A STUDY OF COMMERCIAL

AND

LABORATORY FIRING

by

H. N. Troy

Thesis submitted to the Graduate Faculty of the

Virginia Polytechnic Institute

in candidacy for the degree of

MASTER OF SCIENCE

in

Ceramic Engineering

APPROVED:	APPROVED:
Director of Graduate Studies	Head of Department
Dean of Engineering	Supervisor

1951

Blacksburg, Virginia

TABLE OF CONTENTS

ACKNOWLEDGMENTS

The investigation reported herein is the result of a joint program between the Department of Ceramic Engineering, under the V.P.I. Research Foundation, Inc., Blacksburg, Virginia, and the Edward Orton, Jr. Ceramic Foundation, Columbus, Ohio. The principal portion of the cost of the project was financed by the Edward Orton, Jr. Ceramic Foundation.

The author wishes to express his sincere appreciation to Dean J. W. Whittemore and Prof. P. S. Dear of the Ceramic Engineering Department of the Virginia Polytechnic Institute for their guidance and assistance during the progress of this investigation.

The cooperation of the West Virginia Brick And Tile Company, Charleston, West Virginia; of the Salem Brick Company, Salem, Virginia; of the Roanoke-Webster Brick Company, Roanoke, Virginia; and of the Daniels Brick Company, Richmond, Virginia was very helpful in this investigation and was appreciated by the author.

I. INTRODUCTION

For a long time many people of the structural clay products industry have debated the values of laboratory investigation of clays and shales for use in industry. There are those who ignore or reject these results as useless. Few, however, have tried either to justify or to disprove the use of the laboratory by planned experimentation with clays and shales.

The principal objection advanced by opponents of laboratory tests is that there is no correlation between laboratory results and the results obtained from commercial products made from the same clay or shale on a plant-scale basis. The objection arises from the many existing differences between treatments of the raw materials in the laboratory as compared with the treatments received in the commercial plant.

Principal differences in the results are caused by differences in grinding, tempering and pugging, methods of forming, and the methods of firing.

Differences in grinding may be due to the machinery used or the length of grinding or both. Grinding could be controlled easily by allowing the plant to do all the grinding of the material to be tested in the laboratory. Thus, the particle size effect could be eliminated largely as a factor influencing the results.

Tempering and pugging play an important role in influencing the results, for these two processes are a means of mixing the particles of the material and the water. More uniform mixing and larger amounts of water are usually required in laboratory work.

The formation of samples in the laboratory does not impart the same intimacy of the particles as the methods of formation in the plant, for the pressure are lower in the machines usually used in the laboratory than in the machines used in the plant processes.

Firing is perhaps the main factor influencing the results. It is a complex factor of three main components; namely, temperature, length of firing, and kiln atmospheres.

Temperatures can be measured by pyrometric means. Temperatures readings may be duplicated and from these readings a person can tell when the temperatures have been duplicated.

Temperature and length of firing combined are the principal factors in the heat treatment of the ware fired in a kiln. Heat treatments in industrial plants are affected by the great length of firing since most of the plants are firing schedules for periods of a day in the case of tunnel kilns to a week or more in periodic kilns. In laboratories, firings seldom last over 14 to 15 hours, but by the use of pyrometric cones, heat treatments can be more nearly duplicated regardless of time.

The variations of fuel and atmospheres in the kilns cause differences in the results obtained by the two means of firings.

There has been some thought that a correlation could be obtained between the laboratory and commercial firing of products made form the same clays, especially in the structural clay products industry. With the above mentioned factors in mind a study seemed justified.

Four plants were chosen in this study so as to have different clays and different means of firing represented. The materials were (1) a coal-measure clay, from the West Virginia Brick and Tile Company, Charleston, West Virginia; (2) a disintegated shale, from the Salem Brick Company, Salem, Virginia; (3) a shale, from the Roanoke-Webster Brick Company, Roanoke, Virginia; (4) a sandy clay, from the Daniels Brick Company, Richmond, Virginia.

II. REVIEW OF LITERATURE

Little has been done or published on the relation between the physical and pyro-chemical tests made on clays in the laboratory and the same properties determined on structural clay products made from the clays in commercial plants.

W. H. Vaughn[1] made tests at the Ceramic Laboratory of the Georgia School of Technology and at the Daisy, Tennessee plant of the B. Mifflin Hood Company in 1931 and reported factors which would relate the physical properties of samples fired in the laboratory to the properties of the commercial products. Vaughn pointed out that there was one factor for each property measured. The factors apply only to the particular clay and plant and can not be used for other clays and plants.

Since Vaughn's work there seemingly has been no further work attempted or at least notreported in the literature.

---

1 Geological Survey of Georgia, Bul.45, "Shales and Brick Clays of Georgia", Smith, Richard W., Stein Printing Co., Atlanta, Ga., pp 25-27.

III. EXPERIMENTAL PROCEDURE

A. Materials

Thirty plastic bricks were taken from the off-bearing belt in each of the commercial plants. Fifteen of these bricks were marked, cried, and fired at the plant. The remaining fifteen bricks were taken to the laboratory. The bricks representing four different materials: (1) a coal-measure clay, from the West Virginia Brick and Tile Company, Charleston, West Virginia; (2) a disintegrated shale, from the Salem Brick Company, Salem, Vriginia; (3) a shale, from the Roanoke-Webster Brick Company, Roanoke, Virginia; and (4) a sandy clay, from the Daniels Brick Company, Richmond, Virginia.

B. Forming

Part of the plastic bricks from each plant were broken by hand, tempered, and pugged in a Lancaster mixer. Twenty-four samples, approximately 4"x1"x1", and twenty-four samples, approximately 1"x1"x1", were formed from each material by hydraulic extrusion.

The remaining bricks were dried and from these bricks were cut twenty-four samples, approximately 4"x1"x1", and twenty-four samples, approximately 1"x1"x1", representing the disintegrated shale and the coal-measure clay. Only eighteen samples of each size were obtained from the sandy clay for there were not enough bricks left after the hydraulically extruded samples were formed to obtain twenty-four samples. It was impossible to obtain samples from the shale for the particles in the bricks were too large to allow cutting.

The samples of each material were divided equally. One half was returned to the plants to be fired. The remaining half was retained for laboratory firings. At the plants, the samples and bricks were divided into three groups. One group was placed in the bottom of the kilns, another in the middle and the third in the top. Along with each group there was a cone plaque so that the heat treatment could be measured. In the case of tunnel kilns the groups were set in the bottom, middle and top of the kiln car.

After the samples and bricks had been fired in the plant kilns, the remaining samples of each material were divided into three groups and these groups fired separately to the same cones as the groups in the commercial kilns.

D. Testing

All samples and bricks from each material were tested in accordance with A.S.T.M. procedures[2] for firing shrinkages (except the bricks), cold water absorption, boiling water absorption, compressive strength and suction rate. The only change that was made was in the calculation of the compressive strengths of the bricks that had holes in them. The net area was used in place of the gross area so that the comparison with the small samples would be more nearly correct.

---

2 A.S.T.M. Designation: C67-44, A.S.T.M. STANDARDS, Part II, Nonmetallic Materials, Constructional, pp. 183-190, Amer. Soc. Test. Mat., Phila., Pa., 1946.

IV. EXPERIMENTAL DATA

A. Data on the West Virginia Brick and Tile Company Material

TABLE 1

Specimens Formed in the Laboratory by Hydraulic Extrusion and Fired at the Plant

Sample	Heat Treatment	Wt. Fired (gms.)	Wt. After 24 hr. Soak (gms.)	Wt. After 5 hr. Boil (gms.)
1	Cone 3	41.30	43.50	44.18
2	↓	40.09	42.27	42.88
3	↓	40.20	42.39	42.93
4	↓	38.96	41.12	41.65
5	Cone 5	36.86	38.78	39.24
6	at 2 o'clock	39.17	41.25	41.92
7	↓	36.54	38.45	38.96
8	↓	43.07	45.38	45.92
9	Cone 5	36.61	38.37	38.94
10	↓	41.65	43.67	44.30
11	↓	42.32	44.40	44.97
12	↓	38.59	40.47	40.98

TABLE 1 (Cont.)

Sample	Vol. Dry (cc)	Vol. Fired (cc)	Cross-Sect. Area (in^2)	Load (lbs)
1	22.1	19.4	1.16	8,850
2	21.4	18.9	↓	12,250
3	21.4	18.9		11,125
4	20.9	18.3		11,100
5	21.0	17.2		10,675
6	19.9	18.4		9,650
7	19.6	17.1		12,500
8	22.3	18.3		11,250
9	19.9	17.1		12,350
10	22.4	19.4		9,850
11	22.8	19.8		11,675
12	21.0	17.8	↓	15,200

TABLE 2

Specimens Cut From Plant Formed Dried Brick

and Fired at the Plant

Sample	Heat Treatment	Wt. Fired (gms.)	Wt. After 24 hr. Soak (gms.)	Wt. After 5 hr. Boil (gms.)
11	Cone 3	51.09	53.76	54.30
21	↓	44.28	46.59	47.14
31	↓	42.32	44.63	45.00
41	↓	34.97	36.93	37.18
51	Cone 5	35.41	37.21	37.56
61	at 2 o'clock	38.48	40.49	40.81
71	↓	47.31	49.69	50.11
81	↓	42.69	44.71	45.16
91	Cone 5	34.60	36.21	36.52
101	↓	37.50	39.17	39.52
111	↓	39.53	41.27	41.71
121	↓	43.15	45.06	45.49

TABLE 2 (Cont.)

Sample	Vol. Dry (cc)	Vol. Fired (cc)	Cross-Sect. Area (in^2)	Load (lbs.)
11	26.4	23.4	0.79	4,225
21	22.9	20.2	0.86	4,175
31	21.8	19.4	0.92	7,125
41	18.0	16.1	1.10	10,400
51	18.3	16.1	1.06	10,525
61	19.8	17.5	0.88	5,300
71	24.4	21.6	0.94	6,450
81	22.2	19.5	0.91	10,250
91	18.0	15.7	1.02	6,450
101	19.6	17.0	0.94	7,750
111	20.6	17.9	0.98	11,675
121	22.4	19.6	1.07	8,175

TABLE 3

Specimens Formed in the Laboratory by Hydraulic Extrusion and Fired in the Laboratory

Sample	Heat Treatment	Wt. Fired (gms.)	Wt. After 24 hr. Soak (gms.)	Wt. After 5 hr. Boil (gms.)
1	Cone 3	40.00	42.69	43.39
2	↓	41.19	43.90	44.65
3	↓	41.22	44.18	44.90
4	↓	43.47	47.18	47.96
5	Cone 5	39.38	41.74	42.50
6	at 2 o'clock	37.57	39.90	46.65
7	↓	39.04	41.51	42.24
8	↓	39.82	42.66	43.49
9	Cone 5	42.83	45.25	46.01
10	↓	35.76	37.86	38.50
11	↓	40.42	43.04	43.77
12	↓	43.16	46.03	46.81

TABLE 3 (Cont.)

Sample	Vol. Dry (cc)	Vol. Fired (cc)	Cross-Sect. Area (in^2)	Load (lbs.)
1	24.2	19.7	1.17	12,400
2	24.9	20.3	│	15,175
3	24.7	20.2	│	13,350
4	24.5	20.0	│	8,250
5	24.5	20.0	│	9,100
6	24.1	19.8	│	14,750
7	24.0	19.8	│	15,475
8	24.4	20.3	│	13,675
9	23.5	19.6	│	11,350
10	22.5	18.4	│	15,075
11	23.6	19.2	│	15,000
12	25.0	20.3	↓	14,700

TABLE 4

Specimens Cut From Plant Formed Dried Brick

and Fired in the Laboratory

Sample	Heat Treatment	Wt. Fired (gms.)	Wt. After 24 hr. Soak (gms.)	Wt. After 5 hr. Boil (gms.)
11	Cone 3	43.00	45.82	46.35
21	↓	41.39	44.19	44.61
31	↓	45.94	49.19	49.61
41	↓	43.02	46.67	47.05
51	Cone 5	45.90	48.58	49.14
61	at 2 o'clock	43.18	45.67	46.20
71	↓	43.00	45.68	46.12
81	↓	48.51	51.79	52.33
91	Cone 5	39.37	41.43	41.93
101	↓	46.30	48.89	49.46
111	↓	42.32	44.73	45.22
121	↓	46.04	48.96	49.41

TABLE 4 (Cont.)

Sample	Vol. Dry (cc)	Vol. Fired (cc)	Cross-Sect. Area (in^2)	Load (lbs.)
11	22.3	19.8	0.72	6,650
21	21.3	18.9	0.68	5,900
31	23.8	21.1	0.73	8,125
41	22.3	20.3	0.73	3,725
51	23.6	21.0	0.74	5,675
61	22.4	19.8	0.72	6,975
71	22.1	19.8	0.67	5,350
81	25.1	22.6	0.82	7,275
91	20.4	17.9	0.64	8,200
101	24.0	21.1	0.76	8,075
111	21.8	19.3	0.70	4,950
121	24.0	21.1	0.78	7,550

TABLE 5

Bricks Formed and Fired at the Plant

Half Brick	Heat Treatment	Wt. Fired (gms.)	Wt. After 24 hr. Soak (gms.)	Wt. After 5 hr. Boil (gms.)	Load (lbs.)	Mean Area (in^2)
1	Cone 3	819	856	867	181,800	10.2
2	↓	837	877	887	170,500	↓
3	↓	856	901	912	137,200	↓
4	↓	829	868	878	129,000	↓
5	Cone 5	872	911	923	154,500	↓
6	at 2 o'clock	845	882	892	154,500	↓
7	↓	863	902	912	130,800	↓
8	↓	868	911	923	170,500	↓
9	Cone 5	835	874	886	178,200	↓
10	↓	883	920	933	180,100	↓
11	↓	856	896	910	164,500	↓
12	↓	873	914	926	168,500	↓

TABLE 6

Bricks Formed and Fired at the Plant

Whole Brick	Heat Treatment	Wt. Fired (gms.)	Wt. Wet (gms.)	Mean Area (in^2)
1	Cone 3	1710	1714	20.4
2	↓	1726	1733	↓
3	↓	1713	1720	↓
4	↓	1712	1718	↓
5	Cone 5	1705	1710	↓
6	at 2 o'clock	1716	1720	↓
7	↓	1708	1712	↓
8	↓	1715	1721	↓
9	Cone 5	1702	1707	↓
10	↓	1726	1730	↓
11	↓	1684	1689	↓
12	↓	1708	1712	↓

TABLE 7

Specimens Formed in the Laboratory by Hydraulic Extrusion

and Fired in the Laboratory

Long Sample	Heat Treatment	Length (in.)	Width (in.)	Wt. Fired (gms.)	Wt. Wet (gms.)
1	Cone 3	4.14	1.06	161	162
2	↓	4.18	↓	163	165
3	↓	4.17	↓	164	166
4	↓	4.19	↓	165	167
5	Cone 5	4.19	↓	163	165
6	at 2 o'clock	4.19	↓	163	164
7	↓	4.17	↓	163	165
8	↓	4.17	↓	163	164
9	Cone 5	4.15	↓	161	162
10	↓	4.15	↓	163	164
11	↓	4.15	↓	163	164
12	↓	4.21	↓	165	166

TABLE 8

Specimens Cut From Plant Formed Dried Brick

and Fired in the Laboratory

Long Sample	Heat Treatment	Length (in.)	Width (in.)	Wt. Fired (gms.)	Wt. Wet (gms.)
11	Cone 3	3.74	1.08	94	96
21	↓	3.82	1.20	103	106
31	↓	3.68	1.13	96	99
41	↓	3.80	1.12	93	96
51	Cone 5	3.86	1.08	98	100
61	at 2 o'clock	3.96	1.12	100	102
71	↓	3.54	1.07	89	91
81	↓	3.71	1.14	99	101
91	Cone 5	3.92	1.09	105	107
101	↓	3.67	1.10	91	93
111	↓	3.83	1.14	93	95
121	↓	3.52	1.07	86	88

TABLE 9

Specimens Formed in the Laboratory by Hydraulic Extrusion

and Fired at the Plant

Long Sample	Heat Treatment	Length (in.)	Width (in.)	Wt. Fired (gms.)	Wt. Wet (gms.)
1	Cone 3	4.25	1.06	166	167.0
2	↓	4.17	↓	161	162.0
3	↓	4.32	↓	166	168.0
4	↓	4.20	↓	163	164.0
5	Cone 5	4.19	↓	162	163.0
6	at 2 o'clock	4.19	↓	164	165.0
7	↓	4.19	↓	166	167.5
8	↓	4.19	↓	166	166.5
9	Cone 5	4.21	↓	169	169.5
10	↓	4.25	↓	168	168.5
11	↓	4.19	↓	163	164.0
12	↓	4.21	↓	165	165.5

TABLE 10

Specimens Cut From Plant Formed Dried Brick

and Fired at the Plant

Long Sample	Heat Treatment	Length (in.)	Width (in.)	Wt. Fired (gms.)	Wt. Wet (gms.)
1	Cone 3	3.84	1.14	95	96
2	↓	3.78	1.14	94	96
3	↓	3.53	1.18	99	101
4	↓	3.72	1.14	97	99
5	Cone 5	3.80	1.14	85	86
6	at 2 o'clock	3.82	1.06	86	87
7	↓	3.72	1.06	76	77
8	↓	3.78	1.12	99	101
9	Cone 5	3.70	1.06	81	83
10	↓	3.68	1.14	98	99
11	↓	3.88	1.16	96	98
12	↓	3.72	1.15	102	104

B. Data on Roanoke-Webster Brick Company Material

TABLE 11

Specimens Formed in the Laboratory by Hydraulic Extrusion and Fired at the Plant

Samples	Heat Treatment	Wt. Fired (gms.)	Wt. After 24 hr. Soak (gmas.)	Wt. After 5 hr. Boil (gms.)
1	Cone 06	32.86	35.41	35.88
2	at 3 o'clock	32.78	35.37	35.83
3	↓	33.05	35.54	36.00
4	↓	32.62	35.10	35.51
5	Cone 04	33.31	34.60	35.17
6	↓	30.81	32.18	32.68
7	↓	33.14	34.46	35.02
8	↓	32.51	33.93	34.35
9	Cone 02	32.55	33.90	34.49
10	↓	30.49	31.94	32.48
11	↓	32.72	34.12	34.81
12	↓	32.34	33.67	34.20

TABLE 11 (Cont.)

Sample	Vol. Dry (cc)	Vol. Fired (cc)	Cross-Sect. Area (in^2)	Load (lbs.)
1	19.9	15.7	1.18	7,300
2	19.8	15.4	↓	6,175
3	19.9	15.4	↓	7,250
4	19.7	15.2	↓	7,075
5	20.1	15.0	1.06	7,350
6	18.3	14.1	↓	5,800
7	20.1	15.1	↓	7,175
8	19.7	14.7	↓	6,000
9	19.6	15.5	1.03	4,825
10	18.3	14.6	↓	5,075
11	20.0	15.6	↓	4,850
12	19.6	15.2	↓	3,750

TABLE 12

Specimens Formed in the Laboratory by Hydraulic Extrusion

and Fired in the Laboratory

Sample	Heat Treatment	Wt. Fired (gms.)	Wt. After 24 hr. Soak (gms.)	Wt. After 5 hr. Boil (gms.)
1	Cone 06	32.57	38.62	49.19
2	at 3 o'clock	33.65	39.83	40.45
3	↓	33.41	39.75	40.31
4	↓	33.08	39.35	39.86
5	Cone 04	33.13	37.45	38.12
6	↓	32.70	37.12	37.73
7	↓	32.65	37.28	37.89
8	↓	33.43	38.43	39.04
9	Cone 02	31.96	34.68	35.35
10	↓	30.44	32.85	33.47
11	↓	31.67	34.09	34.73
12	↓	33.58	35.82	36.61

TABLE 12 (Cont.)

Sample	Vol. Dry (cc)	Vol. Fired (cc)	Cross-Sect. Area (in^2)	Load (lbs.)
1	19.7	18.3	1.17	4,325
2	20.3	19.1	↓	4,050
3	20.2	19.0	↓	4,275
4	20.0	18.6	↓	3,950
5	20.0	16.9	1.08	4,825
6	19.8	16.8	↓	4,575
7	19.8	16.8	↓	3,900
8	20.3	17.5	↓	3,900
9	19.6	15.2	1.04	4,325
10	18.4	14.0	↓	5,050
11	19.2	14.6	↓	4,625
12	20.3	15.3	↓	6,800

TABLE 13

Bricks Formed and Fired at the Plant

Half Brick	Heat Treatment	Wt. Fired (gms.)	Wt. After 24 hr. Soak (gms.)	Wt. After 5 hr. Boil (gms.)	Load (lbs.)	Mean Area (in^2)
1	Cone 06	819	856	867	174,000	13.66
2	at 3 o'clock	837	877	887	170,000	↓
3	↓	856	901	912	146,500	↓
4	↓	829	868	878	140,000	↓
5	Cone 04	872	911	923	127,600	↓
6	↓	845	882	892	Broken	↓
7	↓	863	902	912	115,000	↓
8	↓	868	911	923	118,600	↓
9	Cone 02	835	874	886	115,000	↓
10	↓	883	920	933	100,000	↓
11	↓	856	896	910	108,800	↓
12	↓	873	914	926	105,000	↓

TABLE 14

Bricks Formed and Fired at the Plant

Whole Brick	Heat Treatment	Wt. Fired (gms.)	Wt. Wet (gms.)	Mean Area (in^2)
1	Cone 06	2255	2289	27.32
2	at 3 o'clock	2175	2201	↓
3	↓	2231	2268	↓
4	↓	2250	2283	↓
5	Cone 04	Broken →	→	→
6	↓	2234	2258	↓
7	↓	2221	2242	↓
8	↓	2275	2304	↓
9	Cone 02	2236	2290	↓
10	↓	2204	2260	↓
11	↓	2220	2274	↓
12	↓	2229	2306	↓

TABLE 15

Specimens Formed in the Laboratory by Hydraulic Extrusion

and Fired in the Plant

Long Sample	Heat Treatment	Length (in.)	Width (in.)	Wt. Fired (gms.)	Wt. Wet (gms.)
1	Cone 06	3.86	0.98	129	134
2	at 3 o'clock	3.90	0.98	129	135
3	↓	3.86	0.98	129	136
4	↓	3.88	0.98	132	138
5	Cone 04	3.84	0.98	129	133
6	↓	3.86	0.99	132	136
7	↓	3.86	1.00	131	135
8	↓	3.88	1.00	132	136
9	Cone 02	3.86	1.01	131	136
10	↓	3.86	1.01	131	135
11	↓	3.86	0.99	131	134
12	↓	3.86	0.99	130	134

TABLE 16

Specimens Formed in the Laboratory by Hydraulic Extrusion and Fired in the Laboratory

Long Sample	Heat Treatment	Length (in.)	Width (in.)	Wt. Fired (gms.)	Wt. Wet (gms.)
1	Cone 06	4.12	1.04	133	140
2	at 3 o'clock	4.12	1.06	133	140
3	↓	4.12	1.04	134	141
4	↓	4.20	1.06	136	145
5	Cone 04	4.08	1.02	138	143
6	↓	4.08	1.06	142	149
7	↓	4.10	1.04	137	146
8	↓	3.99	1.02	130	137
9	Cone 02	3.78	0.98	128	131
10	↓	3.84	0.99	131	136
11	↓	3.84	0.98	130	133
12	↓	3.90	0.99	132	132

C. Data on Salem Brick Company Material

TABLE 17

Specimens Formed in the Laboratory by Hydraulic Extrusion and Fired at the Plant

Sample	Heat Treatment	Wt. Fired (gms.)	Wt. After 24 hr. Soak (gms.)	Wt. After 5 hr. Boil (gms.)
1	Cone 8	41.45	43.43	44.47
2	↓	41.28	43.39	44.44
3	↓	40.50	42.55	43.47
4	↓	40.55	42.68	43.67
5	↓	41.79	43.88	45.10
6	↓	41.14	44.37	45.40
7	↓	41.95	44.01	45.10
8	↓	42.74	44.65	45.72
9	↓	41.91	43.94	44.97
10	↓	43.03	45.07	46.10
11	↓	45.63	47.86	48.91
12	↓	39.47	41.40	42.28

TABLE 17 (Cont.)

Sample	Vol. Dry (cc)	Vol. Fired (cc)	Cross-Sect. Area (in^2)	Load (lbs.)
1	22.1	19.4	1.19	16,250
2	22.0	19.3	↓	12,150
3	21.5	19.1	↓	17,750
4	21.5	19.2	↓	17,400
5	22.3	19.9	↓	14,950
6	22.5	19.8	↓	15,450
7	22.3	19.8	↓	12,125
8	22.6	20.1	↓	13,675
9	22.2	19.5	↓	14,750
10	22.7	20.1	↓	12,525
11	24.1	21.2	↓	14,225
12	20.8	18.3	↓	11,325

TABLE 18

Specimens Cut From Plant Formed Dried Brick

and Fired at the Plant

Sample	Heat Treatment	Wt. Fired (gms.)	Wt. After 24 hr. Soak (gms.)	Wt. After 5 hr. Boil (gms.)
1	Cone 8	42.89	44.76	45.64
2	↓	51.89	54.59	55.61
3	↓	53.28	55.52	56.53
4	↓	48.31	50.95	52.00
5	↓	47.97	50.23	51.33
6	↓	41.02	43.13	43.86
7	↓	51.02	53.36	54.55
8	↓	48.77	49.53	51.95
9	↓	48.55	51.06	52.17
10	↓	40.95	42.97	43.86
11	↓	53.60	56.38	57.56
12	↓	49.24	51.80	52.76

TABLE 18 (Cont.)

Sample	Vol. Dry (cc)	Vol. Fired (cc)	Cross-Sect. Area (in^2)	Load (lbs.)
1	22.5	19.8	1.24	17,300
2	27.2	24.1	1.26	5,250
3	27.8	24.3	1.33	11,675
4	25.4	22.9	1.34	16,425
5	25.2	22.2	1.13	5,600
6	21.6	19.1	1.20	7,575
7	26.9	22.1	1.34	16,725
8	25.5	20.8	1.20	9,775
9	25.4	20.9	1.30	4,825
10	21.4	19.1	1.25	6,325
11	28.2	25.0	1.26	6,475
12	25.9	23.1	1.06	4,900

TABLE 19

Specimens Formed in the Laboratory by Hydraulic Extrusion and Fired in the Laboratory

Sample	Heat Treatment	Wt. Fired (gms.)	Wt. After 24 hr. Soak (gms.)	Wt. After 5 hr. Boil (gms.)
1	Cone 8	41.82	44.39	45.26
2	↓	43.65	46.37	47.31
3	↓	44.92	47.57	48.64
4	↓	42.61	45.15	46.11
5	↓	43.23	45.09	46.81
6	↓	44.37	46.92	47.94
7	↓	42.51	45.32	46.33
8	↓	44.85	47.92	48.91
9	↓	43.49	46.02	46.98
10	↓	43.14	45.80	46.78
11	↓	40.44	42.92	43.81
12	↓	42.32	45.19	46.03

TABLE 19 (Cont.)

Sample	Vol. Dry (cc)	Vol. Fired (cc)	Cross-Sect. Area (in^2)	Load (lbs.)
1	22.3	19.7	1.10	15,600
2	24.2	20.6	↓	15,575
3	23.9	21.0	↓	13,400
4	22.5	20.0	↓	16,025
5	23.0	20.2	↓	17,725
6	23.3	20.8	↓	15,725
7	22.5	20.1	↓	12,225
8	23.8	21.4	↓	14,400
9	23.1	20.2	↓	13,525
10	22.9	20.3	↓	11,900
11	21.3	18.8	↓	11,825
12	22.3	19.9	↓	11,675

TABLE 20

Specimens Cut From Plant Formed Dried Brick

and Fired in the Laboratory

Sample	Heat Treatment	Wt. Fired (gms.)	Wt. After 24 hr. Soak (gms.)	Wt. After 5 hr. Boil (gms.)
1	Cone 8	39.98	42.29	43.10
2	↓	50.29	53.51	54.47
3	↓	49.69	52.69	53.63
4	↓	49.92	52.92	53.78
5	↓	42.92	45.56	46.39
6	↓	44.28	47.24	48.00
7	↓	41.16	43.99	44.69
8	↓	46.21	48.88	50.25
9	↓	44.52	47.44	48.24
10	↓	45.69	48.74	49.47
11	↓	39.97	42.60	43.36
12	↓	44.78	47.95	48.73

TABLE 20 (Cont.)

Sample	Vol. Dry (cc)	Vol. Fired (cc)	Cross-Sect. Area (in^2)	Load (lbs.)
1	21.0	18.9	1.12	11,325
2	26.5	23.5	1.24	8,075
3	25.9	23.2	1.29	7,500
4	26.0	23.3	1.22	6,275
5	22.4	20.1	1.08	4,900
6	23.2	21.0	1.16	5,500
7	21.5	19.4	1.11	4,375
8	24.2	22.4	1.19	4,875
9	23.2	21.0	1.19	13,550
10	23.9	21.6	1.23	11,025
11	21.0	18.7	1.17	12,075
12	23.4	21.1	1.23	13,950

TABLE 21

Bricks Formed and Fired at the Plant

Half Brick	Heat Treatment	Wt. Fired (gms.)	Wt. After 24 hr. Soak (gms.)	Wt. After 5 hr. Boil (gms.)	Load (lbs.)	Mean Area (in^2)
1	Cone 8	1141	1184	1211	26,000	15.0
2	↓	1110	1164	1187	26,200	↓
3	↓	1145	1200	1226	26,600	↓
4	↓	1119	1178	1198	23,400	↓
5	↓	1120	1163	1190	23,400	↓
6	↓	1140	1184	1212	27,800	↓
7	↓	1146	1191	1216	29,800	↓
8	↓	1135	1182	1206	31,000	↓
9	↓	1183	1230	1257	30,000	↓
10	↓	1106	1158	1182	25,600	↓
11	↓	1121	1167	1196	27,000	↓
12	↓	1108	1156	1184	30,200	↓

TABLE 22

Bricks Formed and Fired at the Plant

Whole Brick	Heat Treatment	Wt. Fired (gms.)	Wt. Wet (gms.)	Mean Area (in^2)
1	Cone 8	2269	2296	30.0
2	↓	2289	2312	↓
3		2315	2338	
4		2265	2285	
5		2250	2263	
6		2285	2300	
7		2323	2337	
8		2311	2321	
9		2391	2408	
10		2303	2315	
11		2290	2308	
12		2285	2307	

TABLE 23

Specimens Formed in the Laboratory by Hydraulic Extrusion and Fired at the Plant

Long Sample	Heat Treatment	Length (in.)	Width (in.)	Wt. Fired (gms.)	Wt. Wet (gms.)
1	Cone 8	4.23	1.07	176	178
2	↓	4.23	1.11	176	178
3	↓	4.19	1.10	165	167
4	↓	4.27	1.11	175	178
5	↓	Broken →			
6	↓	4.19	1.09	165	167
7	↓	4.19	1.08	166	169
8	↓	4.19	1.09	168	171
9	↓	4.22	1.08	172	175
10	↓	4.18	1.09	165	167
11	↓	4.18	1.10	169	171
12	↓	4.20	1.10	168	170

TABLE 24

Specimens Cut From Plant Formed Dried Brick

and Fired at the Plant

Long Sample	Heat Treatment	Length (in.)	Width (in.)	Wt. Fired (gms.)	Wt. Wet (gms.)
1	Cone 8	3.63	1.16	133.5	139.0
2	↓	3.49	1.19	170.0	176.0
3	↓	3.50	1.13	136.0	141.5
4	↓	3.56	1.18	141.5	146.0
5	↓	3.57	1.12	135.5	139.0
6	↓	3.49	1.20	148.5	151.0
7	↓	3.52	1.05	134.0	136.5
8	↓	3.56	1.14	135.0	138.0
9	↓	3.56	1.15	130.5	134.0
10	↓	3.50	1.14	138.0	142.5
11	↓	3.46	1.16	132.5	136.5
12	↓	3.42	1.21	147.5	151.5

TABLE 25

Specimens Formed in the Laboratory by Hydraulic Extrusion and Fired in the Laboratory

Long Sample	Heat Treatment	Length (in.)	Width (in.)	Wt. Fired (gms.)	Wt. Wet (gms.)
1	Cone 8	4.24	1.07	168.0	171.5
2	↓	4.23	1.11	167.5	171.5
3	↓	4.19	1.10	169.0	174.5
4	↓	4.19	1.09	171.5	175.0
5	↓	4.21	1.09	171.5	173.0
6	↓	4.19	1.09	169.0	173.0
7	↓	4.19	1.08	168.5	173.0
8	↓	4.19	1.09	170.0	173.0
9	↓	4.22	1.08	171.0	173.5
10	↓	4.18	1.09	168.5	171.5
11	↓	4.18	1.10	168.0	171.5
12	↓	4.20	1.10	170.0	173.5

TABLE 26

Specimens Cut From Plant Formed Dried Brick

and Fired in the Laboratory

Long Sample	Heat Treatment	Length (in.)	Width (in.)	Wt. Fired (gms.)	Wt. Wet (gms.)
1	Cone 8	3.48	1.14	126.0	131.5
2	↓	3.48	1.25	158.5	164.0
3	↓	3.46	1.05	129.5	134.0
4	↓	3.44	1.11	117.5	123.5
5	↓	3.46	1.13	106.5	111.5
6	↓	3.58	1.06	125.0	131.0
7	↓	3.49	1.11	148.5	155.0
8	↓	3.52	1.16	158.0	165.0
9	↓	3.43	1.17	123.5	128.5
10	↓	3.54	1.22	150.5	156.0
11	↓	3.50	1.08	125.5	129.5
12	↓	3.49	1.17	133.5	139.0

D. Data on Daniels Brick Company Material

TABLE 27

Specimens Formed in the Laboratory by Hydraulic Extrusion and Fired at the Plant

Sample	Heat Treatment	Wt. Fired (gms.)	Wt. After 24 hr. Soak (gms.)	Wt. After 5 hr. Boil (gms.)
1	Cone 08	37.10	41.02	41.58
2	↓	37.74	41.74	42.34
3	↓	36.76	40.55	41.17
4	↓	37.12	40.56	41.06
5	↓	35.29	38.37	38.93
6	↓	31.73	34.75	35.19
7	Cone 06	39.02	41.55	42.11
8	↓	34.34	36.56	37.07
9	↓	33.24	35.79	35.85

TABLE 27 (Cont.)

Sample	Volume Dry (cc)	Volume Fired (cc)	Cross-Sect. Area (in^2)	Load (lbs.)
1	20.8	18.8	1.24	16,175
2	21.2	19.2	↓	13,075
3	20.6	18.5	↓	17,400
4	20.4	18.3	↓	17,175
5	20.7	18.6	↓	23,350
6	20.9	18.8	↓	20,275
7	20.6	17.8	↓	22,400
8	20.7	17.9	↓	23,425
9	20.5	17.8	↓	22,250

TABLE 28

Specimens Cut From Plant Formed Dried Brick

and Fired at the Plant

Sample	Heat Treatment	Wt. Fired (gms.)	Wt. After 24 hr. Soak (gms.)	Wt. After 5 hr. Boil (gms.)
1	Cone 08	33.31	36.67	37.25
2	↓	38.61	42.76	43.25
3	↓	31.97	42.53	43.00
4	↓	29.62	31.86	32.18
5	↓	38.27	35.60	36.02
6	↓	26.28	28.38	28.74
7	Cone 06	32.54	34.51	34.90
8	↓	30.52	32.39	32.73
9	↓	31.78	33.67	34.07

TABLE 28 (Cont.)

Sample	Volume Dry (cc)	Volume Fired (cc)	Cross-Sect. Area (in^2)	Load (lbs.)
1	18.1	16.8	0.78	5,480
2	21.2	19.4	0.81	11,290
3	18.1	16.3	0.67	4,560
4	16.1	14.4	0.74	16,260
5	20.9	18.9	0.98	5,150
6	14.6	12.6	0.84	10,420
7	18.1	15.4	1.01	13,720
8	16.9	14.4	1.03	13,390
9	17.5	15.0	0.82	11,710

TABLE 29

Specimens Formed in the Laboratory by Hydraulic Extrusion and Fired in the Laboratory

Sample	Heat Treatment	Wt. Fired (gms.)	Wt. After 24 hr. Soak (gms.)	Wt. After 5 hr. Boil (gms.)
1	Cone 08	35.47	41.84	42.20
2		37.34	44.28	44.75
3		38.81	45.80	46.12
4		38.90	46.21	46.76
5		36.71	43.30	43.70
6		36.73	43.35	43.71
7	Cone 06	37.51	44.02	44.44
8		37.05	43.65	44.06
9		32.21	38.29	38.65

TABLE 29 (Cont.)

Sample	Volume Dry (cc)	Volume Fired (cc)	Cross-Sect. Area (in^2)	Load (lbs.)
1	20.7	19.8	1.25	7,600
2	20.6	21.0	↓	5,825
3	21.0	21.8	↓	6,575
4	21.6	22.6	1.23	4,750
5	21.9	23.7	↓	4,025
6	21.5	22.0	↓	5,250
7	20.5	21.3	1.21	5,525
8	20.8	21.7	↓	6,225
9	20.5	21.4	↓	4,350

TABLE 30

Specimens Cut From Plant Formed Dried Brick

and Fired in the Laboratory

Sample	Heat Treatment	Wt. Fired (gms.)	Wt. After 24 hr. Soak (gms.)	Wt. After 5 hr. Boil (gms.)
1	Cone 08	26.09	30.28	30.44
2	↓	20.32	23.70	24.53
3	↓	21.82	25.44	26.87
4	↓	25.47	29.87	31.05
5	↓	23.85	27.74	27.96
6	↓	22.51	26.20	26.38
7	Cone 06	19.80	23.08	23.25
8	↓	24.19	28.23	28.44
9	↓	20.28	23.71	23.89

TABLE 30 (Cont.)

Sample	Volume Dry (cc)	Volume Fired (cc)	Cross.-Sect. Area (in^2)	Load (lbs.)
1	14.1	14.1	0.71	2,875
2	11.1	11.0	0.77	3,075
3	12.0	12.0	0.76	4,150
4	14.1	14.1	0.86	3,150
5	13.0	14.8	0.70	1,850
6	12.3	12.6	0.77	3,500
7	10.8	11.0	0.58	1,800
8	13.3	13.5	0.71	3,600
9	11.2	11.8	0.61	2,500

TABLE 31

Bricks Formed and Fired at the Plant

Half Brick	Heat Treatment	Wt. Fired (gms.)	Wt. After 24 hr. Soak (gms.)	Wt. After 5 hr. Boil (gms.)	Load (lbs.)	Mean Area (in^2)
1	Cone 08	1191	1307	1328	179,500	15.05
2	↓	1154	1266	1285	163,500	↓
3		1121	1225	1246	191,500	
4		758	813	827	220,000	
5		987	1055	1072	231,500	
6		1042	1119	1138	229,500	
7	Cone 06	1143	1201	1224	259,000	
8	↓	1184	1243	1265	237,500	
9		1206	1267	1290	239,500	

TABLE 32

Bricks Formed and Fired at the Plant

Whole Brick	Heat Treatment	Wt. Fired (gms.)	Wt. Wet (gms.)	Mean Area (in^2)
1	Cone 08	2274	2302	30.1
2	↓	2318	2347	↓
3	↓	2343	2371	↓
4	↓	2362	2401	↓
5	↓	Broken	→	→
6	↓	2301	2319	↓
7	Cone 06	2330	2340	↓
8	↓	2337	2346	↓
9	↓	2327	2337	↓

TABLE 33

Specimens Formed in the Laboratory by Hydraulic Extrusion and Fired at the Plant

Long Sample	Heat Treatment	Length (in.)	Width (in.)	Wt. Fired (gms.)	Wt. Wet (gms.)
1	Cone 08	4.08	1.07	147	153
2	↓	4.05	1.07	146	152
3	↓	3.99	1.08	148	153
4	↓	4.11	1.08	158	160
5	↓	4.11	1.07	157	161
6	↓	4.02	1.05	146	149
7	Cone 06	4.06	1.05	154	157
8	↓	3.98	1.05	150	152
9	↓	4.02	1.06	152	154

TABLE 34

Specimens Cut From Plant Formed Dried Brick

and Fired at the Plant

Long Sample	Heat Treatment	Length (in.)	Width (in.)	Wt. Fired (gms.)	Wt. Wet (gms.)
1	Cone 08	3.86	1.00	140	144
2	↓	4.01	1.12	184	191
3	↓	4.07	1.04	149	154
4	↓	3.96	1.08	179	182
5	↓	3.88	1.12	145	148
6	↓	3.92	1.08	157	161
7	Cone 06	3.91	1.07	150	153
8	↓	3.92	1.04	182	183
9	↓	3.96	1.05	144	146

TABLE 35

Specimens Formed in the Laboratory by Hydraulic Extrusion

and Fired in the Laboratory

Long Sample	Heat Treatment	Length (in.)	Width (in.)	Wt. Fired (gms.)	Wt. Wet (gms.)
1	Cone 08	4.21	1.10	150.0	154.0
2	↓	4.24	1.08	149.0	153.0
3	↓	4.24	1.08	148.0	153.0
4	↓	4.26	1.10	149.5	153.0
5	↓	4.29	1.10	149.5	153.5
6	↓	4.27	1.10	147.5	151.5
7	Cone 06	4.26	1.10	148.0	151.0
8	↓	4.28	1.10	148.0	151.5
9	↓	4.23	1.10	149.0	152.5

TABLE 36

Specimens Cut From Plant Formed Dried Bricks

and Fired in the Laboratory

Long Sample	Heat Treatment	Length (in.)	Width (in.)	Wt. Fired (gms.)	Wt. Wet (gms.)
1	Cone 08	4.12	1.12	189.0	195.0
2	↓	4.08	0.94	141.0	146.0
3	↓	4.15	1.09	134.0	139.0
4	↓	4.08	1.06	134.5	138.0
5	↓	4.08	1.16	155.5	159.5
6	↓	3.99	1.19	149.0	154.0
7	Cone 06	4.03	1.15	144.0	148.5
8	↓	4.10	1.08	143.5	147.0
9	↓	4.15	1.09	157.0	161.0

V. RESULTS

A. Results on West Virginia Brick and Tile Company Material

TABLE 37

Specimens Formed in the Laboratory by Hydraulic Extrusion and Fired at the Plant

Sample	Heat Treatment	Vol. Shr. (%)	Absorption Cold Water (%)	Absorption Boiling Water (%)	Sat. Coef.	Comp. Str. (psi)	Suct. Rate (g/30 in^2/min)
1	Cone 3	12.2	5.2	7.0	0.74	7,650	6.7
2		11.7	5.4	7.0	0.77	10,780	6.7
3		11.7	5.4	6.8	0.79	9,600	13.1
Mean		12.0	5.4	6.9	0.78	9,350	8.3
5	Cone 5	18.1	5.2	6.6	0.79	9,200	6.8
6	at	7.5	5.3	7.0	0.76	8,320	6.8
7	2 o'clock	12.8	5.2	6.6	0.79	10,780	4.4
8		17.9	5.4	6.6	0.82	9,690	4.4
Mean		14.1	5.3	6.7	0.79	9,500	5.1
9	Cone 5	14.1	4.8	6.1	0.79	10,580	3.4
10		13.4	4.8	6.4	0.75	8,500	3.3
11		13.2	4.9	6.3	0.79	10,160	6.8
12		15.2	4.9	6.2	0.79	13,230	3.4
Mean		14.0	4.8	6.2	0.76	10,610	4.2

TABLE 38

Specimens Cut From Plant Formed Dried Brick

and Fired at the Plant

Sample	Heat Treatment	Vol. Shr. (%)	Absorption Cold Water (%)	Absorption Boiling Water (%)	Sat. Coef.	Comp. Str. (psi)	Suct. Rate (g/30 in²/min)
1	Cone 3	11.4	5.2	6.3	0.82	5,040	10.3
2		14.8	5.2	6.4	0.81	4,850	13.9
3		15.6	5.4	6.3	0.86	7,750	14.4
4		11.8	5.6	6.3	0.89	9,460	14.1
Mean		13.4	5.4	6.3	0.84	6,770	13.2
5	Cone 5	12.0	5.1	6.1	0.84	9,930	6.9
6	at	11.6	5.2	6.1	0.85	6,020	7.4
7	2 o'clock	11.5	5.0	5.9	0.86	6,750	7.6
8		12.2	4.7	5.8	0.81	12,130	14.2
Mean		11.8	5.0	6.0	0.84	8,710	9.0
9	Cone 5	12.8	4.6	5.5	0.84	6,230	15.3
10		13.3	4.4	5.4	0.81	8,240	7.1
11		13.1	4.4	5.5	0.80	11,920	13.3
12		12.5	4.4	5.4	0.81	7,640	14.0
Mean		12.9	4.4	5.4	0.82	8,510	12.4

TABLE 39

Specimens Formed in the Laboratory by Hydraulic Extrusion

and Fired in the Laboratory

Sample	Heat Treatment	Vol. Shr. (%)	Absorption Cold Water (%)	Absorption Boiling Water (%)	Sat. Coef.	Comp. Str. (psi)	Suct. Rate (g/30 in²/min)
1	Cone 3	12.6	6.7	8.5	0.79	10,600	6.8
2		13.2	6.6	8.4	0.79	12,970	13.5
3		11.8	7.2	8.9	0.81	11,410	13.6
4		10.7	8.5	10.3	0.82	7,050	13.5
Mean		12.1	7.2	9.0	0.82	10,510	11.8
5	Cone 5	14.6	6.0	7.9	0.76	7,780	13.5
6	at	13.4	6.2	8.2	0.76	12,600	6.8
7	2 o'clock	12.4	6.3	8.2	0.77	13,230	13.6
8		12.5	6.9	8.9	0.78	11,690	6.8
Mean		13.2	6.4	8.3	0.77	11,330	10.2
9	Cone 5	14.3	5.4	7.4	0.73	9,700	6.8
10		15.0	5.9	7.7	0.77	12,890	6.8
11		14.1	6.5	8.3	0.78	12,820	6.8
12		13.0	6.6	8.4	0.78	12,560	6.7
Mean		14.1	6.1	8.0	0.76	11,990	6.8

TABLE 40

Specimens Cut From Plant Formed Dried Brick

and Fired in the Laboratory

Sample	Heat Treatment	Vol. Shr. (%)	Absorption Cold Water (%)	Absorption Boiling Water (%)	Sat. Coef.	Comp. Str. (psi)	Suct. Rate (g/30 in²/min)
1	Cone 3	11.2	6.6	7.8	0.85	9,340	14.8
2	↓	11.3	6.8	7.8	0.87	8,750	19.6
3	↓	11.3	7.0	8.0	0.88	11,100	21.8
4	↓	9.0	8.2	9.4	0.87	5,100	21.1
Mean	↓	10.7	7.2	8.2	0.87	8,570	19.3
5	Cone 5	11.0	8.0	9.0	0.89	7,600	14.4
6	at	11.6	5.8	7.0	0.83	9,670	13.5
7	2 o'clock	10.4	6.2	7.2	0.86	8,040	14.2
8	↓	10.0	6.6	7.9	0.84	8,880	14.2
Mean	↓	10.8	6.6	7.8	0.86	8,550	14.1
9	Cone 5	12.2	5.2	6.5	0.80	12,710	14.1
10	↓	12.1	5.6	6.8	0.82	10,670	14.8
11	↓	11.5	5.4	6.8	0.79	7,050	13.7
12	↓	12.1	6.3	7.3	0.86	9,720	15.9
Mean	↓	12.0	5.6	6.8	0.82	10,040	14.6

TABLE 41

Brick Formed and Fired at the Plant

Brick	Heat Treatment	Absorption Cold Water (%)	Absorption Boiling Water (%)	Sat. Coef.	Comp. Str. (psi)	Suct. Rate (g/30 in²/min)
1	Cone 3	4.5	5.9	0.76	17,850	5.9
2	↓	4.8	6.0	0.80	16,680	10.3
3	↓	5.3	6.5	0.82	13,430	10.3
4	↓	4.7	5.9	0.80	12,610	8.8
Mean	↓	4.8	6.1	0.80	15,140	8.8
5	Cone 5	4.5	5.8	0.78	15,130	7.3
6	at	4.4	5.6	0.78	15,130	5.9
7	2 o'clock	4.5	5.7	0.79	12,800	5.9
8	↓	5.0	6.3	0.79	16,680	8.8
Mean	↓	4.6	5.8	0.78	14,940	7.0
9	Cone 5	4.7	6.1	0.77	17,460	7.3
10	↓	4.2	5.7	0.74	17,650	5.9
11	↓	4.7	6.3	0.75	16,100	7.3
12	↓	4.5	6.1	0.74	16,490	5.9
Mean	↓	4.5	6.1	0.75	16,930	6.6

TABLE 42

Means for Specimens From West Virginia Brick and Tile Company Material

Sample	Cone	Vol. Shr. (%)	Absorption: Cold Water (%)	Absorption: Boiling Water (%)	Sat. Coef.	Comp. Str. (psi)	Suct. Rate (g/30 in²/min)
Lab. Formed	3	12.0	5.4	6.9	0.78	9,350	8.3
Plant	5 at 2 o'clock	14.1	5.3	6.7	0.79	9,500	5.1
Fired	5	14.0	4.8	6.2	0.76	10,610	4.2
Lab. Formed	3	12.1	7.2	9.0	0.82	10,510	11.8
Laboratory	5 at 2 o'clock	13.2	6.4	8.3	0.77	11,330	10.2
Fired	5	14.1	6.1	8.0	0.76	11,990	6.8
Cut Samples	3	13.4	5.4	6.3	0.84	6,770	13.2
Plant	5 at 2 o'clock	11.8	5.0	6.0	0.84	8,710	9.0
Fired	5	12.9	4.4	5.4	0.82	8,510	12.4
Cut Samples	3	10.7	7.2	8.2	0.87	8,570	19.3
Laboratory	5 at 2 o'clock	10.8	6.6	7.8	0.86	8,550	14.1
Fired	5	12.0	5.6	6.8	0.82	10,040	14.6
Brick	3	no values	4.8	6.1	0.80	15,140	8.8
Plant	5 at 2 o'clock		4.6	5.8	0.78	14,940	7.0
Fired	5		4.5	6.1	0.75	16,930	6.6

B. Results on Salem Brick Company Material

TABLE 43

Specimens Formed in the Laboratory by Hydraulic Extrusion and Fired at the Plant

Sample	Heat Treat- ment	Vol. Shr. (%)	Absorption Cold Water (%)	Absorption Boiling Water (%)	Sat. Coef.	Comp. Str. (psi)	Suct. Rate (g/30in²/min)
1	Cone 8	12.1	4.8	7.3	0.66	13,650	13.2
2		12.3	5.1	7.6	0.67	10,210	12.8
3		11.2	5.1	7.6	0.67	14,920	13.0
4		10.7	5.7	7.7	0.74	14,620	19.0
Mean		11.6	5.2	7.6	0.68	13,350	14.5
5		10.8	5.0	7.9	0.63	12,560	Broken
6		12.0	5.2	7.7	0.68	12,980	13.2
7		11.2	4.9	7.5	0.65	10,190	19.9
8		11.1	4.5	7.0	0.64	11,490	19.7
Mean		11.3	4.9	7.5	0.65	11,800	17.6
9		12.2	4.8	7.3	0.66	12,390	19.7
10		11.4	4.7	7.1	0.66	10,520	13.2
11		12.0	4.9	7.2	0.68	11,950	13.1
12		12.0	5.0	7.1	0.70	9,520	13.0
Mean		11.9	4.8	7.2	0.68	11,100	14.8

TABLE 44

Specimens Formed in the Laboratory by Hydraulic Extrusion

and Fired in the Laboratory

Sample	Heat Treat-ment	Vol. Shr. (%)	Absorption Cold Water (%)	Absorption Boiling Water (%)	Sat. Coef.	Comp. Str. (psi)	Suct. Rate (g/30 in²/min)
1	Cone 8	11.6	6.1	8.3	0.73	12,890	23.1
2		14.9	6.2	8.4	0.74	12,780	25.5
3		12.1	5.9	8.3	0.71	11,070	22.8
4		11.1	6.0	8.2	0.73	13,240	26.2
Mean		12.4	6.1	8.3	0.73	12,500	24.4
5		12.2	4.3	8.3	0.52	14,650	22.9
6		10.7	5.7	8.0	0.71	13,000	26.2
7		10.7	6.6	9.0	0.73	10,100	29.9
8		10.1	6.8	9.1	0.75	11,900	19.7
Mean		10.9	5.8	8.6	0.68	12,400	24.7
9		12.6	5.8	8.0	0.73	11,200	16.4
10		11.4	6.2	8.2	0.76	9,800	19.7
11		11.7	3.7	8.3	0.44	9,770	22.8
12		10.8	6.5	8.8	0.74	9,650	22.7
Mean	↓	11.6	5.6	8.3	0.67	10,100	20.4

TABLE 45

Specimens Cut From Plant Formed Dried Bricks

and Fired at the Plant

Sample	Heat Treatment	Vol. Shr. (%)	Absorption Cold Water (%)	Absorption Boiling Water (%)	Sat. Coef.	Comp. Str. (psi)	Suct. Rate (g/30 in²/min)
1	Cone 8	12.0	4.4	6.4	0.69	13,950	39.2
2		11.4	7.1	9.1	0.78	4,170	43.4
3		12.6	4.2	6.1	0.69	8,780	41.7
4		9.8	5.5	7.6	0.71	12,260	32.1
Mean		11.4	5.3	7.3	0.72	9,790	39.1
5		11.9	4.7	7.0	0.67	4,960	26.2
6		11.6	5.1	6.8	0.75	6,310	17.9
7		17.8	4.6	6.9	0.67	12,480	20.3
8		18.4	4.6	6.5	0.69	8,140	22.2
Mean		14.9	4.8	6.8	0.69	7,970	21.6
9		17.7	5.2	7.4	0.70	3,720	25.7
10		10.7	4.9	7.1	0.69	5,060	33.8
11		11.3	5.2	7.4	0.70	5,140	29.9
12		10.8	5.2	7.2	0.72	4,620	29.0
Mean	↓	12.6	5.1	7.3	0.70	4,640	29.6

TABLE 46

Specimens Cut From Plant Formed Dried Bricks

and Fired in the Laboratory

Sample	Heat Treatment	Vol. Shr. (%)	Absorption Cold Water (%)	Absorption Boiling Water (%)	Sat. Coef.	Comp. Str. (psi)	Suct. Rate (g/30 in^2/min)
1	Cone 8	10.0	5.8	7.8	0.74	10,110	41.6
2	↓	11.3	6.4	8.3	0.77	6,510	37.9
3	↓	10.4	6.0	7.9	0.76	5,810	37.2
4	↓	10.4	6.0	7.7	0.78	5,140	47.1
Mean	↓	10.5	6.1	7.9	0.76	6,890	41.0
5	↓	10.3	6.2	8.1	0.76	4,540	38.4
6	↓	9.5	6.7	8.4	0.80	4,740	47.5
7	↓	9.8	6.9	8.6	0.80	3,940	50.4
8	↓	9.2	5.8	8.7	0.67	4,100	51.5
Mean	↓	9.7	6.4	8.4	0.76	4,330	47.0
9	↓	9.5	6.6	8.4	0.78	11,390	37.4
10	↓	9.6	6.7	8.3	0.81	8,960	38.2
11	↓	11.0	6.6	8.5	0.78	10,320	31.7
12	↓	9.8	7.1	8.8	0.81	11,340	40.4
Mean	↓	10.0	6.8	8.5	0.80	10,500	36.9

TABLE 47

Bricks Formed and Fired at the Plant

Brick	Heat Treat-ment	Absorption Cold Water (%)	Absorption Boiling Water (%)	Sat. Coef.	Comp. Str. (psi)	Suct. Rate (g/30 in²/min)
1	Cone 8	3.8	6.1	0.62	8,660	27
2		4.9	6.9	0.71	8,730	23
3		4.8	7.1	0.68	8,860	23
4		5.2	7.1	0.73	7,800	20
Mean		4.7	6.8	0.68	8,510	24
5		3.8	6.2	0.61	7,800	13
6		3.9	6.3	0.62	9,260	15
7		3.9	6.1	0.64	9,930	14
8		4.1	6.2	0.66	10,330	10
Mean		3.9	6.2	0.63	9,330	14
9		4.0	6.2	0.64	9,990	17
10		4.7	6.8	0.69	8,530	12
11		3.9	6.8	0.57	8,990	18
12		4.3	6.8	0.63	10,660	12
Mean	↓	4.2	6.6	0.63	9,540	14.8

TABLE 48

Means for the Results on the Salem Brick Company Material

Samples	Cone	Vol. Shr. (%)	Absorption Cold Water (%)	Absorption Boiling Water (%)	Sat. Coef.	Comp. Str. (psi)	Suct. Rate (g/30 in²/min)
Lab. Formed	8	11.6	5.2	7.6	0.68	13,350	14.5
Plant	↓	11.3	4.9	7.5	0.65	11,800	17.6
Fired		11.9	4.8	7.2	0.68	11,100	14.8
Lab. Formed	8	12.4	6.1	8.3	0.73	12,500	24.4
Laboratory	↓	10.9	5.8	8.6	0.68	12,400	24.7
Fired		11.6	5.6	8.3	0.67	10,100	20.4
Cut Samples	8	11.4	5.3	7.3	0.72	9,790	39.1
Plant	↓	14.9	4.8	6.8	0.69	7,970	21.6
Fired		12.6	5.1	7.3	0.70	4,640	29.6
Cut Samples	8	10.5	6.1	7.9	0.76	6,890	41.0
Laboratory	↓	9.7	6.4	8.4	0.76	4,330	47.0
Fired		10.0	6.8	8.5	0.80	10,500	36.9
Brick	8	no	4.7	6.8	0.68	8,510	24.0
Plant	↓	values	3.9	6.2	0.63	9,330	14.0
Fired			4.2	6.6	0.63	9,540	14.8

C. Results on Roanoke-Webster Brick Company Material

TABLE 49

Specimens Formed in the Laboratory by Hydraulic Extrusion

and Fired at the Plant

Sample	Heat Treatment	Vol. Shr. (%)	Absorption Cold Water (%)	Absorption Boiling Water (%)	Sat. Coef.	Comp. Str. (psi)	Suct. Rate (g/30 in²/min)
1	Cone 06	21.1	7.8	9.2	0.85	6,200	39.7
2	at	22.2	7.9	9.3	0.85	5,230	47.1
3	3 o'clock	22.6	7.5	8.9	0.84	6,150	55.6
4	↓	22.8	7.6	8.8	0.86	5,980	47.4
Mean	↓	22.2	7.7	9.1	0.85	5,890	47.4
5	Cone 04	25.4	3.9	5.9	0.66	6,930	32.0
6	↓	23.0	4.1	5.7	0.72	5,480	31.4
7	↓	24.9	4.0	5.7	0.70	6,780	31.1
8	↓	25.4	4.1	5.6	0.73	5,670	31.1
Mean	↓	24.7	4.0	5.7	0.70	6,210	31.4
9	Cone 02	20.9	4.1	6.0	0.68	4,770	38.2
10	↓	20.2	4.8	6.5	0.74	4,880	31.1
11	↓	22.0	4.3	6.4	0.67	4,690	23.6
12	↓	22.4	4.4	6.1	0.72	3,630	31.4
Mean	↓	21.4	4.4	6.3	0.70	4,490	31.1

TABLE 50

Specimens Formed in the Laboratory by Hydraulic Extrusion

and Fired in the Laboratory

Sample	Heat Treatment	Vol. Shr. (%)	Absorption Cold Water (%)	Absorption Boiling Water (%)	Sat. Coef.	Comp. Str. (psi)	Suct. Rate (g/30 in²/min)
1	Cone 06	7.1	18.6	20.3	0.92	3,670	49.2
2	at	5.9	15.4	20.2	0.76	3,460	48.2
3	3 o'clock	5.9	19.0	20.6	0.92	3,660	49.2
4	↓	7.0	15.9	20.5	0.78	3,380	47.7
Mean	↓	6.5	17.2	20.4	0.84	3,550	48.6
5	Cone 04	15.5	13.0	15.1	0.86	4,470	50.6
6	↓	10.1	14.1	15.4	0.92	4,240	48.7
7	↓	10.1	14.2	16.0	0.89	3,610	63.5
8	↓	13.8	15.0	16.7	0.90	3,610	51.5
Mean	↓	12.4	14.1	15.8	0.89	3,980	53.6
9	Cone 02	17.3	8.2	10.6	0.77	4,160	24.3
10	↓	23.9	7.9	10.0	0.79	4,860	39.5
11	↓	24.0	7.6	9.7	0.78	4,450	23.9
12	↓	24.6	6.7	9.0	0.74	6,540	31.1
Mean	↓	22.4	7.6	9.8	0.77	5,000	29.7

TABLE 51

Bricks Formed and Fired at the Plant

Brick	Heat Treat-ment	Absorption Cold Water (%)	Absorption Boiling Water (%)	Sat. Coef.	Comp. Str. (psi)	Suct. Rate (g/30 in²/min)
1	Cone 06	4.5	5.9	0.76	12,880	37.3
2	at	4.8	6.0	0.80	12,590	28.5
3	3 o'clock	5.2	6.5	0.80	10,830	40.6
4	↓	4.7	5.9	0.80	10,390	36.2
Mean	↓	4.8	6.1	0.79	11,680	35.6
5	Cone 04	4.5	5.8	0.76	9,520	26.4
6	↓	4.4	5.6	0.78	8,490	23.1
7	↓	4.5	5.7	0.79	Broken	→
8	↓	5.0	6.3	0.79	8,780	31.8
Mean	↓	4.6	5.8	0.78	8,930	27.1
9	Cone 02	4.5	6.1	0.74	8,490	59.3
10	↓	4.2	5.7	0.74	7,320	61.5
11	↓	4.7	6.3	0.75	8,050	48.3
12	↓	4.7	6.1	0.77	7,470	84.5
Mean	↓	4.5	6.1	0.75	7,830	63.4

TABLE 52

Mean Results on Roanoke-Webster Brick Company Material

Samples	Cone	Vol. Shr. (%)	Absorption Cold Water (%)	Absorption Boiling Water (%)	Sat. Coef.	Comp. Str. (psi)	Suct. Rate (g/30 in²/min)
Lab. Formed	06 at 3 o'clock	22.2	7.7	9.1	0.85	5,800	47.4
Plant	04	24.7	4.0	5.7	0.70	6,210	31.4
Fired	02	21.4	4.4	6.3	0.70	4,490	31.1
Lab. Formed	06 at 3 o'clock	6.5	17.2	20.4	0.84	3,550	48.6
Laboratory	04	12.4	14.1	15.8	0.89	3,980	53.6
Fired	02	22.4	7.6	9.8	0.77	5,000	29.7
Brick	06 at 3 o'clock	no	4.8	6.1	0.79	11,680	35.6
Plant	04	values	4.6	5.8	0.78	8,930	27.1
Fired	02		4.5	6.1	0.75	7,830	63.4

D. Results on Daniels Brick Company Material

TABLE 53

Specimens Formed in the Laboratory by Hydraulic Extrusion and Fired at the Plant

Sample	Heat Treatment	Vol. Shr. (%)	Absorption Cold Water (%)	Absorption Boiling Water (%)	Sat. Coef.	Comp. Str. (psi)	Suct. Rate (g/30 $in.^2$/min)
1	Cone 08	9.6	10.6	12.1	0.87	13,040	41.3
2	↓	9.4	10.6	12.2	0.87	10,550	41.5
3	↓	10.2	10.3	12.0	0.86	14,040	34.4
Mean	↓	9.7	10.5	12.1	0.87	12,540	39.1
4	Cone 08	10.4	9.3	10.6	0.88	13,840	13.6
5	↓	10.1	8.7	10.3	0.84	18,810	40.9
6	↓	9.8	9.5	10.9	0.87	16,350	21.3
Mean	↓	10.1	9.2	10.6	0.86	16,330	25.3
7	Cone 06	13.6	6.5	7.9	0.82	18,080	21.1
8	↓	13.5	6.5	7.9	0.82	18,920	14.4
9	↓	13.1	6.5	7.8	0.85	17,990	14.1
Mean	↓	13.4	6.5	7.9	0.83	18,330	16.5

TABLE 54

Specimens Formed in the Laboratory by Hydraulic Extrusion

and Fired in the Laboratory

Sample	Heat Treat-ment	Vol. Shr. (%)	Absorption Cold Water (%)	Absorption Boiling Water (%)	Sat. Coef.	Comp. Str. (psi)	Suct. Rate (g/30in^2/min)
1	Cone 08	4.3	18.0	19.0	0.95	6,080	25.9
2	↓	+1.9	18.6	19.8	0.94	4,660	26.2
3	↓	+3.8	18.0	18.8	0.96	5,260	32.8
Mean	↓	+0.5	18.2	19.2	0.95	5,330	28.3
4	Cone 08	+4.6	18.8	20.2	0.93	3,820	22.3
5	↓	+3.6	18.0	18.9	0.95	3,270	25.5
6	↓	+2.3	18.0	19.0	0.95	4,270	25.5
Mean	↓	+3.5	18.3	19.0	0.94	3,790	24.4
7	Cone 06	+3.9	17.4	18.5	0.94	4,570	19.1
8	↓	+4.3	17.8	18.9	0.94	5,140	22.3
9	↓	+4.4	18.9	19.7	0.96	3,600	22.3
Mean	↓	+4.2	18.0	19.0	0.95	4,440	21.2

TABLE 55

Specimens Cut From Plant Formed Dried Bricks

and Fired at the Plant

Sample	Heat Treatment	Vol. Shr. (%)	Absorption Cold Water (%)	Absorption Boiling Water (%)	Sat. Coef.	Comp. Str. (psi)	Suct. Rate (g/30in.²/min)
1	Cone 08	7.2	10.7	11.8	0.91	7,030	31.2
2	↓	8.5	10.7	12.0	0.89	13,940	46.9
3	↓	8.6	11.1	12.4	0.90	6,800	35.5
Mean	↓	8.1	10.8	12.1	0.90	9,260	37.9
4	Cone 08	10.6	7.6	8.3	0.92	21,980	21.0
5	↓	11.0	11.0	12.3	0.89	5,250	20.7
6	↓	13.7	8.0	9.4	0.85	12,400	28.4
Mean	↓	11.8	8.9	10.0	0.89	13,210	23.4
7	Cone 06	14.9	6.1	7.2	0.85	13,590	21.5
8	↓	14.8	5.8	6.9	0.84	13,000	7.4
9	↓	14.3	5.9	7.2	0.82	14,290	14.4
Mean	↓	14.7	5.9	7.1	0.84	13,620	14.4

TABLE 56

Specimens Cut From Plant Formed Bricks

and Fired in the Laboratory

Sample	Heat Treat-ment	Vol. Shr. (%)	Absorption Cold Water (%)	Absorption Boiling Water (%)	Sat. Coef.	Comp. Str. (psi)	Suct. Rate (g/30in²/min)
1	Cone 08	0.0	16.1	16.7	0.96	4,060	39.1
2	↓	0.9	16.6	20.6	0.81	4,000	39.3
3	↓	0.0	16.6	19.8	0.84	5,390	33.2
Mean	↓	0.3	16.4	19.0	0.87	4,480	37.2
4	Cone 08	0.0	17.3	21.9	0.79	3,660	22.1
5	↓	+1.4	16.3	17.2	0.96	2,640	26.1
6	↓	+2.5	16.4	17.2	0.95	4,540	31.9
Mean	↓	+1.3	16.7	18.8	0.90	3,610	26.7
7	Cone 06	+1.9	16.6	17.4	0.95	3,100	29.3
8	↓	+1.5	16.7	17.6	0.95	5,070	23.9
9	↓	+5.3	16.0	17.8	0.95	4,100	30.0
Mean	↓	+2.9	16.4	17.6	0.95	3,760	27.7

TABLE 57

Bricks Formed and Fired at the Plant

Brick	Heat Treatment	Absorption Cold Water (%)	Absorption Boiling Water (%)	Sat. Coef.	Comp. Str. (psi)	Suct. Rate (g/30in²/min)
1	Cone 08	9.7	11.5	0.85	11,960	27.9
2		9.7	10.5	0.92	10,890	38.9
3		9.3	11.2	0.83	12,760	27.9
Mean		9.6	10.7	0.87	11,870	31.6
4	Cone 08	7.3	9.1	0.80	14,680	38.9
5		7.4	9.2	0.80	15,420	Broken
6		6.9	8.6	0.80	15,280	17.9
Mean		7.2	9.0	0.80	15,120	28.4
7	Cone 06	5.1	7.1	0.72	17,280	10.0
8		5.1	7.1	0.72	15,810	10.0
9		5.0	6.8	0.74	15,950	9.0
Mean		5.1	7.0	0.73	16,340	9.7

TABLE 58

Mean Results on the Daniels Brick Company Material

Samples	Cone	Vol. Shr. (%)	Absorption Cold Water (%)	Absorption Boiling Water (%)	Sat. Coef.	Comp. Str. (psi)	Suct. Rate (g/30 in²/min)
Lab. Formed	08	9.7	10.5	12.1	0.87	12,540	39.1
Plant	08	10.1	9.2	10.6	0.86	16,330	25.3
Fired	06	13.4	6.5	7.9	0.83	18,330	16.5
Lab. Formed	08	+ 0.5	18.2	19.2	0.95	5,330	28.3
Laboratory	08	+ 3.5	18.3	19.4	0.94	3,790	24.4
Fired	06	+ 4.2	18.0	19.0	0.95	4,440	21.2
Cut Samples	08	8.1	10.8	12.1	0.90	9,260	37.9
Plant	08	11.8	8.9	10.0	0.89	13,210	23.4
Fired	06	14.7	5.7	7.1	0.84	13,620	14.4
Cut Samples	08	0.3	16.4	19.0	0.87	4,480	37.2
Laboratory	08	+ 1.3	16.7	18.8	0.90	3,610	26.7
Fired	06	+ 2.9	16.4	17.6	0.95	3,760	27.7
Bricks	08	no values	9.6	10.7	0.87	11,870	31.6
Plant	08		7.2	9.0	0.80	15,120	28.4
Fired	06		5.1	7.0	0.73	16,340	9.7

VI. DISCUSSION OF RESULTS

The methods of the investigation in this work were designed to learn of any correlation between the laboratory firing and commercial firing of the clays and shales of the type commonly used in the structural clay products industry. Control of all variables in such an investigation is extremely difficult. However, particle size, heat treatment, and uniformity of material were controlled as closely as possible.

The bricks that were formed, dried, and fired at the respective plants were representative of the commercial products from those plants. The samples formed in the laboratory by hydraulic-extrusion were typical of the usual laboratory specimens prepared for testing. The samples cut from the plant-formed dried bricks were used so that: (1) the structure imparted by plant formation methods would be retained, and (2) the samples would be approximately the size of the laboratory-formed samples.

By using Standard Orton pyrometric cones with the groups of samples and bricks as they were fired in the plant kilns, it was possible to measure the heat-treatment each group received. By firing the groups of samples in the laboratory with Standard Orton pyrometric cones as control measures, the heat-treatment of each group closely approximated the heat-treatment received by the corresponding group in the plant firing.

Material from the West Virginia Plant

Absorption: The absorption values of all the samples fired in the laboratory were higher than those of the samples or bricks fired in the commercial kiln. These absorption values, however, were close enough to those values of the bricksto allow a very good estimate of the absorption of the bricksto be made. The inequality of absorption was due to two factors. The difference in the size of the samples probably accounted for some of the difference in the absorption. The short firing schedule used in the laboratory as compared to the long firing schedule used in the commercial firing possibly affected the absorption even though the same end-points were obtained for the cones.

Shrinkage: The shrinkage of the laboratory-formed samples fired at the plant was practically the same as that of the same type of samples fired in the laboratory. The shrinkage of the samples cut from the bricks and fired in the laboratory was greater than that of similar samples fired in the commercial kiln.

Compressive Strength: The samples cut from the bricks, both plant-fired and laboratory-fired, had lower strengths than the samples formed by hydraulic-extrusion. All of the small samples had compressive strengths lower than those of the brick but the difference was only 6,000 psi. This could possibly be accounted for by the difference in the samples size.

Suction Rate: No attempt was made to compare the suction rate of the samples and bricks because the variation of the sample sizes and the outside texture of the specimens played too great a role in the results to allow a good comparsion.

Material from the Salem Plant

Absorption: The values of absorption for the samples differ only slightly as can be seen in Table 48. The samples fired at the plant have practically the same absorption regardless of the method of forming. The samples fired in the laboratory had practically the same absorption regardless of the method of forming. The absorption of the brick was lower than that of any of the samples. Some idea of the absorption of the brick could be obtained from the absorption of the hydraulic-extrusion samples which were fired in the laboratory.

Shrinkage: There was little difference in the shrinkage of the samples regardless of the method of forming when fired in the commercial kiln. There was only a slight difference between the two types of samples when fired in the laboratory. The samples cut from the dried bricks and fired in the laboratory had the least amount of shrinkage.

Compressive Strength: All of the samples with the exception of those cut from the bricks and fired in the laboratory had higher compressive strengths or compressive strengths nearly equal to those of the bricks. All of the samples formed by hydraulic-extrusion had higher compressive strengths than the other samples.

Material from the Roanoke-Webster Plant

Absorption: The values in Table 52 show that the samples fired in the laboratory are considerably higher in absorption than the plant-fired samples or brick. The absorption of the plant-fired samples was very nearly that of the bricks in the case of those fired to cones 04 and 02; however, in the case of those fired to cone 06 at 3 o'clock there is considerable difference in the absorption as compared to the bricks. The high values of absorption for the laboratory-fired samples might be attributed to the fact that it was not easy to interpret the end-point of cones used in the commercial firing due to the bloating and distortion of the cones. Thus, the heat-treatments could have been different.

Compressive Strength: None of the samples had compressive strengths that were comparable to the strength of the bricks. The samples fired in the commercial kiln had strengths much lower than those of the bricks and the samples fired in the laboratory had even lower values. The samples fired in the industrial kiln having lower strengths than the bricks indicates that the sample sizes could possibly have had more effect on the strength than was evident in the previous materials.

Material from the Daniels Plant

No correlation could be determined from the samples made from this material because, as can be seen from the values in Table 58, the laboratory firing probably never approached the heat-treatment received by the samples in the commercial firing. This was readily evident by the volume increases in the laboratory-fired samples rather than volume shrinkages. This again is probably due to not being able to properly interpret the cones used in the commercial firing, because these cones were also bloated and distorted.

Factors Pertaining to all Plants

The firing in the West Virginia plant was carried out in a round down-draft kiln fired with gas; that of the Salem plant in an oil-fired tunnel kiln. Roanoke-Webster firing was done in a round down-draft kiln fired with coal; that of the Daniels plant in a round down-draft kiln fired with coal. Laboratory firing was conducted in a Globar-type Electric kiln.

The atmospheres in the kilns differed and had effects on the specimens that could not be controlled. The sulphur gases in the coal-fired kilns greatly affected the deformation of the cones. If cones unaffected by the sulphur gases were used, the heat-treatments could probably be duplicated more nearly in the laboratory.

The values for the samples cut from the bricks showed that the method of forming had little effect on the correlation between laboratory-firing and plant-firing. This was evident by the agreement of the values from the laboratory-formed and cut samples from each material as long as they both were fired by the same means and had the same heat-treatment.

VII. CONCLUSIONS

Several definite conclusions were reached after the results of this investigation had been determined. These conclusions are listed below in the order of importance.

(1) From a consideration of the results over all of the materials used in the investigation, it may be seen that there is some definite relation between laboratory and commercial firing.

(2) The relation is not the same for every material and plant. The relation varies with the material and the plant, but for any one plant and material there is some definite relation.

(3) The difference in the structure imparted to the specimens by the different methods of forming caused very slight differences in the physical properties of the specimens. This was true for all materials regardless of the heat-treatment received.

(4) The use of pyrometric cones which would not be affected by the kiln atmospheres would be helpful in determining the heat-treatment received by the specimens in the commercial firings. This does not mean that cones are needed that are not affected at all by the kiln gases, but rather cones that would not bloat and distort in kiln atmospheres containing gases such as those in a kiln fired with coal.

(5) The correlation between laboratory firing and commercial firing is a very hard object to obtain for materials such as those used in the structural clay products industry for there are many

factors which affect the firings and complete control of these variables is extremely difficult.