (SP.gr.-.815) and subjected to a vacuum of 20 inches of mercury for two hours, during which time they were kept completely submerged. The layers were next weighed, saturated and then weighed suspended in kerosene. The apparent porosity was determined by the following formula;

\[
\text{% Apparent Porosity} = \frac{\text{weight soaked-weight dry}}{\text{weight soaked-weight suspended}} \times 100
\]

The percent porosity was then plotted against the layers (vertical variation) for both the vacuum treated block and the regular block. These curves were both plotted on the same graph which facilitates direct comparison of the two blocks.

The type of clay, method of milling, time of pressure application, moisture content of mix, the degree of vacuum in inches of mercury at the beginning and end of compression, and the average percent apparent porosity of both the vacuum treated, and regular block are given on each set of curves.

The following studies were made in the order given below:

1. "The effect of occluded air in a dry press mix which had been milled by each of the following methods, 1. dry pan, 2. wet pan, 3. rolls (set at 3/32") and 4. Disintegrator."
The clay chosen for this investigation was a mixture of 92% Laclede-Christy Fire Clay (Cheltenham) and 8% Laclede Christy grog. The mix was prepared by each of the above methods of milling, screened through 8 mesh, and the general procedure given above followed for making the block and testing it. See Plot 1.

2. "The effect of occluded air in various clay mixes prepared by the same method and formed at the same pressure." The following clay mixes were chosen for this investigation:

1. Laclede Christy Fire Clay - 92% Dry
   Laclede Christy Grog - 8% through 8 mesh

2. A. P. Green Fire Clay - 92% Dry
   A. P. Green Grog - 8% through 8 mesh

3. Progress Press Brick Surface Clay 100%
   Dry panned through 10 mesh

4. 1/7 Progress Press Brick Surface Clay
   6/7 Hydraulic Press Brick Fire Clay
   (Dry panned through 10 mesh)

5. Forbes Flint - 75%
   Evans and Howard Fire Clay 25%
   (Dry panned through 8 mesh)

Each mix was prepared as stated at the right of
each mix and the general procedure followed for making and testing the block (given under general heading of Procedure). See Plot 2.

3. "The effect of occluded air in dry press mixes at various pressures of 500, 1000, 2000, 3000, and 4000 pounds per square inch".

The clay mix selected for this investigation was a mixture of 92% Laclede Christy Fire Clay and 8% Laclede Christy Crog.

The same general procedure was followed for forming and testing the block as given under general heading of procedure except that the average apparent porosities were plotted against pressure in pounds per square inch. The blocks were formed at pressure of 500, 1000, 2000, 3000, and 4000 pounds per square inch, one of each being made in the regular manner and one under vacuum treatment.
DATA AND RESULTS

TABLE I

The effect of Occluded Air in Dry Press Mixes on Vertical Variation in Apparent Porosity with Various Methods of Milling.

Mix:

Laclede Christy Fire Clay - 92%
Laclede Christy Grog - 8%

(Dry panned and screened through 8 mesh, forming pressure 2000# to the square inch.)
## PERCENT APPARENT POROSITY

<table>
<thead>
<tr>
<th>Layer</th>
<th>Dry Pan</th>
<th>Wet Pan</th>
<th>Disintegrator</th>
<th>Rolls</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>29.12</td>
<td>19.92</td>
<td>22.42</td>
<td>19.45</td>
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<td>23.60</td>
<td>21.90</td>
<td>21.73</td>
<td>19.41</td>
</tr>
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<td>2.</td>
<td>23.04</td>
<td>20.37</td>
<td>21.93</td>
<td>19.85</td>
</tr>
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<td></td>
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<td>22.09</td>
<td>21.58</td>
<td>20.08</td>
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<td>3.</td>
<td>22.33</td>
<td>20.60</td>
<td>21.06</td>
<td>19.78</td>
</tr>
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<td>21.40</td>
<td>21.84</td>
<td>20.50</td>
<td>20.38</td>
</tr>
<tr>
<td>4.</td>
<td>22.02</td>
<td>20.21</td>
<td>20.80</td>
<td>19.24</td>
</tr>
<tr>
<td></td>
<td>20.69</td>
<td>19.70</td>
<td>19.62</td>
<td>19.03</td>
</tr>
<tr>
<td>5.</td>
<td>21.26</td>
<td>20.42</td>
<td>19.50</td>
<td>19.62</td>
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<tr>
<td></td>
<td>20.79</td>
<td>20.00</td>
<td>20.18</td>
<td>18.53</td>
</tr>
<tr>
<td>6.</td>
<td>20.40</td>
<td>20.19</td>
<td>19.03</td>
<td>19.17</td>
</tr>
<tr>
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<td>19.73</td>
<td>18.98</td>
<td>18.98</td>
<td>18.90</td>
</tr>
<tr>
<td>7.</td>
<td>19.92</td>
<td>20.04</td>
<td>18.82</td>
<td>18.98</td>
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<tr>
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<td>20.18</td>
<td>18.53</td>
<td>18.53</td>
<td>18.90</td>
</tr>
<tr>
<td>8.</td>
<td>19.54</td>
<td>19.80</td>
<td>18.30</td>
<td>17.99</td>
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<tr>
<td></td>
<td>18.98</td>
<td>18.64</td>
<td>18.64</td>
<td>18.90</td>
</tr>
<tr>
<td>Av.</td>
<td>21.58</td>
<td>20.19</td>
<td>20.28</td>
<td>19.65</td>
</tr>
<tr>
<td>Bor.</td>
<td></td>
<td></td>
<td>19.87</td>
<td>19.41</td>
</tr>
</tbody>
</table>
DISCUSSION OF THE DATA OF TABLE I.

An examination of the data in Table I shows that in all cases the vacuum treated block was more dense in the bottom layers than the regular block and more porous in the top layers. Thus there is a greater variation from top to bottom of the vacuum treated block than in the regular block.

In general the average porosities of the vacuum treated block are slightly higher than the porosities of the regular block.

The variation in porosity of the four methods of milling is very slight, the maximum variation being 2.4% for vacuum treated block and 2.5% for regular block.

The above facts tend to show that at a pressure of 2000 pounds per square inch, pressure is transmitted more uniformly when the air is not eliminated than when the occluded air is removed by vacuum treatment.

These facts seem to support the theory that a thin film of adsorbed air around the clay grains acts as a lubricant which allows the grains to flow over each other and along the sides of the mold-box more easily. Hence they may be compressed into a denser more uniform block.
The validity of the above theory has been questioned and it is thought by some that the air which acts as a lubricant is only the colloidal air (air films surrounding colloidal particles only). This air is supposed to be very difficult to remove and of course would not be removed by the reduced pressures obtained in this experiment.

It will be noted that the porosity curve for regular block usually starts at a medium value and rises to a maximum. While in the vacuum treated block the maximum porosity occurs in the top layer and gradually drops off as the bottom of the block is approached. This was caused by the floating mold-box which was free to move in the forming of regular block while it was held stationary to prevent breaking the top seal in forming the vacuum treated block.

Attention is again called to the fact that this is a fire clay mix containing 9% grog which holds the body open thus allowing air to escape as pressure is applied.

No cracking or other defects were noted in these blocks.
<table>
<thead>
<tr>
<th>Block #1</th>
<th>92% Laclede Christy Fire Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dry panned through 8 mesh</td>
</tr>
<tr>
<td></td>
<td>8% Laclede Christy Grog</td>
</tr>
<tr>
<td>Block #6</td>
<td>92% A.P. Green Fire Clay</td>
</tr>
<tr>
<td></td>
<td>Dry panned through 8 mesh</td>
</tr>
<tr>
<td></td>
<td>8% A.P. Green Grog</td>
</tr>
<tr>
<td>Block #7</td>
<td>100% Progress Press Brick Surface Clay</td>
</tr>
<tr>
<td></td>
<td>Dry panned through 10 mesh</td>
</tr>
<tr>
<td>Block #8</td>
<td>1/7 Progress Press Brick Surface Clay</td>
</tr>
<tr>
<td></td>
<td>Dry panned through 10 mesh</td>
</tr>
<tr>
<td></td>
<td>6/7 Hydraulic Press Brick Clay</td>
</tr>
<tr>
<td>Block #9</td>
<td>75% Forbes Flint</td>
</tr>
<tr>
<td></td>
<td>Dry panned through 8 mesh</td>
</tr>
<tr>
<td></td>
<td>25% Evans &amp; Howard Fire Clay</td>
</tr>
</tbody>
</table>
### Percent Apparent Porosity

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<th>Location of layers</th>
<th>No. 1 Vacuum</th>
<th>No. 1 Regular</th>
<th>No. 6 Vacuum</th>
<th>No. 6 Regular</th>
<th>No. 7 Vacuum</th>
<th>No. 7 Regular</th>
<th>No. 8 Vacuum</th>
<th>No. 8 Regular</th>
<th>No. 9 Vacuum</th>
<th>No. 9 Regular</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 top</td>
<td>24.12</td>
<td>19.92</td>
<td>21.10</td>
<td>19.17</td>
<td>32.16</td>
<td>29.52</td>
<td>20.41</td>
<td>16.89</td>
<td>26.00</td>
<td>25.60</td>
</tr>
<tr>
<td>2 &quot;</td>
<td>23.04</td>
<td>20.37</td>
<td>20.48</td>
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<td>20.21</td>
<td>17.02</td>
<td>26.92</td>
<td>26.00</td>
</tr>
<tr>
<td>3 &quot;</td>
<td>22.33</td>
<td>20.60</td>
<td>20.10</td>
<td>19.50</td>
<td>31.26</td>
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<td>19.22</td>
<td>17.39</td>
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<td>18.60</td>
<td>17.78</td>
<td>25.19</td>
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</tr>
<tr>
<td>5 &quot;</td>
<td>21.26</td>
<td>20.42</td>
<td>19.00</td>
<td>19.90</td>
<td>30.40</td>
<td>30.66</td>
<td>17.57</td>
<td>17.56</td>
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<td>8 bottom</td>
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<td>17.30</td>
<td>25.21</td>
<td>25.64</td>
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</tbody>
</table>


The values in the above table will be found in the form of curves under the headings of block numbers 1, 6, 7, 8 and 9.
DISCUSSION OF RESULTS OF PLOT II.

The same general characteristics as found in Plot I. are also observed in this plot, i.e., the lower layers of the vacuum treated block are more dense than the lower layers of the regular block and likewise the top layers are more porous than the top layers of the regular block.

Two of these mixes, 100% Progress Press Brick Surface Clay and 75% Forbes Flint + 25% Evans and Howard Fire Clay showed much higher porosities throughout the block than the other mixes, as would be expected, these mixes show very little change in porosity with vacuum treatment.

The porosity curves of these two mixes when formed in the regular manner at 2000 pounds per square inch pressure were almost straight flat lines showing that the pressure was transmitted uniformly throughout the block.

The average apparent porosities of the vacuum treated block are in general slightly higher than the average porosities of the regular block. The blocks formed from the A. P. Green Clay mix diverged very slightly from the general rule although the variation was well within the possible limits of error.
MISSOURI SCHOOL OF MINES
DEPARTMENT OF METALLURGY AND ORE DRESSING
PLOT NO. 2
THE EFFECT OF OCCULDED AIR IN DRY PRESS MIXES WITH VARIOUS TYPES OF CLAYS

A.F. GREEN CLAY MIX
Block No. 6
Avg. Firing Crease at 2500 lb. per sq. in.
Moisture Content of Mix = 17.5%
Vacuum At Beginning of Compression = 27.00 in. Hg
Vacuum At End of Compression = 22.85 in. Hg
Dry Pass 8 Mesh.

PER CENT APPARENT POROSITY

<p>| | | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<td>20</td>
<td>19</td>
<td>18</td>
<td>17</td>
<td>16</td>
</tr>
</tbody>
</table>

Average Porosity
Vacuum Treated = 18.51%
Regular = 12.34%

LEADING (Vertical Variation)

PROGRESS PRESS BRICK CLAY
Block No. 9
Avg. Firing Crease at 2500 lb. per sq. in.
Moisture Content of Mix = 17.5%
Dry Pass 8 Mesh.

PER CENT APPARENT POROSITY

<p>| | | | | | | | | |</p>
<table>
<thead>
<tr>
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<td>20</td>
<td>19</td>
<td>18</td>
<td>17</td>
<td>16</td>
</tr>
</tbody>
</table>

Average Porosity
Vacuum Treated = 30.17%
Regular = 30.15%

LEADING (Vertical Variation)
THE EFFECT OF OCCLUDED AIR IN DRY PRESS MIXES WITH VARIOUS TYPES OF CLAYS

**PROGRESS PRESS BRICK CLAY AND HYDRAULIC PRESS BRICK CLAY**

- **Block No. 6**
  - 1/7 Progress Press Brick Surface Clay
  - 6/7 Hydraulic Press Brick Clay

- **Vacuum**
  - At Beginning of Compression: 28.5 in. Hg
  - At End of Compression: 14.0 in. Hg

- **Forming Pressure**: 2000 lb. per sq. in.

- **Time of Pressure Application**: 2 seconds

- **Moisture Content of Mix**: 7%

- Dry Panned thru 10 mesh

---

**AVG. Porosity**

- Vacuum Treated: 16.14%
- Regular: 17.09%

---

**FOREST PINE AND EVANS & HOWARD FIRE CLAY**

- **Block No. 9**
  - 75% Forest Pine
  - 25% Evans & Howard Fire Clay

- **Vacuum**
  - At Beginning of Compression: 25.75 in. Hg
  - At End of Compression: 22.25 in. Hg

- **Forming Pressure**: 2000 lb. per sq. in.

- **Time of Pressure Application**: 2 seconds

- **Moisture Content of Mix**: 7%

- Dry Panned thru 8 mesh

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**AVG. Porosity**

- Vacuum Treated: 26.09%
- Regular: 25.97%
TABLE III

The Effect of Ooccluded Air in a Dry Press Mix Formed at Various Pressures.

Mix: 92% LaClede Christy Fire Clay 8% LaClede Christy Grog.

The above mix was dry panned and screened through 8 mesh. It was prepared and formed as given under the general heading of procedure. The blocks were formed at pressures of 500, 1000, 2000, 3000, and 4000 pounds per square inch.

<table>
<thead>
<tr>
<th>Layer</th>
<th>500#/sq.in.</th>
<th>1000#/sq.in.</th>
<th>2000#/sq.in.</th>
<th>3000#/sq.in.</th>
<th>4000#/sq.in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25.80</td>
<td>22.99</td>
<td>24.12</td>
<td>19.92</td>
<td>18.85</td>
</tr>
<tr>
<td>2</td>
<td>25.30</td>
<td>23.10</td>
<td>23.04</td>
<td>19.54</td>
<td>19.10</td>
</tr>
<tr>
<td>3</td>
<td>24.82</td>
<td>23.42</td>
<td>Data disc-</td>
<td>22.33</td>
<td>20.60</td>
</tr>
<tr>
<td>4</td>
<td>24.60</td>
<td>23.48</td>
<td>Data disc-</td>
<td>22.02</td>
<td>20.21</td>
</tr>
<tr>
<td>5</td>
<td>23.67</td>
<td>23.21</td>
<td>Data disc-</td>
<td>21.26</td>
<td>20.42</td>
</tr>
<tr>
<td>6</td>
<td>23.41</td>
<td>23.20</td>
<td>Data disc-</td>
<td>20.40</td>
<td>20.19</td>
</tr>
<tr>
<td>7</td>
<td>22.14</td>
<td>22.40</td>
<td>Data disc-</td>
<td>19.92</td>
<td>20.04</td>
</tr>
<tr>
<td>8</td>
<td>22.58</td>
<td>22.18</td>
<td>Data disc-</td>
<td>19.54</td>
<td>19.60</td>
</tr>
<tr>
<td>Ave-</td>
<td>24.19</td>
<td>23.00</td>
<td>21.58</td>
<td>20.19</td>
<td>18.42</td>
</tr>
</tbody>
</table>

Block #10 Block #11 Block #1 Block #12 Block #13
DISCUSSION OF RESULTS AND DATA OF STUDY #3.

At a pressure of 500# per square inch there was a marked difference between the vacuum treated block and the regular block. The apparent porosity of each layer in the vacuum treated block was greater than the apparent porosity of each corresponding layer in the regular block. It is therefore seen that when forming clay blocks at 500# per square inch pressure the evacuation of the occluded air increases the porosity. The average increase in porosity of the entire block in this investigation was 1.19%.

The writer is of the opinion that this increase in porosity is due to the formation of air channels through the block as the air is being removed which are not completely closed at a pressure of 500# per square inch as the pressure increases the closing of these channels progress upward from the bottom of the block. This theory seems to be supported by the data in this study.

At 3000 and 4000 pounds per square inch pressure there is practically no difference in the average apparent porosities of the vacuum treated block and the block formed in the regular manner.
The corresponding individual layers show only very slight variation.

The porosity varies inversely with the pressure.

It however is not a straight line variation but the porosity decreases less rapidly as the pressure becomes greater.
CONCLUSIONS

Although there are no very marked differences existing between the properties of the block formed from dry press mixes milled by dry pan, wet pan, rolls, or disintegrator, the block formed from the mix which had been milled by rolls set at 3/32 inch and screened through 8 mesh was more dense both when formed in the regular manner and under vacuum treatment.

A block formed under vacuum treatment at 2000 pounds per square inch has a slightly greater porosity and is less uniform than a block of the same mix formed in the regular manner at the same pressure.

Very fine clays or clay mixes containing a large percentage of flint clay or grog, remain porous and are affected only very slightly by vacuum treatment.

At a pressure of 500 pounds per square inch there is a distinct increase in the porosity through-out the block, when formed under vacuum treatment. At pressures of 3000 and 4000 pounds per square inch there is no marked difference in the porosities of block formed under vacuum treatment and those formed in the regular manner.

In general it may be said that this investigation shows that for forming pressures from 500 to 2000 pounds
per square inch the removal of occluded air by vacuum treatment increases the porosity.

Attention is called to the fact that the above conclusions have been based on a limited amount of data, but it seems to be in agreement with some of the findings of recent investigators.
RECOMMENDATIONS

The above investigations were made only on green ware, it is therefore suggested that a similar investigation of the physical properties of the fired block be made, especially since it is the finished product in which we are most interested.

Further investigation of the effect of entrapped air at various pressures is suggested. The data presented in this report on this phase is very limited but several interesting facts are indicated which would make further research work on this problem interesting and valuable.

An investigation of the commercial aspects of evacuation is not warranted by the results of this Study.
ACKNOWLEDGMENT

This work has been done in connection with the research investigations of the committee on dry Press Process of the National Brick Manufacturers Association which has been carried on during the past year at the Missouri School of Mines and Metallurgy at Rolla, Missouri. The investigation has been made possible only through the support and cooperation of the committee and the School.

The writer therefore wishes to take this opportunity to thank the members of the committee and the School of Mines for their kind support and cooperation and to personally thank Professor C.M. Dodd for his generous aid and cooperation in making this investigation and report possible.