8TH CANADIAN MASONRY SYMPOSIUM

Jasper, Alberta
May 31 - June 3, 1998

PERFORMANCE EVALUATION OF WATER REPELLENTS FOR ABOVE GRADE MASONRY

Domenic Chiovitti, Mario Gonçalves, Antonio Renzullo
Patenaude-Chiovitti Inc.
Varennes, Quebec, J3X 1P7

ABSTRACT

Water penetration across brick masonry exterior walls is a problem which 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, Patenaude-Chiovitti Inc. carried out an evaluation of such products, exposing 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 repellants. 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..

INTRODUCTION

Water penetration across brick masonry exterior walls is a problem which building owners and construction professionals must deal with frequently. Sources of water leakage are often difficult to determine and are frequently a result of poor workmanship, design and the quality or integrity of the brick masonry units and mortar joints. Water repellents are often used in an attempt to resolve water penetration problems in certain remedial applications. Water repellents can be effective in reducing water infiltration in certain applications, if applied after proper diagnosis of the underlying problem and ensuring that the wall is properly maintained. It is important however to remember that 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 ensure proper performance.

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. The research project presented in this paper exposes the problem of performance evaluation of water repellents for above grade masonry.

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

Another aspect in the evaluation of water repellents, not covered by this study, is vapour diffusion performance. This important characteristic should also be considered in the selection of a water repellant and is currently being investigated under a separate mandate.

OBJECTIVES AND SCOPE OF WORK

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.

PROJECT METHODOLOGY

A specially designed test chamber was built and six brick wall specimens were erected and treated with different water repellents, for comparative testing. The test chamber and specimens were constructed outside and positioned so that the specimens maintained a permanent southern exposure. A series of six tests were undertaken between the months of May to November 1996. The following is a description of the test chamber, sample preparation, choice of water repellents and testing methodologies and procedures.

Test Chamber

The test chamber design criteria included the following considerations.

- Sample size
- Air pressure
- Exterior exposure
- Water collection
- Flexibility
- Working area
- Handling of samples
- Stability
- Access to wall samples

Although ASTM E-514 provides specific guidelines for a water penetration test chamber system, this system does not address all of the primary criteria previously outlined for this project. In order to be able to address all of these criteria, a custom designed test chamber was constructed. The test chamber was designed to receive a total of six brick wall specimens measuring 1.57 m in height by 1.42 m in width. Refer to Fig. 1.

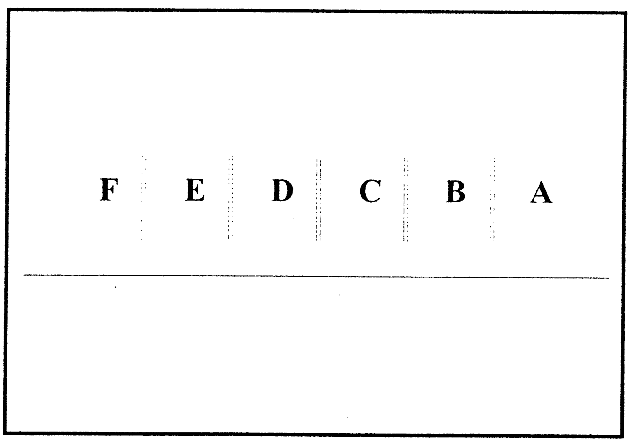

Fig. 1: Identification of Test Panel Assemblies

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.

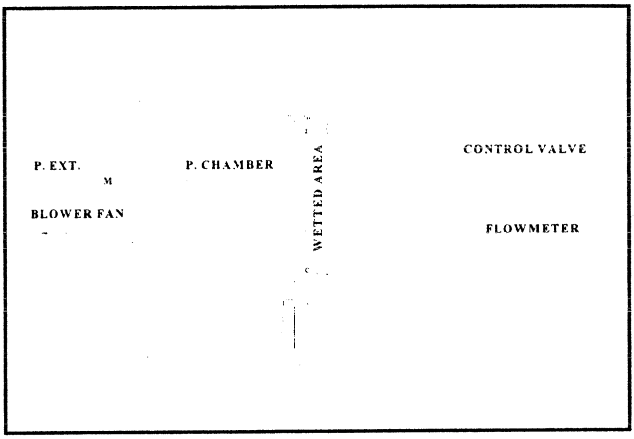

Fig. 2: Modified ASTM E-514 Test Apparatus

Sample Preparation

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

The samples consisted of 20 rows measuring 6 brick lengths in width each, with 10 mm concave tooled mortar joints, for a total dimension of 15,875 mm in height by 14,288 mm in width.

Choice of Water Repellents

A total of five water repellent manufacturers participated in this research project. The selection of manufacturers was based on the following criteria:

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

After discussions with each of the participating manufacturers, a water repellent from their product line was selected. Each of the selected water repellents was specially developed for masonry applications.

Each of the test panels was treated with a different product (with the exception of one of the six panels which remained untreated - control panel). In order to protect the manufacturers' identity, each of the products are identified generically. Product identification per panel is as follows:

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)

Refer to Fig. 1 for the identification of test panel assemblies. The products were applied by their respective manufacturer in accordance with their written recommendations.

Testing Methodology

As previously stated, the evaluation of product performance comprised a modified ASTM E-514 water penetration tests, water uptake tube tests and air infiltration tests. A description of the different test methods is presented in the following sub-sections.

Modified ASTM E-514 Test Method.

The ASTM-E514 test procedure was developed for laboratory testing to evaluate water penetration and leakage through masonry. In order to simulate site conditions, several modifications to the test chamber and procedures were undertaken. These modifications permitted access to both sides of the test specimens during testing. Interchangeable spray racks were built for simultaneous testing of up to three samples. Testing was carried out under field conditions for exposure and weathering.

As per the ASTM E-514 test procedure, a differential test pressure of 500 Pa and a water application rate of 138 l/hr per square metre of wall area were utilized. With regards to sample dimensions, a minimum sample area of 1.11 m^2 exposed to the test and a minimum sample height and width dimensions of 1,219 mm were also respected. As also specified by the test procedure, testing was carried out continuously for a four hour period. Water which penetrated the wall assemblies under test during this time was collected and measured. Refer to Fig. 1 and Fig. 2 , for the test setup and its various components.

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.

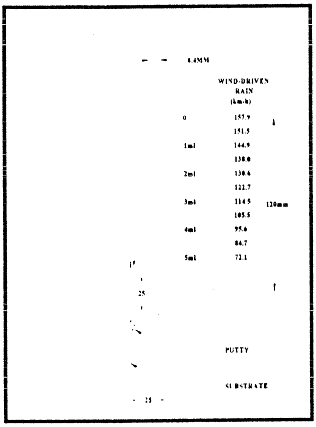

Fig. 3: Water Uptake Tube Test Apparatus

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 as per the 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.

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 rate of air leakage through each of the specimens was determined through the use of calibrated orifice plates. Refer to Fig. 4 for a schematic of the test set-up.

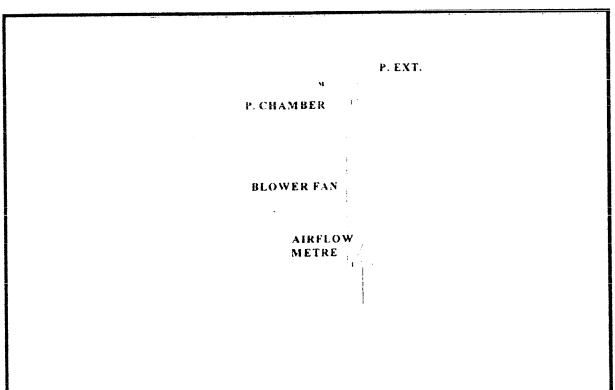

Fig. 4: Air Infiltration Test Apparatus

ANALYSIS OF RESULTS

The goal of the following sections is to discuss the test results and to evaluate the performance of products, assemblies, and test methods. 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.

Modified ASTM E-514 Testing

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

With regards to the rate of water penetration through untreated masonry panels, flow rates ranging from 5,176 ml/hr to 12,265 ml/hr were noted once steady flow conditions were obtained with performances of the various test panels falling into three generalized groupings being 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.

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.

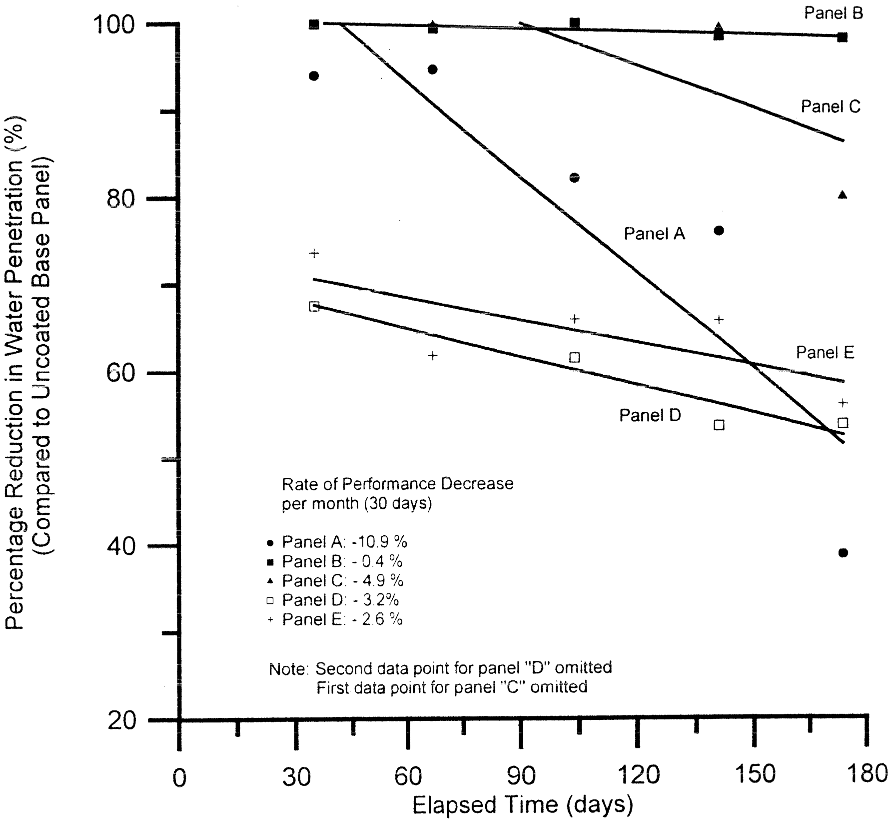

Fig. 5: Estimated Coating Performance vs. Time

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 repellant 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.

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 noticeably more pronounced for the water uptake tube tests given the highly localized 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), excluding 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 34.1% to 99.7% in comparison to the uncoated or base panel assembly were obtained. For brick face locations, reductions in the order of 91.4% to 99.9% were obtained, in which the panel assemblies (at the brick face) were rendered almost totally impervious.

A reduction in the rate of water penetration in the order of 4.5% to 24.6% was also observed at the brick face for the control panel F. In comparison, an increase of approximately 49% to 57% 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 impacted 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 highly 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 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.

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.

CONCLUSIONS AND RECOMMENDATIONS

Several test methods were utilized over a period of seven months for the purpose of evaluating the change in performance brought on by the application of coatings on seven masonry panels. A summary of the results, presented in previous sections of this paper, have indicated substantial improvements in the resistance to water penetration upon application of commercially available masonry coatings. This change in performance was primarily evaluated through the use of a 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 E-514 test, slight, normally occurring imperfections in the wall assembly, including small openings in the mortar to brick interface contributed to its overall leakage rating. 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 conduits through the masonry.

Given this, it becomes evident that the evaluation of the resistance to water penetration for a masonry panel (or any other assembly for that matter) with this method will require 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.

In comparison to the modified ASTM E-514 method, the water uptake tube method for the evaluation of water repellency is also limited. 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 noted at mortar joints in the brick panel assemblies.

Therefore, it is our opinion that 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 improvement in a masonry wall's performance.

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 important 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 as a separate mandate. 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.

ACKNOWLEDGMENTS

This project was carried out for the Canada Mortgage and Housing Corporation (CMHC) by Patenaude-Chiovitti Inc. Project Manager Domenic Chiovitti of Patenaude-Chiovitti Inc. would like to express his appreciation to the following individuals and organizations for making this project a success.

- Jacques Rousseau
  Canada Mortgage and Housing Corporation

- Jean-Claude Grenier
  Institut national de la recherche scientifique

- Armand Patenaude
  Air-Ins Inc.

- Representatives of participating masonry coating Manufacturers

- Domenic Campanozzi
  Restaurations DYC Inc.

- Robert Grignon
  Briqueterie St-Laurent