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by

J. I. Davison

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PREFACE

Further studies of a dry-press brick showing anomalous performance between laboratory tests and field performance have been carried out and are now reported. The author, a research officer on the staff of the Atlantic Regional Station of the Division, in Halifax, has a special interest in the performance of masonry materials and constructions exposed to the climatic conditions of the Atlantic Region.

Ottawa
December 1964

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Previous laboratory freeze-thaw tests on a particular dry-press brick resulted in their deterioration after relatively few cycles. In a test made on 11 of these bricks they all failed between 11 and 32 cycles, the average being 20 cycles (1). Quite the opposite reports have come from field studies where satisfactory durability is indicated in an area subjected to severe driving rains and an above average number of freeze-thaw cycles during the winter season. This contradiction raises a question concerning the correlation between laboratory tests and natural freeze-thaw action.

In order to study the relation between the two, a simple "natural" freeze-thaw test was conducted. Specimens of the dry-press brick were placed on edge in a metal tray located on the roof of the NRC Atlantic Regional Laboratory Building. In the fall of the year water was added to the tray until the bricks were immersed to a depth of 1/2 in. At the end of the freezing season in the spring, the water was removed from the tray and the bricks were bedded in sand for the summer months.

Thus, the bricks were subjected to freezing and thawing, as the temperature fluctuated during the winter, in a fairly saturated condition. They would not be as completely saturated as in the laboratory test, a modification of Method B in ASTM C67-60, in which the bricks are soaked in water for 4 hr between freezing, removed and set in water to a depth of 1/2 in. in a tray and then put into a freezer. The specimens on exposure, even after heavy rain, would normally have some time in which water could drain from the upper part before freezing occurred. The rate of freezing on natural exposure would also be lower than in the laboratory test which requires that the temperature of the air in the freezing chamber must not be above 16°F within an hour after the bricks are placed in the chamber.

The outdoor test is, however, still much more severe than that occurring in a masonry wall where the degree of saturation is undoubtedly much lower even in the most extreme cases, and the rate and extent of freezing are retarded by (a) the interior temperature of the enclosure and (b) the heat capacity of the wall mass.

An outdoor freezing test similar to the one above, except that no water was initially added to the trays, was conducted at the British Building Research Station (2). By way of comparison, the British research workers suggest that as much decay occurs in five years in this type of test as would occur in twenty or more years in a brick-on-edge coping on a parapet - one of the severest conditions in which bricks are normally exposed in the field.

EXPERIMENTAL

On 8 January 1960, four samples were selected and placed in a copper tray for exposure on the Atlantic Regional Laboratory roof. Water was added to the tray until the samples, placed on edge, were immersed to a depth of 1/2 in. The bricks were selected to span a range in suction from 45 to 75 gm/min/30 sq in. Previous tests of this type of brick showed that the saturation coefficient was between 0.71 and 0.80 in this range of suction, and the compressive strength was between 6000 and 9000 psi. The saturation coefficient increased and the compressive strength decreased with increase in suction of the bricks.

During the first winter the bricks were frequently inspected. Longitudinal cracks were first noted on the bottom sides of all four bricks on 28 March 1960. These cracks continued to develop and on 26 April, when the bricks were brought into the laboratory for inspection, it was noted that smaller cracks were branching out from the main cracks. Small hairline cracks were also noted on the top of all of the bricks. The bricks were, however, still relatively sound. During this spring inspection the bricks were dried, weighed, and photographed. They were then replaced in the copper tray and bedded in sand for the summer months. In the fall, as noted above, the sand was removed and replaced with 1/2 in. of water. This procedure of spring and fall inspections was repeated until 10 June 1963 when the test was discontinued because of the advanced state of the cracks in the bricks.

Loss in weight of the bricks as a result of outdoor exposure is shown in Table I.

Deterioration can be followed pictorially in Figures 1 to 4. For comparison it should be recorded that four specimens in the series referred to earlier (1), of comparable suction to the specimens listed above, failed in 15 to 23 cycles during the laboratory test. It is of interest that the loss in weight of the bricks increased with the suction.

Freeze-thaw cycles for the four winters were determined from monthly weather summaries of the local meteorological office and are listed

below. For this determination one cycle was considered to have occurred when the temperature dropped below 30°F and then rose above 33°F.

Winter	Freeze-Thaw Cycles
1960 (from 8 January)	51
1960-61	67
1961-62	52
1962-63	55
	225

DISCUSSION

The "exposure" freeze-thaw testing was carried on beyond the point where specimens were considered to have failed in laboratory tests. In the latter tests the specimens would undoubtedly have been removed not later than the end of the second winter (Figure 2), although tests conducted at different times and judged on visual observation are difficult to assess accurately. The pattern of cracking that occurred in this test was similar to that which occurred in laboratory cycling.

CONCLUSIONS

1. Failures in a dry-press brick, that occurred during early cycles of laboratory freeze-thaw tests, also occurred in an outdoor freeze-thaw test, but required more cycles.

2. The pattern of failure was similar in both laboratory and outdoor tests.

3. The brick does not possess sufficient durability to survive freeze-thaw cycling in a nearly saturated condition.

4. The satisfactory durability of the brick in the field must result from the fact that its degree of saturation when frozen in a wall does not approach that created under conditions of freeze-thaw tests.

REFERENCES

(1) Davison, J. I. Effect of Silicone Treatment on Small Panels Assembled with High Suction Dry-Press Bricks. National Research Council, Division of Building Research, DBR Internal Report No. 241, Ottawa, February 1962.

(2) Building Research 1962, Department of Scientific and Industrial Research, H. M. S. O., London, 1963, p. 30.

TABLE I

LOSS IN WEIGHT OF THE BRICKS AS A RESULT OF OUTDOOR EXPOSURE

Sample	Suction, gm/min/30 sq in.	Final Weight, gm	Original Weight, gm	Weight Loss, gm	Weight Loss of Original, %
1	45.0	2544.3	2545.0	0.7	0.03
2	65.0	2504.5	2506.0	1.5	0.06
3	70.3	2369.5	2371.5	2.0	0.09
4	75.0	2268.0	2277.5	9.5	0.42

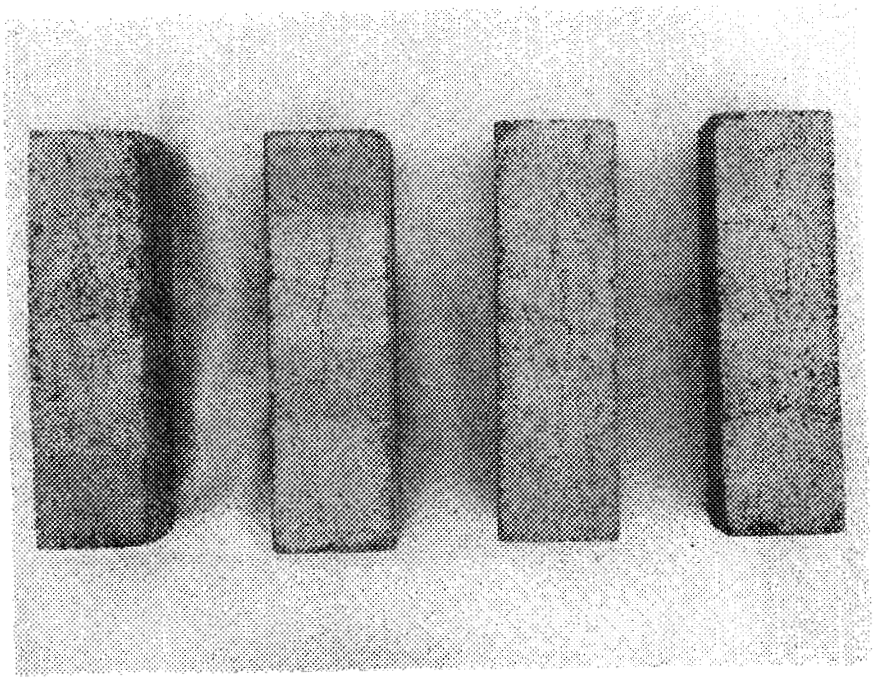


Figure 1 1960 - After 51 Freeze-thaw Cycles.

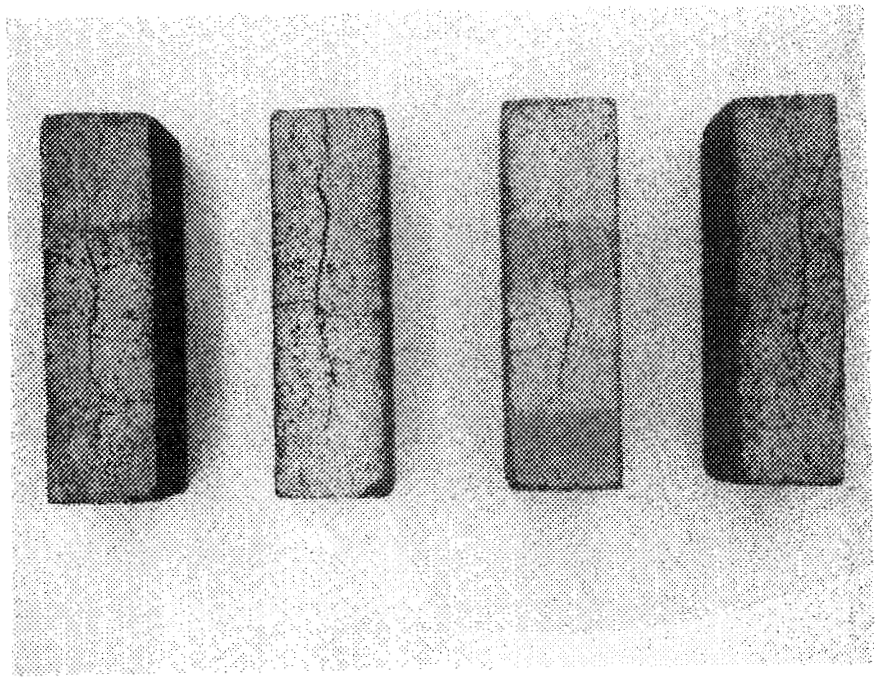


Figure 2 1961 - After 118 Freeze-thaw Cycles.

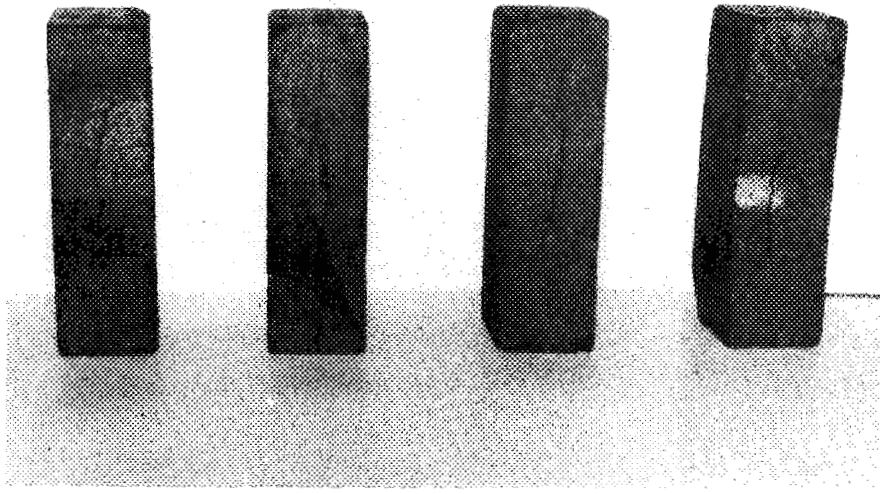
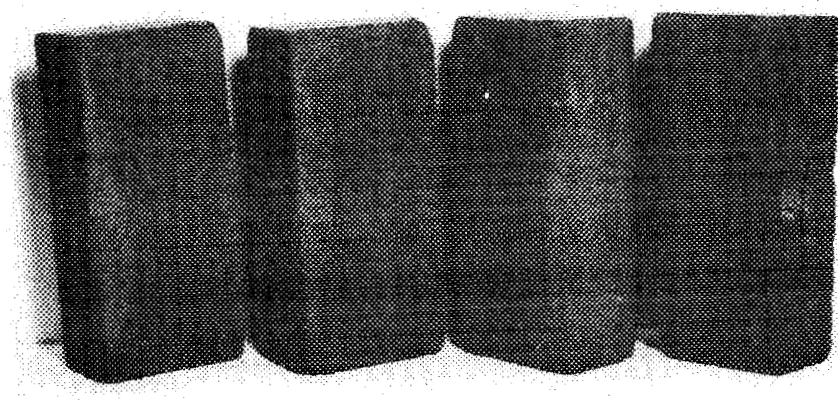
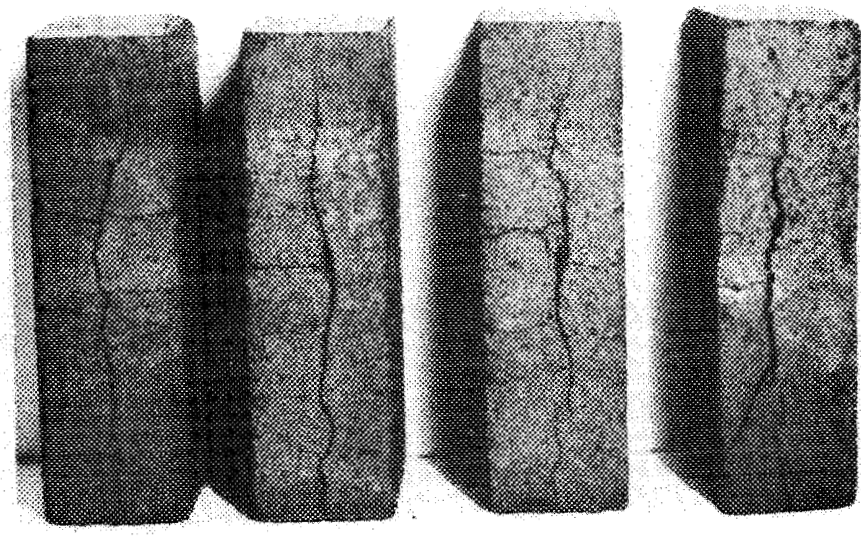


Figure 3 1962 - After 170 Freeze-thaw Cycles.



(a)



(b)

Figure 4 1963 - Two Views of Bricks at End of Test, After 225 Freeze-thaw Cycles Over a 4-Winter Period.