DBR studies relating to rain penetration (August 1959 to April 1962)

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SUBJECT

DBR STUDIES RELATING TO RAIN PENETRATION (August 1959 to April 1962)

Most of the projects mentioned in D.B.R.'s report to the Working Group of August 1959 (1) have been continued. In the work on masonry particular attention has been given to studies of factors affecting the resistance of brick masonry to moisture penetration and the strength of bond. Equipment is being assembled at present for studies of rain penetration of windows and curtain-wall panels.

Masonry Studies

A method of investigating factors influencing the rain penetration and bond strength of masonry by using small panels made of five bricks in stack bond has been described in a paper published by ASTM (2). Nearly 1000 of these small panels have been constructed and tested in the Division's studies in Ottawa and at the DBR Regional Station in Halifax on the Atlantic Coast. The results of the tests have indicated that leakage may in some cases take place through bricks if they are permeable enough, but more usually leakage occurs through channels at the brick-mortar interface. The extent of bond between brick and mortar is critical and depends largely on the condition of the upper surface of the mortar bed when a brick is laid in it. This relationship had been suggested from earlier studies, one of which was a DBR investigation dealing with loss of moisture from fresh mortars to bricks, published by ASTM in 1961 (3).

A paper summarizing the results of DBR's studies using the small-panel method has been prepared for an ASTM symposium on the testing of masonry to be held in June 1962.

The following factors which appear important to properties of brickwork have been investigated in DBR's program, and are reported in the paper.

(i) Permeability of bricks

Canadian bricks made by the extruded (stiff-mud) method do not appear to be sufficiently permeable under conditions of wind-driven rain to leak, but dry-press and soft-mud bricks are permeable, and the leakage through them may be significant. The permeability of dry-press bricks is believed to be related to initial rate of absorption, the permeability increasing with increased suction of the dry-press brick.

(ii) Initial rate of absorption of bricks

The results of DBR tests have confirmed other experiences in North America that the initial rate of absorption of bricks is an important factor in leakage and bond strength. When the value exceeds 30 g/min/30 sq in. it is probable that there will be incomplete extent of bond between mortar and brick, resulting in channels for leakage. Highly permeable brickwork may be expected from the use of high-suction bricks. Strength of bond also depends on initial rate of absorption; there is a maximum value of bond strength (for a particular mortar) when the brick suction is in the range 10 to 20 g/min/30 sq in. The strength of bond is always very low when bricks are high in initial rate of absorption (over 35 g/min/30 sq in.).

(iii) Wetting of bricks and treatment with silicones

DBR tests have confirmed other experiences that the wetting of high-suction bricks generally improves the resistance of the brickwork to rain penetration and generally improves the strength of bond, although in some instances the improvement is not considered to be significant. Treatment of high-suction bricks with a silicone water-repellent has also been found in DBR tests to produce improvement in water-tightness and in strength of the brickwork. Three DBR Internal Reports (4, 5, 6) have been prepared recently on studies of the effects of silicone treatment of bricks prior to their use in construction of masonry. Two of the reports (5, 6) compare properties of masonry of silicone-treated bricks and of wetted bricks. The effect of treatment of the surface of masonry with silicone was studied in one of the reports (5).

(iv) Roughness of bedding surfaces

In some tests it was observed that leakage occurred because a crack or depression across the brick's surface was too deep to be filled with mortar, leaving a channel for leakage. Similarly, some bricks were warped, which interfered with the development of bonding with mortar. There are no standard methods available at present for measuring these properties of bricks but nevertheless they appear to be important in the performance of the masonry.

(v) Consistency of mortar

It has been observed in several North American studies, and confirmed by those of DBR, that the fluidity of mortar at the time it is used to lay bricks has an important influence on tightness and strength of bond of the masonry. It is generally accepted that the mortar should be as wet as possible when used, but not to the point at which segregation of cementing material from the sand takes place, or at which the mortar is so fluid that it runs from the joints.

In DBR studies the use of mortar which had stood for several hours after mixing and was then re-tempered to the same fluidity as fresh mortar, produced masonry which was inferior in tightness and strength to that of mortar which was used fresh.

(vi) Water retention value of mortar

Results of DBR tests confirm those of other laboratories which indicate that this property of mortar has a significant influence on resistance of masonry to moisture penetration, and also on the strength of bond, superior performance of brickwork being associated with higher water retention values of the mortar.

(vii) Time interval in laying bricks

Besides careless work, in which mortar joints are not completely filled or where bricks are moved after the mortar around them has stiffened, there are other factors connected with the technique of laying bricks that affect the properties of the brickwork. One such factor is the length of time between laying a bed of mortar on a course of bricks and placing bricks in it. This time interval may vary over a wide range depending on the distance the bricklayer strings out the mortar bed in advance of placing bricks in it. DBR studies have shown that the permeability of masonry generally increases as the time interval is increased; in

many cases a time factor of 1½ or 2 minutes was sufficient to produce extremely permeable masonry, whereas with the same materials a time factor of 1 minute or less resulted in "tight" masonry. Bond strength also depends on the time interval; in general it decreases sharply when the time interval is increased.

(viii) Tapping bricks into mortar

Bricks may be tapped with the trowel to "bring them to line", or, depending on the circumstances, they may be shoved into place without tapping. This part of the bricklayer's work may be subject to considerable variation. Many tests have been made by DBR to determine the effect of variation in the manner of bedding bricks in mortar. It has been found in general that by increasing the energy expended in bedding the brick in mortar (by increasing the impact of tapping) the resistance of the masonry to rain penetration is improved and there is an increase in bond strength.

The studies made by DBR have confirmed the results of those made elsewhere that the resistance of brick masonry to moisture penetration and the strength of bond between brick and mortar depend on many factors, notably the properties of the materials used, and the manner in which brick and mortar are brought together to form masonry. The extent of bond established between brick and mortar is critical to the performance of the masonry; it depends in great measure on the condition of the upper surface of the mortar bed when a brick is laid in it.

Rain penetration of windows and curtain walls

An apparatus is being constructed for research on rain penetration of curtain wall panels and windows, designed on the basis of the Norwegian method of test. An air pressure difference across the test sample will be employed, with drops of water thrown against the surface; provision will be made for varying the angle at which the water drops strike the surface.

Tests of the air leakage characteristics of windows are being made at present in the Division.

Cavity Walls

Although cavity walls have not been used extensively in North America, there is increasing interest in their use, particularly in connection with insulated cavity walls. It may be possible with newly developed insulating materials to fill the cavity, but at the same time not harm the resistance of the wall to rain penetration. A rain penetration test of

such a wall, in which water-repellent vermiculite was used, has been described (7).

Weather studies

Observations are being continued of directional rainfall on vertical surfaces at the Division's test hut installations at Ottawa. The observations have been made for several years and it is hoped to analyze them soon to correlate the amounts of directional rainfall with the ordinary vertical rainfall and wind speed and direction. Measurement of evaporation of water is also being continued.

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