PERFORMANCE EVALUATION OF WATER REPELLENTS FOR ABOVE GRADE MASONRY

Performance of water repellents for masonry

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Abstract

Water penetration across brick masonry exterior walls is a problem which asset managers, building owners and construction professionals must deal with frequently. Water repellents are often used in an attempt to resolve water penetration problems in certain remedial applications. Unfortunately the information available to building owners and construction professionals regarding the use and evaluation of water repellents is limited. Little practical information exists to assist in the selection of such products and in the evaluation of their performance and durability. As part of a CMHC research project, an evaluation of such products was carried out, exposing the problems of performance evaluation of water repellents for above grade masonry. Six series of tests were conducted using a modified ASTM E-514 procedure and water uptake tube methods to evaluate the performance of five commercially available masonry water repellents. The results of the study have indicated substantial improvements in the resistance to water penetration upon application of these products to clay brick wall assemblies. The data accumulated during this study may have also revealed a trend indicating an increase in the rate of water penetration from the time of product application (i.e.; reduced repellency), necessitating product reapplication after a given time interval. Readers are cautioned in the interpretation of the test data without additional information pertaining to the vapour diffusion characteristics of the applied products and durability concerns.

Keywords: water repellent, masonry, performance, durability, water penetration

1 Introduction

Water repellents are too frequently used as a quick fix in an attempt to resolve water penetration problems for certain remedial applications on brick masonry exterior walls. Water repellents can be effective in reducing water infiltration in certain applications if applied following a thorough diagnosis of the underlying problems and providing that the wall is properly maintained. However, the application of a water repellent is not a miracle remedy for water penetration problems and proper selection of an appropriate product to meet a project's particular needs is essential to secure the performance sought. Unfortunately, information regarding the use and evaluation of water repellents is limited. Little practical information exists to assist in the selection of such products and in the evaluation of their performance and durability. The research project presented in this paper explains and discloses the problem of performance evaluation of water repellents for above grade masonry.

The primary objectives of the research work were to independently evaluate the performance of various water repellents on a comparative basis and to develop practical methods to evaluate their effectiveness in reducing water penetration. In addition, the intent was to monitor short and long term performance of repellents after exposure.

2 Project methodology

In order to address these objectives, three test procedures were used for purposes of evaluating water repellent performance. These tests included a modified ASTM E-514 test procedure and RILEM water uptake tube tests, to evaluate water penetration performance and air infiltration tests to evaluate air leakage characteristics of panel assemblies.

Another very important aspect in the evaluation of water repellents, not covered by this study, is vapour diffusion performance. This essential facet must also be considered in the selection of a water repellent and is currently being investigated.

2.1 Test chamber

A specially designed test chamber was built and six brick wall specimens were erected as shown in Fig. 1 below. Five of the panels were treated with different water repellents for comparative testing. The test chamber was positioned so that the specimens maintained a permanent southern exposure. A series of six tests of both types were undertaken between the months of May to November 1996.

The ASTM E-514 test method provides specific guidelines for a water penetration test chamber system. However, in order to be able to address all of the project’s criteria, a custom designed test chamber was constructed. The test chamber was designed to receive the six brick specimens measuring each 1.57 m in height by 1.42 m in width. Refer to Fig. 1.

With particular attention to air tightness, all chamber joints were sealed from the interior and special care was taken to ensure a continuous air seal. The chamber was provided with an airtight access door, interior lighting, a water collection system and an exterior pressure reference. Refer to Fig. 2 for a schematic representation of the test set-up.

2.2 Sample preparation

The brick wall specimens were erected by professional masons. Standard clay brick with nominal dimensions 230 mm x 70 mm x 88 mm and pre-mixed mortar was used to construct the samples and were erected over a consecutive two day period under conditions similar to normal site conditions. Particular attention was taken to ensure consistency in the laying of the bricks and mortar preparation.

The test panels were each treated with a different product specially developed for masonry applications. One of the six panels remained untreated and served as a control panel. Refer to Fig. 1 for the identification of test panel assemblies.

2.3 Choice of water repellents

Five water repellent products were used in this research project. Their selection was based on the following criteria:

- Reputability and sound technical support
- Product selection and presence in the market place
- Commitment to product research and development
- Willingness to participate

The products evaluated are identified generically as:

Panel A: 40% Silane (solvent based)
Panel B: Polysiloxane blend (solvent based)
Panel C: Silane/polysiloxane blend (water based)
Panel D: Siloxane/silane blend (water based)
Panel E: Elastomeric waterproof coating
Panel F: Control Panel (no coating)

The products were applied by their respective manufacturers in accordance with their written recommendations.

2.4 Testing methodology

A description of the various test methods utilized for this research project is presented in the following sections.

2.4.1 Modified ASTM E-514 test method

The ASTM-E514 test procedure was developed for laboratory testing to evaluate water penetration and leakage through masonry. Several modifications to the standardized test chamber and procedures were undertaken to accommodate all of the proposed tests and to permit weathering to simulate field conditions. In order to accelerate the tests, interchangeable spray racks were built for simultaneous testing of up to three samples.

In accordance with ASTM E-514, a differential test pressure of 500 Pa and a water application rate of 138 l/hr per square metre of wall area were utilized. A minimum sample area of 1.11 m^2 was exposed to the test and a minimum sample height and width dimension of 1,219 mm was also respected. As specified by the test

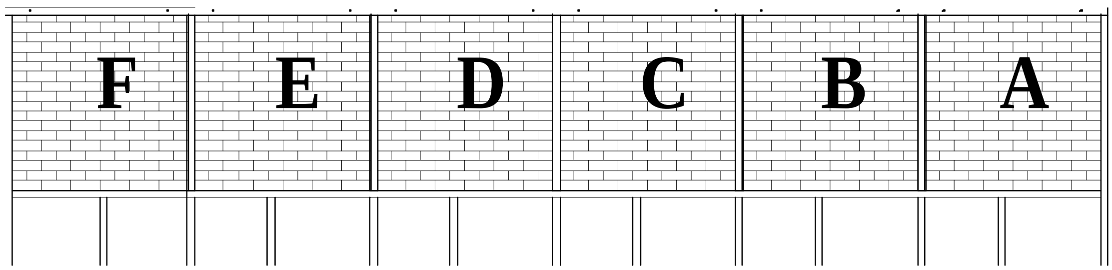

Fig. 1: Identification of test panel assemblies

procedure, testing was carried out continuously for a four hour period. Water which penetrated the wall assemblies under test conditions during this time was collected and measured. The test setup and its various components are shown in Fig. 1 and Fig. 2, respectively.

2.4.2 RILEM water uptake tube test method

The testing apparatus consists of a graduated pipe-like apparatus designed for measuring water uptake on vertical surfaces (refer to Fig. 3). Several versions of the tube are available and vary in construction depending on their supplier. A tube manufactured by ProSoCo was arbitrarily chosen for use in the testing.

The tube is graduated from 0 to 5 ml with each graduation representing an increment of 0.5 ml. The tube was fixed and sealed to the masonry surface under evaluation and filled with water. The quantity of water absorbed by the surface of the masonry material over a specific period of time was recorded and used to characterize the walls' repellency. Testing was conducted in accordance with RILEM II.4 test method, developed by the International Union of Testing and Research Laboratories for Materials and Structures or RILEM (Reunion Internationale des Laboratories d'Essais et de Recherches sur les Matériaux et les Constructions). At most four readings were carried out per wall specimen; two readings at mortar joints and two readings on the face of the brick unit.

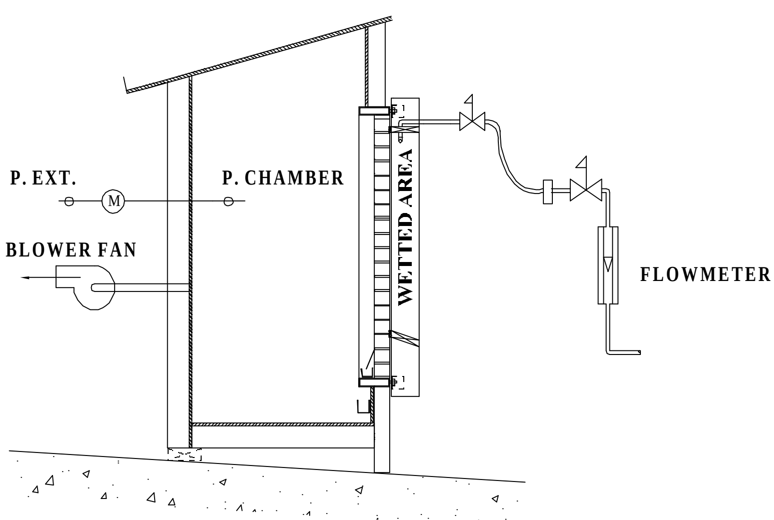

Fig. 2: Modified ASTM E-514 test apparatus

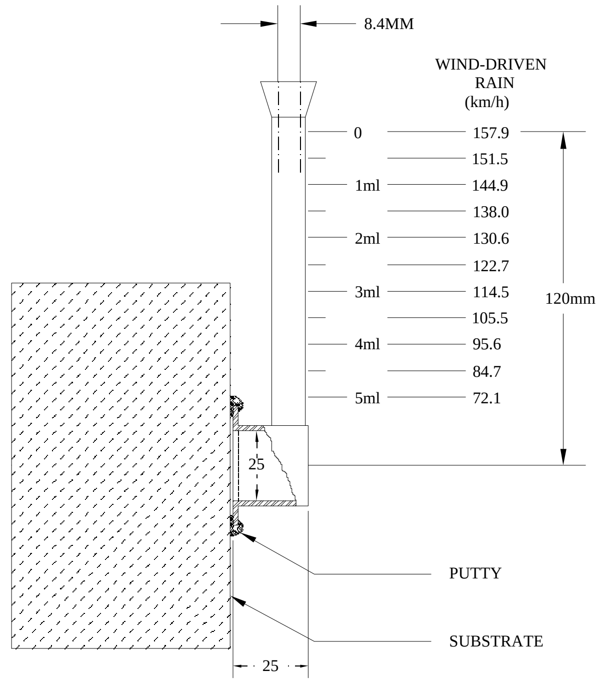

Fig. 3: Water uptake tube test apparatus

2.4.3 Air infiltration test

Air infiltration tests were undertaken with a separate air chamber designed to fit on the interior side of the wall specimen and clamped to the chamber framing for testing of individual specimens. The chamber and test set-up are shown schematically in Fig. 4. The rate of air leakage through each of the specimens was determined through the use of calibrated orifice plates.

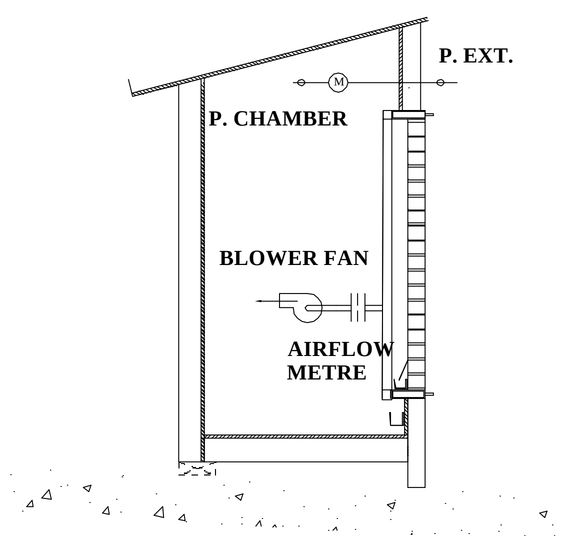

Fig. 4: Air infiltration test apparatus

3 Analysis of results

Given the preliminary nature of the experiments and the limited available data, comments presented in the following sections are solely for general discussion purposes. It is not the intent of this paper to draw any definite conclusions from the data. As such, the basis of the following discussions will be that of establishing possible trends and to obtain an understanding of the performance of products under evaluation and the limitations of the test methods employed.

3.1 Modified ASTM E-514 testing

The relationship between accumulated water (which passed through the specimens) and elapsed time of the test were examined.

The rates of water penetration through the untreated masonry panels ranging from 5,176 ml/hr to 12,265 ml/hr were noted once steady flow conditions were obtained. Three generalized bands of flow rates:5,000 to 6,000 ml/hr, 11,000 to 12,000 ml/hr and 9,000 ml/hr for panels A and E, panels B, C, and D, and F, respectively were recorded.

Upon first examination of the data, the relationship between accumulated water and elapsed time appeared to be quasi-linear after an initial transitory period, for most of the test specimens (coated and uncoated). However, this transitory period appeared to be very short for untreated panels where an almost true linear relationship was attained after approximately one half hour of testing. For panels treated with masonry coatings, this transitory period was estimated to be approximately two to three hours prior to attaining steady flow conditions.

The variation in water penetration rates for the untreated panels may be attributed to the inherent anisotropic nature of the materials and slight imperfections introduced during the assembly of the test panels.

Application of the various masonry coatings to test panels A through E resulted in a dramatic decrease in the rate of water penetration for all coated panels; as was demonstrated by a series of tests which were conducted 35 days after product application. Generally, a reduction of 44% to 99% from the initial water penetration rates of the uncoated panel assemblies were obtained.

A consistent drop in the performance of masonry panel assemblies was noted for the water penetration test results conducted over the seven month testing period. The performance of panel assemblies was plotted with respect to time and is presented in Fig.5. The gathered data may indicate a trend of decreasing performance over time. However, additional data is required to fully support this claim.

Based on the limited test data, the rate of percentage decrease in performance over the initial base performance of the uncoated panels was estimated for the various masonry water repellent materials. Based on these rates, the performance decrease and the projected reduction in water penetration for the assemblies were estimated for periods of three, six and nine months, and one, two and three years following application of the masonry coatings. Based on the estimated rates of performance decrease, several of the applied coatings may require reapplication within two years in order to maintain a suitable level of effectiveness.

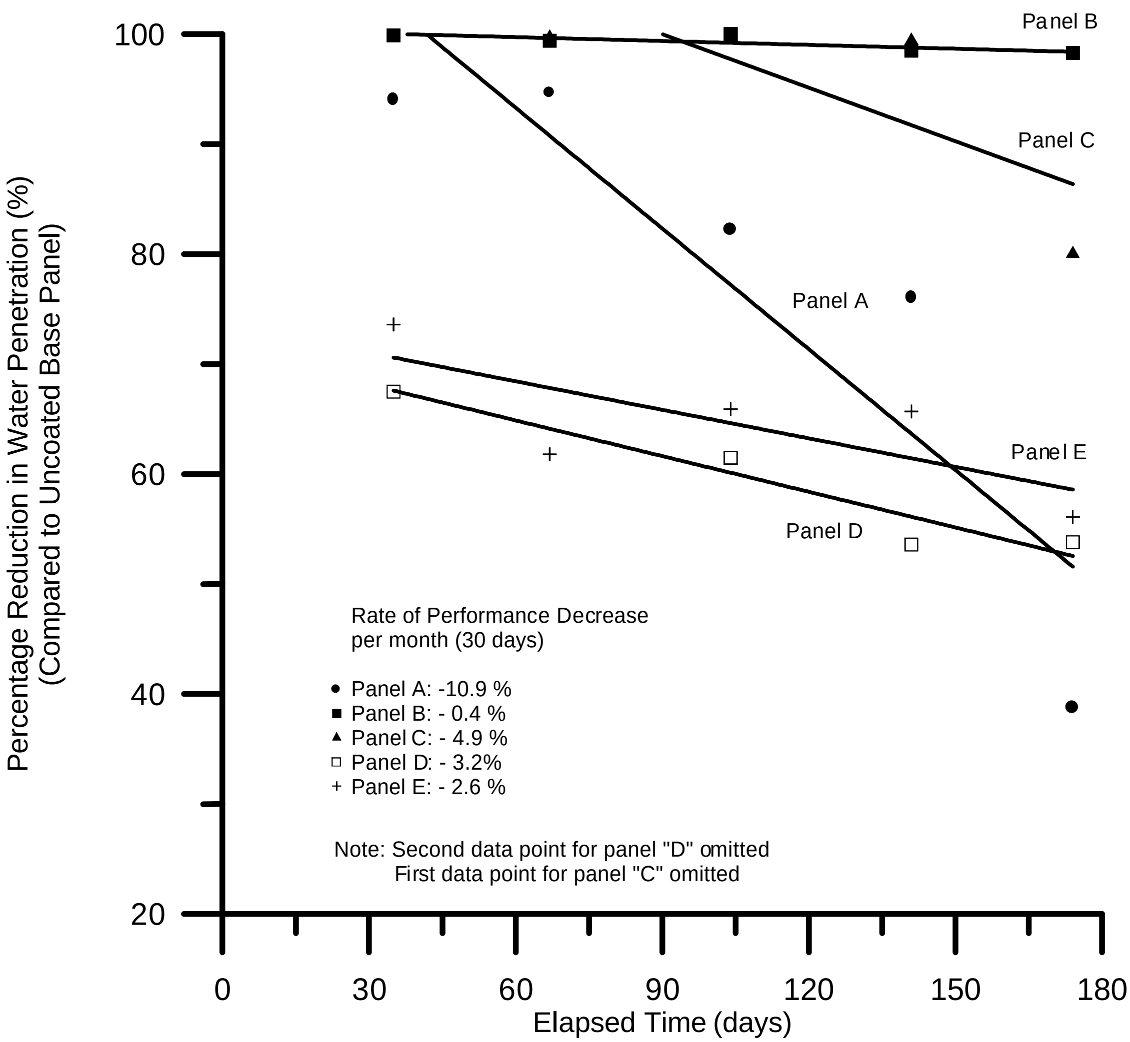

Fig. 5: Estimated coating performance vs. time

3.2 RILEM Water uptake tube tests

Detailed data representing the time required to empty the graduated 5 ml volume of the test tube was recorded for predetermined locations on the surface of panel assemblies A through F. The data retrieved from these initial tests was observed to exhibit variability similar to that noted for the modified ASTM E-514 tests. In particular, substantial differences were noted between the results obtained from complementary test positions for mortar joints and brick face of uncoated panel assemblies.

As noted in the analysis of results for the modified E-514 tests, this variability may be attributed to localized material anomalies and minor imperfections introduced within the test panels during assembly. This phenomena was more pronounced for the water uptake tube tests given the highly confined nature of the test. At some of the test locations, the volume of the uptake tube was emptied instantaneously due to voids within mortar joints or through the seal between the uptake tube and the masonry surface. In these particular cases the results were discarded.

In comparison, the rate of water penetration obtained across masonry joints exceeded that through the brick face locations by a factor of 5 to 30 (approximately), disregarding high and low values. With regards to the reduction in the rate of water penetration across the panel assemblies at the mortar joints, reductions in the order of 30% to 100% in comparison to the uncoated or base panel assembly were obtained. Reductions in the order of 90% to 100% were obtained at the brick face test positions.

A reduction in the rate of water penetration in the order of 5% to 25% was also observed at the brick face for the control panel F. In comparison, an increase of approximately 50% to 60% was observed for the rate of water penetration in the control panel at mortar joints. This variation may be exposure related as climatic factors may have had an impact on the results of the experiments.

The limited data presented in this part of the discussion would indicate that water penetration test results obtained though the water uptake tube method are drastically influenced by the location at which the test is conducted. Given significant differences obtained between measurements at mortar joints and the face of the brick, it was clear that considerably more data would be required to accurately evaluate the performance of masonry coatings on a masonry substrate utilizing this method. As such, an evaluation of individual product performance cannot be undertaken. However, the available data indicates that as a whole, all of the products exhibited very high levels of water repellency.

With regards to changes in performance over time, four of seven water uptake tube tests conducted at mortar joints indicated a decrease in water repellency over time. In comparison, eight of twelve tests conducted at the brick faces likewise demonstrated a decrease in repellency over time. Given the limited data, no generalization can be made regarding the performance of repellents over an extended period, based on the water uptake tube method.

3.3 Air infiltration testing

The experimental data obtained prior to and following the application of the masonry coatings indicated no significant change in performance for any of the panel assemblies. As such, it was concluded that the application of masonry coatings had no impact on the air flow characteristics of the panel assemblies. In addition, very similar leakage characteristics were obtained for all panel assemblies (including coated assemblies) at various differential test pressures. Average leakage rates were determined to range from 0.23 $l/s\bullet m^2$ at 25 Pa differential pressure to 1.85 $l/s\bullet m^2$ at 300 Pa differential pressure. All air infiltration rate determinations were conducted prior to water tests.

4 Conclusions and recommendations

Three test methods were utilized over a period of seven months for the purpose of evaluating the change in performance of repellency induced by the application of coatings on six masonry panels. A summary of the results has indicated substantial improvements in the resistance to water penetration upon application of commercially available masonry repellents. This change in performance was primarily evaluated through the use of a RILEM water uptake tube method and by ASTM E-514 test method adapted for the requirements of this particular study.

Although these improvements in water repellency were generally confirmed by these two test methods, limitations were noted for each of the methods. Several factors were identified which could influence or bias test results.

With regards to the modified ASTM E-514 test, slight, normally occurring imperfections in the wall assembly, including small openings in the mortar to brick interface provoked variations in performance. The importance of these small openings at the given test pressure of 500 Pa cannot be neglected as significant amounts of water may easily be transported through the presence of these small discontinuities through the masonry.

As such, the evaluation of the resistance to water penetration for a masonry panel (or any other assembly for that matter) with this method requires a larger sample population to better evaluate the effect of imperfections of the assembly on the test results. Otherwise, an evaluation based on the modified E-514 method would be more representative of a combined assembly performance (i.e. masonry & water repellent) rather than the performance of the repellent itself.

The water uptake tube method for the evaluation of water repellency also has limitations. By the very nature of this particular test method, results obtained by the water uptake tube method are representative for a highly localized area and are very susceptible to surface imperfections. This is especially important at points of material transition, as was confirmed for mortar joints in the brick panel assemblies. An accurate assessment of a material's water repellency or resistance to water penetration based on this method would require a significant number of tests distributed over a large surface.

Barring local material or assembly imperfections, the evaluation of a masonry coatings by the water uptake method should in theory be a better gauge for a comparative evaluation of coating performance (as opposed to that of the assembly). This is supported by the preliminary data in which all coating materials exhibited high water repellency characteristics, as evaluated for the brick face of the masonry. These same coatings, evaluated by the modified ASTM E-514 procedure, produced significantly different results.

The modified ASTM E-514 test data may have revealed a trend indicating an increase in the rate of water penetration over time in comparison to results obtained following the initial application of the masonry coating products. As mentioned earlier in this report, this phenomena may be due to product deterioration which would necessitate reapplication of some products after a given time interval. Additional investigation is required to evaluate this phenomena.

With regards to the air leakage characteristics of the wall assembly, the preliminary test data indicated no significant change due to application.

Although the resistance to water penetration is an important criteria in the selection of a water repellant, consideration to vapour diffusion performance is also an essential performance characteristic which must be considered prior to selection. The study of vapour diffusion through masonry panel assemblies coated with water repellents is currently being evaluated. Readers are cautioned in the interpretation of the test data without additional information pertaining to the vapour diffusion characteristics of the applied products and the durability of performance.

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