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DETROIT MANUFACTURED BRICK FOR CATCH BASINS AND MANHOLES

by

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The City of Detroit recommends the use of soft clay brick manufactured in the Detroit area for the construction of manholes and catch basins on Federal-State-City financially supported highway projects in the Metropolitan area, even though the brick do not meet State Highway Specifications in respect to water absorption properties. They base their recommendations on the fact that these brick have been used for this purpose for many years and that they are giving satisfactory service.

With this problem in mind, the Highway Department has requested that a study be made of the several brands of brick manufactured in the Detroit area giving special consideration to their resistance to frost action and performance under field conditions.

Brick samples from four manufacturers in Dearborn, Michigan were procured and subjected to a definite number of freeze and thaw cycles and their deterioration noted. In addition, a field survey was made in Wayne County to observe the physical condition of different makes of brick in manholes and catch basins which have undergone normal weathering for a great many years.

The laboratory work substantiates in general the findings of others in that it is difficult to predict the service behavior of brick from a given source on the basis of water absorption characteristics alone. Of the five brick groups tested, two passed the freezing and thawing test and the others failed. One of the two groups passing the test had an average absorption value of 4.6 percent, the other 22.1 percent, from the five-hour boiling test.

The most serious structure failures observed during the field survey were obviously caused in the most part by poor workmanship in laying the bricks, rather than by any lack of durability on the part of the brick used in the structure.

The evidence submitted, although not conclusive, indicates that certain brick manufactured in the Detroit area would be suitable for use in manholes and catch basins even though they do not conform to the absorption requirements of the Highway Department, or to those recommended by the American Society for Testing Materials, provided the brick are carefully selected from uniformly and well burnt stock and properly installed in the structure.

The report presents a brief discussion on the durability of brick, the results of laboratory freezing and thawing tests on selected brick samples from several Detroit manufacturers, and notes on a field survey of subsurface structures in the Detroit area.

QUALITY OF BRICK SUITABLE FOR CATCH BASINS AND MANHOLES

The latest American Society for Testing Materials specifications (Designation C 32-42) specify the following physical requirements for sewer brick made from clay and shale. They include three grades, designated SA, MA, and NA.

Grade SA

Brick intended for use in structures requiring imperviousness and resistance to the action of sewage carrying large quantities of abrasive material at velocities exceeding 8 feet per second.

Grade MA

Brick intended for use in structures requiring imperviousness and resistance to the action: (1) of sewage free from abrasive materials: and (2) of sewage carrying abrasive materials at velocities of 8 feet per second or less.

Grade NA

Brick intended for use in structures not requiring high degrees of imperviousness nor of abrasive resistance. Brick of Grade NA are suitable for use in catch basins, arches, the upper portions of manholes, and for backing.

Physical Requirements

	Minimum compressive strength, (brick flat-wise), psi., average gross area		Maximum water absorption by 5-hr. boiling per cent	
Designation	Avg. of 5 brick	Individual	Avg. of 5 brick	Individual
Grade SA	8,000	5,000	6	9
Grade MA*	5,000	3,000	12	24
Grade NA*	2,500	2,000	20	24

*Where resistance to frost action in the presence of moisture is required, Grades MA and NA shall conform to the additional requirement that the saturation coefficient (C/B) - that is, ratio of absorption by 24-hour submergence in cold water to that after 5 hours in boiling water - shall not exceed 0.80.

Under explanatory notes for standard American Society for Testing Materials specifications for "Building Brick" (made from Clay and Shale), (Designation C 62-44) there are several comments which no doubt equally apply to "Sewer Brick" (made from Clay and Shale), (Designation C 32-42), especially the last paragraph which states: In using these specifications the purchaser is urged to consider both the requirements of the structure and the physical properties of the brick available. To a degree at least, brick are a natural product since such properties as color, compressive strength, and absorption are more or less inherent in the raw material and frequently can be changed only within narrow limits by different methods of manufacture. While the committee believes that the specifications as they now stand provide the best means available of specifying the desirable properties of brick, it recognizes that the specifications are not perfect and that, due to the wide variation in raw materials and methods of manufacture, it is probable that some brick which do not conform to the requirements of Grade SW still have satisfactory durability. It may also be true that some products which meet these requirements, particularly of Grade MW, do not have satisfactory resistance to weathering. For this reason, and because of the lack of data on some properties that may have an important bearing upon the performance of masonry, the purchaser should be guided to a degree by the record of performance of any particular product.

The Highway Department now specifies the use of sewer brick (Grade NA) for sewers, manholes and catch basins with the special provision that when used for such purposes they shall not have an absorption greater than 15 percent when all samples are averaged, nor shall an individual unit have an absorption greater than 17 percent when tested for absorption by the 5-hour boiling test in accordance with American Society for Testing Materials Designation C-67.

Durability of Clay Brick in Relation to Absorption

A study of existing literature concerning freezing and thawing tests on clay building brick will reveal that many factors other than absorption influence the resistance of a given brick to deterioration by frost action. In other words, a brick with high absorptive properties may not necessarily fail under freezing and thawing action. However, brick with high absorption should be looked upon with suspicion and should not be used unless their service record is well established.

Table I presents a summary by McBurney(1) of freezing and thawing data on clay brick which substantiate the above points. In general, the data in Table I indicate that, for good performance, the saturation coefficient of brick should be under 0.80 which is the value recommended by the American Society for Testing Materials for brick subjected to frost action in the presence of moisture. Also the data in Table I indicate an absorption range with a saturation coefficient above 0.80 in which brick may fail or pass the freezing and thawing test. The same relationship exists if absorption values based on the 24-hour cold immersion or 5-hour boiling tests are considered.

FREEZING AND THAWING TESTS ON DETROIT BRICK

Samples of clay and concrete brick were obtained from the following sources which supply the Detroit area:

(1) Relations Between Results of Laboratory Freezing and Thawing and Several Physical Properties of Certain Soft-Mud Bricks, by John W. McBurney, A.S.T.M. Proceedings, page 837, vol. 42, 1942.

Series	Manufacturer	Plant Location	Type
A	Daniel Brick Co.	Dearborn	Clay
B	Daniel Brick Co.	"	Clay
C	Clippert Brick Co.	"	Clay
D	J. A. Mercier Brick Co.	"	Concrete
E	J. S. Haggerty Brick Co.	"	Clay
F	J. A. Mercier Brick Co.	"	Clay

After determining the saturation coefficient (C/B) - that is, ratio of absorption by 24-hour submergence in cold water to that after 5 hours in boiling water - the brick were subjected to a 48-hour immersion period followed by 51 cycles of freezing and thawing. A freezing and thawing cycle consisted of freezing the bricks on their sides in a 1/2 inch depth of water at zero degrees F. for 16 hours, followed by an 8-hour thawing period in water at 70 degrees F. The test was conducted on 1/2 brick specimens. The criterion for failure was complete breakage or loss in weight exceeding 3 per cent of the dry weight of the brick.

In conducting the freezing and thawing test, the procedure of American Society for Testing Materials, Designation C 32-42, was followed with certain modifications necessary to conserve time and space.

The remaining half portions of the brick samples not subjected to freezing and thawing were tested in compression. The surviving brick sections from the freezing and thawing test were also tested in compression for comparative study.

A complete summary of test data is presented in Table II. Photographs of the brick specimens after freezing and thawing for 51 cycles are shown in Figure 1.

Discussion of Test Results

The clay brick designated Series A had a very low absorption and high compressive strength. This would indicate a face brick and therefore they should not be considered in the same category as the balance of the brick samples.

The other clay brick samples, designated Series B, C and E, had absorption values higher than those recommended by the American Society for Testing Materials for brick in Grade NA, and as a group all failed the freezing and thawing test. However, not all of the individual specimens in each group failed the test. As may be seen in Figure 1, failure occurred by either loss of weight due to spalling or by complete breakage of the specimen. All brick in these three series passed the 2,000 pound per square inch compression strength requirement before subjection to freezing and thawing. After the test the compression strengths of the various brick dropped considerably. For example; Series B lost 22 percent, Series C lost 12 percent, and Series E lost 22 percent of their original compression strength value. Series E, however, dropped below the 2,000 pound requirement.

The clay brick in Series F, although they had the highest saturation coefficient of any of the brick tested, passed the freezing and thawing test. The compressive strength dropped only 13 percent to a value of 3400 pounds per square inch after test.

The concrete bricks of Series D, with relatively low absorption values, failed to pass the freezing and thawing test by loss of weight. With the exception of specimen 5, which crumbled completely as may be seen in Figure 1, the concrete brick failed by gradual disintegration and subsequent crumbling only at the fractured face. All of the smooth outside faces of the individual concrete bricks remained intact. This would indicate that a whole brick of this material, if subjected to the freezing and thawing test, might not show any failure in 51 cycles. During the freezing and thawing test, however, these brick lost 32 percent of their original compressive strength. Their average compressive strength after test was 1,895 pounds per square inch.

In summary, the tests indicate that the clay brick in Series F would be satisfactory for subsurface structures even though they have a high absorption property. Although the brick in the other series failed to comply in letter to the requirement of the freezing and thawing test, the photographs in Figure 1 show that they were not in general materially damaged by the accelerated test. In other words, it is difficult to predict the behavior of the various bricks in service by their reaction to the laboratory freezing and thawing test, although it might indicate in a general way how these brick will ultimately behave in service.

FIELD SURVEY

On January 7, 1948, a field survey was made in Wayne County by the author accompanied by Mr. W. J. Worth of the Wayne County Road Commission and Mr. C. J. Olsen, Materials Engineer of the Highway Department. The survey included the inspection of brick in manholes and catch basins at 14 different locations in the vicinity of Wayne, Michigan. During the survey samples of brick from several catch basins and manholes were obtained for laboratory comparative study with the brick recently procured from manufacturers in Dearborn. Pictures of brick specimens taken from several structures are shown in Figure 2. Absorption data and other pertinent information associated with these brick are summarized in Tables III, IV and V.

It is of interest to note from the data presented in Tables II, III and IV that the absorptive properties of the field samples are practically identical with those procured from the same sources for laboratory freezing and thawing tests. Their respective compressive strengths follow somewhat in the same order.

The service life of the brick inspected varied from 13 to 26 years. With the exception of a very few instances, the brick in all structures examined were apparently in excellent condition considering the number of years in service. It is apparent from the pictures in Figure 2 of the brick specimens taken from the field that the brick were badly chipped and broken. From a visual examination of the brick in the structure, it is believed that this condition was brought about by workmen in handling and dressing the brick to fit the structure rather than by frost action.

Typical examples of failures encountered are illustrated in Figures 3 to 6 inclusive. Figures 3 and 4 illustrate brick failure under frost action as manifested by chipping or spalling. In both cases the bricks shown in the photographs were the only ones in the structure showing signs of deterioration from this cause. Figure 5 illustrates the failure of only one brick in a catch basin by cracking and chipping. Figure 6 illustrates a manhole in bad condition. It is questionable whether in this case the failure was due to faulty workmanship or deterioration of the brick, or to a combination of both. Similar conditions were observed in several other manholes. Deterioration of manholes was in all cases immediately under the casting.

TABLE IV

SUMMARY OF COMPRESSION STRENGTH DATA FOR BRICK OBTAINED DURING FIELD SURVEY

Sample No.	Series A Clippert	Series B Clippert	Series C Daniels	Series D J. S. Haggerty	Series E W and F
1	2955	3500	3335	3790	2670
2	3310	2950	--	1410	1578
3	2960	--	--	1975	1013
4	3160	2670	--	1465	3195
5	1925	2615	--	--	--
Average	2860	2935	3335	1910	2110

TABLE V - SUMMARY OF ABSORPTION DATA FOR BRICK OBTAINED DURING FIELD SURVEY IN 1948

Specimen Number	SERIES A Clippert Brick Co. Laid 1932			SERIES B Clippert Brick Co. Laid 1939			SERIES C Daniels Brick Co. Laid 1941		
	Absorption 24 hr. Imm. Percent	Absorption 5 hr. boil Percent	Saturation Coefficient	Absorption 24 hr. Imm. Percent	Absorption 5 hr. boil Percent	Saturation Coefficient	Absorption 24 hr. Imm. Percent	Absorption 5 hr. boil Percent	Saturation Coefficient
1	18.9	19.6	.971	19.5	19.9	.976	18.8	23.1	.813
2	18.2	19.2	.951	19.1	19.7	.969	---	---	---
3	18.8	19.7	.958	19.6	20.5	.953	---	---	---
4	19.9	20.3	.979	20.9	22.6	.923	---	---	---
5	21.5	24.4	.883	21.2	23.4	.908	---	---	---
Average	19.4	20.6	.948	20.1	21.2	.946	18.8	23.1	.813

Specimen Number	SERIES D J. S. Haggerty Brick Co. Laid 1925			SERIES E W and F Brick Co. Laid 1930		
	Absorption 24 hr. Imm. Percent	Absorption 5 hr. boil Percent	Saturation Coefficient	Absorption 24 hr. Imm. Percent	Absorption 5 hr. boil Percent	Saturation Coefficient
1	20.6	22.3	.920	20.6	22.1	.935
2	21. 5	24.4	.879	20.7	22.6	.917
3	21.7	24.6	.883	21.0	22.7	.927
4	20.7	23.4	.887	19.9	21.1	.944
5	---	---	---	---	---	---
Average	21.1	23.7	.892	20.5	22.1	.931

Figure 3. Brick failure by spalling. In catch basin at Pelham Drive and Wabash R.R. grade separation. Daniels Brick. Only one brick in poor condition. Age 7 years.

Figure 4. Brick failure by spalling in another catch basin at Pelham Drive and Wabash R.R. grade separation. Daniels Brick. Only two bricks in catch basin have spalled. Age 7 years.

Figure 5. Brick failing by cracking. Catch basin at Middle Belt and N.Y.C. R.R. grade separation. Daniels Brick. Only one brick in catch basin had started to fail. Age 7 years.

Figure 6. Brick failure. Manhole at Outer Drive and Rotunda Drive. Age 17 years. Brick cracked and displaced. May be due to either frost action or workmanship or both. Brick marked W & F.

The field survey did not disclose any conclusive evidence that the brick examined were not suitable for manhole and catch basin construction.

CONCLUSIONS

The ultimate service life of brick is most difficult to determine or predict from laboratory durability tests because of the many inherent factors associated with their manufacture and subsequent physical behavior in underground structures such as manholes or catch basins. Therefore, in the setting up and enforcement of specifications, the purchaser should consider the requirements of the structure and the physical properties of the brick available.

Experience indicates three ranges of freeze-thaw resistance related to water absorption; there is the range of low absorption where no failures take place, an intermediate range where both failures and no failures take place, and a high range where all bricks fail. Sewer brick of Grade NA will evidently fall in the intermediate and high absorption range because of their inherent high absorptive properties. Bricks with a saturation coefficient of less than 0.80 will be less likely to fail under frost action than those with a higher saturation coefficient ratio. Therefore, specification limits should be established with that in mind. However, there is evidence that brick with high saturation coefficients give excellent service and, unquestionably, brick of this type from many sources could be used with reasonable assurance that they will give satisfactory service for a long period of time. Certain brick from the Detroit area apparently come under this category and their field record must be correlated with laboratory tests.

It was obvious during the field inspection that practically all of the worse conditions encountered in the manholes and catch basins were a direct result of poor workmanship in laying the brick rather than frost action.

Brick failures accountable to direct frost action were manifested by chipping or spalling of the exposed surfaces or breakage of the brick. In no case were the failures due to frost action serious.

It was evident during the field survey that brick are less susceptible to frost action in manholes than in catch basins because of differences in the construction and function of these units. The brick in catch basins are directly exposed to water, snow, ice, and salt solutions and large fluctuation in daily temperature; whereas, the exposed surfaces of manhole brick are protected from the elements by the manhole cover and, in addition, inside temperature fluctuations are moderated to a large degree by the presence of the sewer water. Therefore, brick for catch basins should be selected with greatest care.

The evidence submitted, although not conclusive, indicates that certain brick manufactured in the Detroit area would be suitable for use in manholes and catch basins even though they do not conform to the absorption requirements of the Highway Department or to those of the American Society for Testing Materials, provided the brick are carefully selected from uniformly and well burnt stock and properly installed in the structure.

ACKNOWLEDGMENT

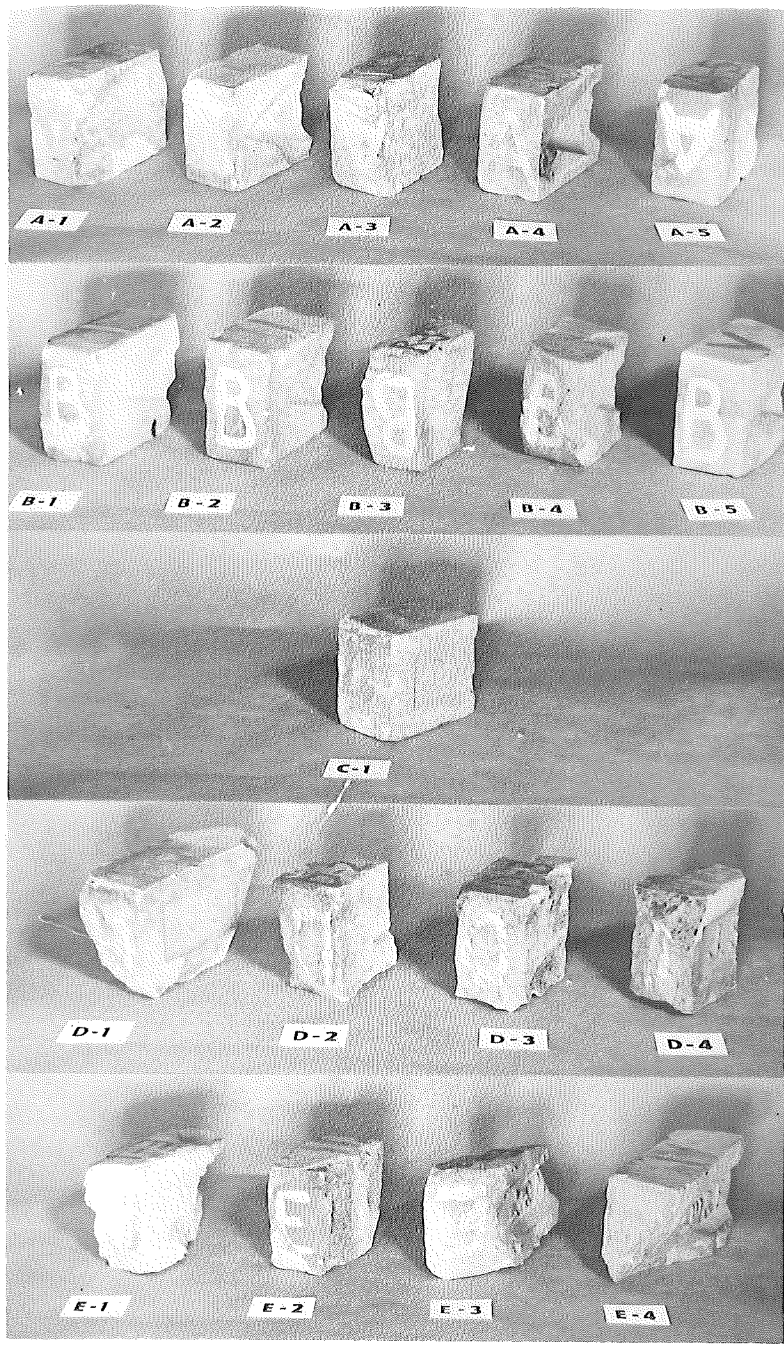
The actual performance of laboratory tests was the responsibility of William Martin, Physical Research Engineer. The work on the project was greatly facilitated by the cooperation of C. J. Olsen, Materials Engineer of the Michigan State Highway Department, and W. J. Worth of the Wayne County Road Commission.

CONDITION *of* BRICK
AFTER FREEZING *and* THAWING
(51 CYCLES)

Figure 1

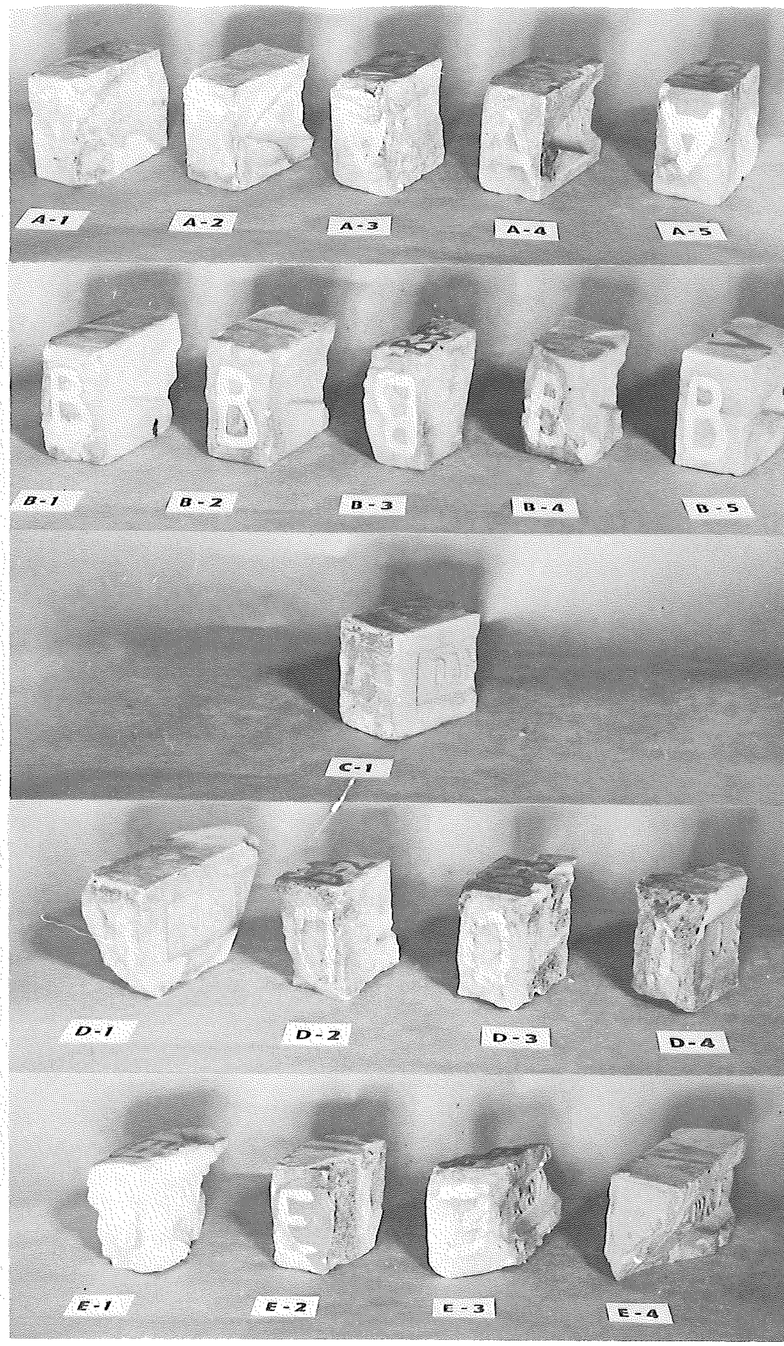
CONDITION of BRICK
AFTER FREEZING and THAWING
(51 CYCLES)

Figure 1



CONDITION *of* BRICK
TAKEN *from* MANHOLES *and* CATCH BASINS
(16-23 YEARS IN SERVICE)

Figure 2



CONDITION *of* BRICK
TAKEN *from* MANHOLES *and* CATCH BASINS
(16-23 YEARS IN SERVICE)

Figure 2

TABLE III.—COMPARISON OF RESULTS OF 50 AND 175 CYCLES OF FREEZING AND THAWING WITH ABSORPTIONS, SATURATION COEFFICIENTS AND STRENGTHS OF 50 SOFT-MUD, SURFACE-CLAY BUILDING BRICKS.

P = passed, *F* = failed, *T* = total bricks in range.

Property and Range in Property	Number of Cycles	Range Within Which All Bricks Passed[a]	Number of Bricks in Range, *P*	Range Within Which Bricks Both Passed and Failed[a]	Number of Bricks *P*	Number of Bricks *F*	Number of Bricks *T*	Range Within Which All Bricks Failed[a]	Number of Bricks, *F*
Water Absorptions:									
1-min. cold immersion (0.6 to 12.7 per cent)	50	0.6 to 1.2	6	1.9 to 10.8	29	14	43	12.7[b]	1
	175	0.6 to 1.2	6	1.9 to 4.2	6	3	9	4.3 to 12.7	35
24-hr. cold immersion (3.4 to 19.8 per cent)	50	3.4 to 9.6	11	9.7 to 19.8	24	15	39	[c]	..
	175	3.4 to 9.6	11	9.7 to 10.9 (*M*)	1	1	2	11.7 to 19.8	37
				9.8 to 11.2 (*N*)					
5-hr. boiling (4.6 to 24.0 per cent)	50	4.6 to 11.9	8	12.2 to 24.0	27	15	42	[d]	..
	175	4.6 to 11.9	8	12.2 to 13.8 (*M*)	4	1	5	15.0 to 24.0	37
				12.0 to 13.2 (*N*)					
Saturation Coefficients:									
C/B (0.61 to 0.96)	50	0.61 to 0.73	10	0.74 to 0.96	25	15	40	[e]	..
	175	0.61 to 0.72	7	0.73 to 0.80(*M*)	5	17	22	0.81 to 0.96	21
				0.75 to 0.80 (*N*)					
W/V (0.37 to 0.82)	50	0.37 to 0.60	8	0.61 to 0.80	27	14	41	0.82[f]	1
	175	0.37 to 0.60	8	0.61 to 0.65	4	4	8	0.66 to 0.82	34
Strengths:									
Modulus of rupture (275 to 1600 psi.)	50	[g]	..	275 to 1600	35	15	50	[g]	..
	175	[g]	..	275 to 1600	12	38	50	[g]	..
Compressive strength (2000 to 12 600 psi.)	50	7050 to 12 600	10	2000 to 6400	25	15	40	[h]	..
	175	7050 to 12 600	10	5500 to 6400	2	5	7	2000 to 5450	33
Porosity:									
(volume) (15.7 to 41.6 per cent)	50	5.7 to 29.1	11	29.8 to 41.7	24	15	39	[i]	..
	175	15.7 to 29.1	11	29.8 to 30.9	1	1	2	32.8 to 4.7	37

[a] The criterion for passing is no breakage or loss in weight not exceeding 1.0 per cent at stated number of cycles.
[b] The brick with the next highest absorption (10.8 per cent) passed.
[c] The brick with the highest absorption (19.8 per cent) passed.
[d] The brick with the highest absorption (24.0 per cent) passed.
[e] The brick with the highest saturation coefficient *C/B* (0.96) passed.
[f] The brick with the highest saturation coefficient *W/V* (0.82) passed.
[g] Failures occurred at random throughout the entire range including the brick with highest modulus of rupture (1600 psi.).
[h] The brick with the lowest strength passed.
[i] The brick with the highest porosity passed.