WATER PENETRATION TEST ON CONCRETE BLOCK MASONRY

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This paper considers the actual standards in the Brazilian building code related to the performance parameters of external walls resistance to water penetration. It describes a test method to assess the resistance to rain water penetration and leakage of structural masonry walls with concrete block and mortar rendering. Specific equipment was developed in order to measure the effects of abrupt temperature changes on the permeability of the coating. The results of the experiments are discussed and the high performance of structural masonry to water penetration was verified in walls with mortar coatings, even in the cases of unfilled vertical joints. The test method includes the development of a simple test chamber to performance assessment of the resistance to rain water penetration in walls, of structural masonry or other materials.

Keywords: resistance to water penetration, performance, structural masonry

INTRODUCTION

The new Performance standard NBR-15575 (2010) of the Brazilian Building Code is in the approval phase and in its Part 4 establishes test methods to assess the resistance to rain water penetration of external structural masonry walls.

The Performance standard indicates two methods; one to test wall specimens in laboratory conditions, and another to test built walls in the construction site conditions. For the laboratory tests the use of a test chamber with water spray pipe ensuring continuous flow and homogeneous water coverage, with air pressure applied uniformly over the surface. For the tests in the construction site a test chamber with a box format, with internal dimensions of 160 mm x 340 mm, without air pressure, has been used.

The laboratory test chambers normally have large dimensions and different measuring devices, allowing for larger wall areas to be evaluated and for better control of the test parameters.

In this work, a test chamber is presented, which is neither as sophisticated as the ones normally used by the large laboratories, nor that simple as the one indicated by the code for tests in the construction site. However, its dimensions and regulating devices allow the test to be performed both in the laboratory and in the construction site with a good level of acceptance for the expected results in this type of test.
The results of tests to assess the resistance to water penetration through concrete block walls, with traditional mortar rendering, are presented to illustrate the use of the developed test chamber.

**SPECIMENS AND EQUIPMENT**

Two specimens with the geometrical characteristics represented in Figure 1 were built to the tests for water penetration and leakage. These walls were executed with concrete blocks of 8 MPa and laying mortar trace 1:1:6. One side has a mortar coating of also trace 1:1:6, applied in a single layer with 25 mm of thickness. In this face of the wall it was intended to represent what would be a common type of external coating. Each wall has 2.40 m in height and 2.40 m in length.

![Figure 1: Test walls for rain water penetration and leakage](image)

The test chamber was designed and built with reference to the specifications of the ASTM E 514 (1990), the Project EPUSP/TEBAS (1988) and the defined method in IPT (1998).

The test chamber was designed for easy handling and transportation and so has smaller dimensions than the specified by the methods of the ASTM (1990) and IPT (1998). The effective area for water application is 700 x 700 mm. Another characteristic in the configuration of the equipment is that it can be fixed both in structural masonry or in non-structural masonry walls. In the case of non-structural masonry it would be fixed with screws going through the wall, in the case of structural walls the same method can be used as well as the use of screws with bushings, but the feasibility of using screws and bushings will depend on the regularity of the surface of the coating and of the total thickness of the coating, and the thickness of the block.

Figure 2 shows the sequence of assembly of the chamber during a test for adjustment of the equipment on a panel of non-structural masonry. According to the figure, these steps would be: (a) counterframe setting, (b) counterframe fixed with through bolts, (c) counterframe internal sealing with silicone, d) fixing the test chamber, e) calibration of water flow, f) tank with water pump.
TESTS AND RESULTS
Initially, two tests were performed on the wall with the air pressure of 500 Pa (50 mm c.w.) and water flow rate of 1.5 dm$^3$/min, corresponding to a wind of 102 km/h and a rain of 180 mm/h, respectively. This wind pressure is 10 times higher than the procedure specified by the IPT (1998) and NBR-15575 (2010). After two tests of 8 hours duration it was not reported any damp patch on the uncoated back face of the wall.

Considering the results, it was decided to double the parameters of the test using an air pressure of 1000 Pa and a water flow of 3 dm$^3$/min, and the test duration was extended to 10 h. The ASTM standard defines the test has a duration of 4 hours and the method of IPT 7 hours. However, in these extreme test conditions, it was not record any damp patch in any of
the four positions tested. Regarding the number of measurements, the IPT method specifies two evaluations and ASTM three evaluations. Figure 3 shows a test in progress and the fixing used.

**Figure 3: Water penetration and leakage test and the fixing of the counterframe**

In a second phase of testing, it is introduced another type of procedure that consists of aging the coating by thermal shock to evaluate the influence of temperature and humidity variations in the resistance to rain water penetration. The method is defined in IPT (1998) and NBR-15575 (2010).

To raise the temperature of the coating a radiant panel is used, with the heat source consisting of incandescent lamps of 150 watts, and to wet the wall surface it is used a rolling paint brush, as the ones used to apply paint on walls. According to procedure, the coating temperature should be taken to 80°C and maintained for one hour, and then the coating was wetted until the temperature drops to 20°C. With the equipment used it took half an hour to reach the 80°C and about 20 minutes to the temperature to drop to 30°C. The temperature measurements were made at five points distributed uniformly in the area tested and the value achieved was measured with laser-like surface thermometer. During the time that the temperature was maintained at 80°C, the uncoated side of the wall has the average temperature of 40°C. Figures 4-a e 4-b show the test procedure.

Although the standard specifies 10 cycles of heat and water, for each wall studied 12 cycles were applied. By the time a crack appeared it was identified with the cycle number corresponding to its formation, the length was measured by a string that follows the path of the crack and the average width was measured by a fissuremeter with an accuracy of 0.02 mm. Figures 4-c 4-d. At the time of these cracks measurements the walls already had 11 months. To measure the length and width of crack it was considered a centered area 1.50 m wide x 1.80 m high. Table 1 shows the results of these measurements.

Once the coating cracked, leakage tests can be repeated to evaluate the occurrence of changes in the performance of walls. In this second phase three positions were tested on each wall and with static pressure of 500 Pa (50 mm c.w.) after 10 h of testing there was any damp patch.
Table 1: Length and width of the cracks

<table>
<thead>
<tr>
<th>Dimensions and statistics</th>
<th>Length (mm)</th>
<th>Width (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>508</td>
<td>0.024</td>
</tr>
<tr>
<td>n</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Deviation</td>
<td>182</td>
<td>0.014</td>
</tr>
<tr>
<td>SD (%)</td>
<td>36</td>
<td>60</td>
</tr>
</tbody>
</table>

With a static pressure of 1000 Pa (100 mm c.w.) during a 10-hour test, damp patches appear on the wall after 8 h of the test, 3 h and 5 h according to the position of the test, Figure 5.

In all cases where a damp patch appeared, it always starts in the laying mortar joint and then propagated along this joint with a greater speed than on the surface of the block.

The positions tested were inspected every hour, the perimeter of the damp patch was outlined and the number of hours of testing recorded, so we can make a numerical evaluation of the total moistened area and its speed of propagation. One way to facilitate this calculation is to transfer the outline of these areas to a sheet of tracing paper, Figure 6.
CONCLUSIONS
The tests results obtained indicate that a wall external coating without cracks does not guarantee the tightness of the wall to any level of rain and wind force acting on the wall.

Once the external coating is cracked, the performance of the wall is considered satisfactory since in only one case the area of the damp patch exceeded 5% of the tested area, which is the minimum in the performance standard of NBR-15575 (2020). However, it must be considered that the test parameters were much larger than those specified by the standard.
The developed test chamber is simple and inexpensive, allows users to control adequately the test parameters and its dimensions make it portable and so it can be used for tests both in the laboratory and on the construction site.

Today, with the implementation of new technologies in the construction industry, masonry and renderings, and with the proximity of the date of entry into force the performance standard, the developed equipment and the test method described in this paper serve as a subsidy for manufacturers of materials and builders to evaluate their products.

REFERENCES


ACKNOWLEDGEMENTS
Mackenzie Presbyterian University, School of Engineering, São Paulo.