Performance of a cavity wall in laboratory moisture penetration tests

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SUBJECT PERFORMANCE OF A CAVITY WALL IN LABORATORY MOISTURE PENETRATION TESTS

Testing the resistance to moisture penetration of brick walls was undertaken in 1960-61 to determine the influence of brick and mortar properties on the performance of brick masonry. A cavity wall was included for comparison with solid walls under study. The effect of filling the cavity with a specially prepared insulating material on the performance of the wall was also studied.

CAVITY WALL CONSTRUCTION

Cavity walls have been used extensively in Great Britain and other European countries as a means of overcoming rain penetration of masonry walls. In recent years in the United States many important buildings have been constructed of cavity walls. The principle of operation, method of construction, and properties of cavity walls have been reviewed (1).

The cavity wall used in the tests now reported was a conventional 10-inch (nominal) wall, consisting of two 4-inch brick walls separated by a 2-inch air space. The two walls were tied together with galvanized steel Z-bars, and the "gutter" at the base of the wall was formed of combined copper foil and tarred paper flashing. Vertical joints of the bottom course of bricks in the outer half of the wall were omitted to provide drains for the cavity. A "window" was formed in the back part of the wall by omitting several bricks. The opening was covered by a rigid sheet of

clear plastic material sealed to the brickwork, through which the inner surface of the outer part of the wall could be observed during the test. In a later test, when the cavity was filled, the back of the insulating material could be observed during the test.

The walls were about 3 1/2 feet wide and 4 feet high, constructed by an experienced bricklayer, and were stored for a month before being tested for moisture penetration. The method of test described in reference (2) was followed, except that an air pressure difference of 2 inches of water was used (approximately equivalent to wind of 50 mph blowing against the wall of a building). The 10-inch cavity wall was compared with 8-inch walls of conventional construction, in which header bricks were used every sixth course. The same types of brick and mortar were used for both types of wall.

MATERIALS

The bricks were smooth-faced yellow bricks made in the Toronto area. They had been formed by the extrusion method and had three perforations. The initial rate of absorption of the bricks was high; it ranged from 63 to 81 grams per minute per 30 square inch for 20 samples tested. The average compressive strength of 5 samples was 7840 psi.

The mortar was made of masonry cement and sand in proportions by volume of 1:3. The materials were hoe-mixed with water in a trough to a consistency considered suitable by the bricklayer. During construction of the walls the mortar joints of one face were tooled to concave shape.

RESULTS

The 8-inch solid wall was extremely leaky. Dampness appeared on the back surface 12 minutes after the start of the test. In the first hour of test close to 4 gallons of water had leaked from the back surface of the wall, and in 24 hours of test more than 110 gallons of water had passed through the wall.

In testing the cavity wall without insulation in the air space it was not possible to establish an air pressure difference across the wall of 2 inches of water. The weep holes in the outer part of the wall required the air pressure difference to be established across the inner part of the wall, but it was too air-permeable for the capacity of the apparatus. Air leakage from some of the joints could be felt with the hand, and only about 1 1/4 inches of air pressure difference across the wall was obtained

in the test. When the cavity was filled with insulation, however, pressure of 2 inches of water was obtained for the test.

During the test of the unfilled cavity wall streams of water could be seen flowing down the inner surface of the outer wall. In 24 hours of test, however, no dampness was seen on the back surface of the inner wall, and no moisture apparently had crossed the cavity.

After 24 hours the wall was removed from the test apparatus, and the cavity was filled with "water-repellent" vermiculite, poured into the cavity from the top. Sheets of plastic sealed to the bricks at the sides of the wall held the material in the cavity. The insulation-filled cavity wall was tested for 6 days and in that time there was no sign of dampness on the back of the wall. The insulating material could be observed through the window, and there appeared to be no dampness in that part of it next to the window. When the test was completed the wall was removed from the apparatus and the cavity was opened by removing the sheets of plastic along the sides. It was observed that the insulating material adjacent to the outer part of the wall was damp, and the dampness extended into the material about 1/4 to 3/8 inch. The moisture content of the insulating material as received was 0.5 per cent of the oven-dry weight (80°C) and that of a sample of the material taken from the wall immediately after the test was 7.3 per cent. There was no noticeable loss of insulating material from the cavity during the test due to drainage of water from the weep-holes.

ADDITIONAL TESTS

The same brick used in the walls described previously was also used in constructing a solid 8-inch wall with a mortar composed of portland cement, lime and sand (1:1:6). Although this wall performed considerably better than the 8-inch wall in which the masonry cement mortar was used it was nevertheless considered to be quite permeable. In 24 hours of test more than 69 gallons of water passed through it. In another wall, built of masonry cement mortar, the bricks were treated with a silicone water-repellent material before construction to reduce the high rate of water absorption of the bricks which is generally associated with poor bonding of mortar to brick and water permeability of the brickwork. The performance of this wall was better than that of the cement-lime mortar, but even so, an appreciable amount of leakage through the wall took place.

CONCLUSIONS

A particular brick was used with a masonry cement mortar and a

cement-lime mortar to construct 8-inch solid brick walls. Under test conditions simulating heavy wind-driven rain the walls were quite permeable. When the same brick was used by the same bricklayer to construct a 10-inch cavity wall, however, there was no penetration of moisture through the wall. The usefulness of cavity wall construction as a means of overcoming moisture penetration of brick walls appeared to be well demonstrated in these tests.

The particular combinations of brick and mortars used in the tests resulted in relatively permeable masonry; the performance probably could have been improved somewhat by the use of a more suitable mortar. Some degree of water permeability of a solid wall constructed of this particular brick would be expected, however, regardless of the mortar. Cavity wall construction therefore appears to be a positive means of overcoming leakage through this type of brickwork which probably would occur under severe wetting conditions.

The performance of the insulation-filled cavity wall was considered highly satisfactory. There was no evidence that water leaking through the outer part of the wall could travel across this type of insulating material to the inner part of the wall.

REFERENCES

(1) Ritchie, T. Cavity walls. National Research Council, Division of Building Research, Canadian Building Digest No. 21. Ottawa, September 1961.

(2) Ritchie, T. and W. G. Plewes. Moisture penetration of brick masonry walls. ASTM Bulletin No. 249, October 1960, p. 39-43. (Reprinted as NRC 5999.)