Further studies of the effect of silicone treatment of bricks on properties of masonry

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FURTHER STUDIES OF THE EFFECT OF SILICONE TREATMENT OF BRICKS ON PROPERTIES OF MASONRY

by

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PREFACE

Some further tests of the resistance to moisture penetration of brick masonry made from bricks pretreated with silicone have now been carried out, using large wallettes rather than the small panels on which previous work was based. The results of this work are now reported as a further contribution to the continuing study of masonry performance being carried out by the Division both at its Ottawa Laboratories and at its Atlantic Regional Station.

The author, a research officer with the Building Materials Section of the Division, devotes full time to brick masonry studies.

Ottawa
February 1962

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FURTHER STUDIES OF THE EFFECT OF SILICONE TREATMENT OF BRICKS ON PROPERTIES OF MASONRY

by

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Silicone treatment of bricks prior to their use in construction as a means of reducing efflorescence and improving the strength of bond and resistance to moisture penetration of masonry has been reviewed previously (1). At the same time results of tests made in the Division of Building Research indicated that the treatment of high-suction bricks with silicone resulted in improved performance of brickwork with respect to resistance to moisture penetration, compared with similar brickwork of untreated high-suction bricks. Additional tests have now been made in which large wallettes, constructed by a bricklayer, have been used instead of small panels. The wallettes were similar to those used in earlier DBR studies of moisture penetration (2).

SCOPE

Bricks were obtained from two plants which normally market silicone-treated bricks as well as untreated bricks. High-suction bricks, with and without silicone treatment were obtained from each plant. No particular silicone or method of application was specified. Untreated bricks of moderate suction were obtained from another plant, and the wallettes made of them were used as a reference for comparison with the others.

The bricks were laid with cement-lime mortar and with masonry cement mortar. One of the bricks was used in three ways: laid dry in the mortar, soaked in water before laying, and silicone-treated. The second brick was used in two conditions, untreated and silicone-treated. The moderate-suction brick was laid dry.

The wallettes were stored for a month after construction in a laboratory where the humidity and temperature were not controlled. A test for moisture penetration was then made with an air pressure difference of 2 in. of water across the wallette. The time for dampness to appear on the back of the wallette, the rate of leakage at various times during the test and the total leakage of water in 24 hr were recorded. The wallettes were then stored for a month, when a solution of silicone in mineral spirits was sprayed on the face of the wallette. After a storage period of 48 hr or more to cure the silicone, a re-test of the wallette for moisture penetration was carried out. Following the second

moisture penetration test there was another storage period for a month, when a test for the transverse strength of the wallette was made. In this test two horizontal bars, 44 in. apart were placed against the back surface of the wallette, and a third bar mid-way between them was brought to bear against the front surface. A gradually increasing force was applied through this bar, and the load required to break the wallette was recorded.

PROPERTIES OF BRICKS

All three types of bricks were smooth-faced and cored with three holes. Two of the bricks were made by the extrusion method; the third was made by the dry-press method. Two of the bricks were yellow, and the third was red.

The properties of twenty of the dry-press bricks, without the silicone treatment, were determined. The range in initial rate of absorption or suction was from 66 to 109 gm per min for an area of 30 sq in. The total absorption on immersion in water for 24 hr ranged from 16.5 to 20.4 per cent of the dry weight, and the saturation coefficient was in the narrow range of 0.84 to 0.85. The average compressive strength of 5 samples was 5175 psi. Twenty samples of the same brick, with silicone treatment, were also tested. For these samples, the range of suction was found to be from 0.2 to 2.7 gm. Additional tests made later in the program because of inconsistencies in the results showed that many of the treated bricks were much higher in suction. For one silicone-treated brick of this type, the suction was 67 gm.

Wallettes were constructed of dry-press brick wetted before use. The bricks were soaked in water for a short period and then laid in the mortar. The effect of the wetting on the suction of the brick when laid was not determined.

Twenty samples of the high-suction extruded brick without the silicone treatment were tested. The range in suction for these bricks was 63 to 81 gm, the absorption on immersion in water for 24 hr was 15.8 to 20.1 per cent of the dry weight, and the saturation coefficient was in the range 0.88 to 0.90. The average compressive strength of 5 samples was 7840 psi. When twenty of the silicone-treated bricks of this type were tested it was found that the suction was still high, from 27 to 73 gm, and the absorption (24-hr immersion) was also high, from 15.0 to 18.4 per cent. Although some of the silicone-treated bricks were used as received for the construction of wallettes, others were re-treated by immersion in a water solution of silicone to reduce the suction to a lower value. Re-treated bricks covering a wide range of

suction, but mainly of moderate suction (up to 19 gm) were used in some wallettes, and other re-treated bricks of low suction (0.6 to 6.0 gm) were also used.

The variation in suction of the silicone-treated bricks as received from the plants indicated that the process of treating the bricks at these plants was not under careful control. In the case of the dry-press bricks, it appeared that the bricks of the first pallets used had been uniformly treated and the suction was in a narrow range, but many of the bricks taken from pallets used later were high in suction and this property was variable. In the case of the silicone-treated extruded bricks, it was thought that they had not received adequate treatment at the plant, as judged by the effect on suction.

Twenty untreated moderate-suction bricks for the "reference" wallettes were found to have suction between 14.0 to 23.5 gm, in the range generally considered most desirable for the development of high resistance to moisture penetration and high strength of bond of brickwork. The absorption of these bricks on immersion for 24 hr was between 7.7 and 9.4 per cent of the dry weight, and the saturation coefficient ranged from 0.82 to 0.87. The average compressive strength of five of the bricks was 12,600 psi.

MORTARS

Mortars of four compositions were used. Two were cement-lime mortars, each containing equal parts of lime and portland cement by volume. In one mortar, the proportions of cement, lime and sand were 1:1:6 while in the other the mix was made slightly richer, 1:1:5. The lime was a dry hydrated lime, soaked in water overnight before it was used and proportioned for the mix on the basis of the volume of the paste. The two other mortars were made of masonry cement, of the portland cement: limestone type. In one of them the proportions were 1:3 by volume of masonry cement to sand, and in the other the proportions were 1:2½. This natural well-graded sand was used in all the mortars.

The mortars were prepared by the bricklayer's helper who mixed the materials by hoeing them in a trough. Sufficient water was added to produce a suitable consistency. The size of the batch was about 2 cu ft. Samples of the mortar used in each wallette were tested on the flow table. The values obtained were consistently high and in many cases exceeded the capacity of the table (150 per cent flow). The bricklayer appeared to favour mortar of high flow regardless of the type of brick laid. He was instructed to adjust the consistency of the mortar to suit his requirements. When the flow of a

sample of mortar was determined, a water retention test was also made. The results were variable even for mortars of the same composition, but water retention values of all mortars fell in the range of 66 to 80.

WALLETTES

The wallettes were about $3\frac{1}{2}$ ft wide by 4 ft high, and nominally 8 in. thick (the length of a header brick, actually close to 8-3/8 in.). A common bond pattern was used which consisted of five courses of stretcher bricks between the courses of headers. The mortar joints of the "exterior" face of the wallette were concave-tooled.

RESULTS

The results of the tests are shown in Table I. Information obtained from the moisture penetration test is listed first, followed by that from the transverse strength test. The time taken for the first damp spot to appear on the back of the wallette after the start of the leakage test is shown along with the time taken for water to start falling off the back surface. The total amount of water that passed through the wall in 24 hr of test (expressed in ml) is given next, along with the maximum rate of leakage of water through the wall (expressed in ml per min). The load in pounds required to break the wallette is listed in the next column followed by the tensile strength (modulus of rupture) of the wallette (psi), calculated from the results of the transverse loading test.

Improvement in the "tightness" of the brickwork in the moisture penetration test as a result of the silicone treatment of the bricks is apparent from the results given in Table I. Increased transverse strength also accompanied the use of the silicone-treated bricks; usually the increase in strength was considerable. In one case the load required to break the wallette of silicone-treated bricks was ten times that required to break the wallette of untreated bricks (dry-press brick with 1:1:6 mortar). The performance of several of the wallettes of silicone-treated bricks was superior to that of the wallettes of the moderate-suction brick, although the latter brick with 1:1:6 mortar produced the strongest wallette of all that were tested.

The properties of brickwork made of the dry-press brick were improved as a result of soaking the brick in water before it was laid which is the traditional method of reducing suction, but the improvement was not nearly as great as that which resulted from silicone treatment of the bricks.

Inconsistencies in the results were noted. The dry-press silicone-treated bricks with both 1:3 and 1:1:6 mortars produced relatively "tight" and strong brickwork, but with the 1:2½ and 1:1:5 mortars inferior results were obtained, although better than those of the same bricks used in the untreated condition. One might conclude that the change in mortar composition was responsible for the change in properties, except that it was noted during the moisture penetration tests that areas of dampness had appeared on the bricks of wallettes of 1:2½ and 1:1:5 mortar. Such dampness was not observed on the bricks of wallettes of 1:3 and 1:1:6 mortar; less effective silicone treatment of the bricks appeared to be the cause. This was confirmed by testing the bricks taken from the wallettes after the strength test. It was found that the suction was variable, and for many bricks was much higher than the values obtained for the first bricks used. The suction of one of the bricks was 67 gm. Variation in properties of the silicone-treated dry-press bricks was therefore considered to be the cause, in part at least, of the variable results obtained.

The effect of the degree of silicone treatment of the bricks on the performance of the brickwork was also clearly indicated with the extruded brick. This brick was used as received from the plant (in a condition of relatively high suction, in spite of the silicone treatment). It was also used after additional silicone treatment, applied to lower the suction. In one case the suction was reduced to a moderate but variable amount (up to 19 gm) and in the other to a low amount (less than 6 gm). These silicone treatments, designated (A), (B) and (C) in Table I had different effects on the properties of the brickwork.

CONCLUSIONS

The resistance to moisture penetration and the transverse strength of brickwork was increased when high-suction bricks were treated with silicone prior to use, confirming previous experiences in DBR studies (1) and those made elsewhere (3). In some cases, the performance of brickwork made of silicone-treated bricks, which were originally high in suction, equalled or bettered that of a moderate-suction brick used with the same mortar. Soaking high-suction bricks in water before laying them improved the properties of the brickwork, but not to the same extent as was achieved by the silicone treatment.

The silicone-treated bricks used in this study were obtained from two different plants and had not received uniform application of the silicone which resulted in a highly variable performance of the brickwork. Careful

control of the application of the silicone treatment to the bricks appears to be necessary to develop fully the benefits of the treatment. There are indications that the best results are obtained with silicone-treated high-suction bricks when the suction has been reduced to a relatively low value.

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TABLE I

TEST RESULTS

Condition of brick	Mortar composition (*)	Time from start of test for first dampness to appear hr	min	for first leakage from back of wall hr	min	Total leakage, ml/24 hr	Maximum rate of leakage, ml/min	Load to break wallette, lb	Tensile strength (Modulus of Rupture), psi
High-Suction Dry-Press Brick									
Laid Dry	1:3 MC:S	-	5	-	50	210,760	186	720	15.5
Laid Wet	1:3 MC:S	-	9	1	-	144,160	113	1,300	27.9
Siliconed	1:3 MC:S	-	50	1	30	6,750	7	3,240	69.5
Laid Dry	1:2½ MC:S	-	2	-	40	262,820	228	440	9.5
Laid Wet	1:2½ MC:S	-	33	1	7	170,360	142	530	11.4
Siliconed	1:2½ MC:S	-	3	-	10	130,240	124	2,020	43.5
Laid Dry	1:1:6 C:L:S	-	9	-	45	263,000	372	600	12.9
Laid Wet	1:1:6 C:L:S	-	36	1	5	241,200	210	1,720	37.0
Siliconed	1:1:6 C:L:S	7	20	7	30	2,760	5	6,400	137.8
Laid Dry	1:1:5 C:L:S	-	24	1	5	151,000	131	1,420	30.6
Laid Wet	1:1:5 C:L:S	-	10	1	-	126,870	102	800	17.2
Siliconed	1:1:5 C:L:S	-	4	-	40	63,310	61	3,600	77.5
High-Suction Extruded Brick									
Laid Dry	1:3 MC:S	-	12	-	15	509,590	460	700	15.0
(**) Siliconed (A)	1:3 MC:S	-	16	-	45	247,300	218	1,000	21.5
Siliconed (B)	1:3 MC:S	-	23	-	50	97,395	95	2,925	62.9
Siliconed (C)	1:3 MC:S	-	5	-	18	40,000	36	2,820	60.7
Laid Dry	1:1:6 C:L:S	-	20	-	45	320,020	325	520	11.2
(**) Siliconed (A)	1:1:6 C:L:S	-	33	1	15	417,940	370	720	15.5
Siliconed (B)	1:1:6 C:L:S	-	42	7+	-	7,810	11	3,400	73.2
Moderate-Suction Extruded Brick									
Laid Dry	1:3 MC:S	-	1	-	20	24,650	33	1,370	29.5
Laid Dry	1:2½ MC:S	-	7	-	10	52,030	45	2,010	43.2
Laid Dry	1:1:6 C:L:S	-	28	6	30	17,735	23	7,150	153.9
Laid Dry	1:1:5 C:L:S	-	11	2	15	45,750	43	4,320	93.0

(*) MC - masonry cement, C - portland cement, S - sand, L - lime

(**) Siliconed (A) - bricks as received from plant, suction high and variable (27 to 73 gm)
Siliconed (B) - bricks re-treated in laboratory with silicone to lower value (2 to 19.2 gm)
Siliconed (C) - bricks re-treated to low value of suction (0.6 to 6.0 gm)