Characteristics of Effective Waterproof Sealers for Masonry Project

Introduction and Background

As Canada's large stock of existing buildings age, the enclosure systems need to be repaired, and retrofit, usually by replacing joint sealant, repairing cracks, adding flashing. Sometimes buildings are upgraded through the addition of insulation, new cladding, air barriers, etc. to prolong or change the building's function while reducing energy use. All of these changes are intended to improve enclosure performance and prolong its life. However, is not uncommon for these "improvements" to cause failure in a short time because these retrofits result in effects that cannot be predicted using existing design guidelines or techniques.

A promising range of products that are not often used, likely because of fear of failure, are waterproof sealers for masonry and concrete walls. Masonry waterproofing coatings are used to reduce the absorption and penetration of rainwater into and through masonry or concrete walls. A significant proportion of high-rise residential buildings, and many commercial structures, is clad with masonry or concrete.

Water penetration through the cladding, a common complaint, can sometimes be solved by the application of waterproof sealers.

When upgrading older buildings, the addition of an internal layer of insulation may be economical and aesthetically desirable, but results in severe exposure for the cladding. The cladding can experience accelerated deterioration due to the upgrade. The application of waterproof sealers may allow the cladding to be exposed to colder temperatures without damage if it can be kept dry.

However, if the sealers do not allow sufficient drying, accelerated deterioration can occur. Experience has shown that some water-repellent sealers, when applied to masonry, can inhibit the drying of walls and thereby actually increase the risk of freeze-thaw damage and sub-fluorescence spalling.

Most manufacturers of such products maintain that properly used, such problems are unlikely. However, despite the assurances of the sealer industry, users are cautious. Even the most vapour permeable (or "breathable") sealers will limit the outward movement of moisture by capillary action to the brick surface, where most of the evaporation normally takes place. Further, overly zealous homeowners or contractors are often inclined to put more sealer onto the wall than is necessary, sometimes aggravating the situation. There are also no effective procedures available for the assessment and application of sealers to buildings.

As a result of the above, the brick industry has been reluctant to recommend the use of water repellents on brickwork in areas which experience freeze-thaw conditions. For example, the Brick Institute of America (BIA), the largest Canadian brick manufacturers (e.g., Canada and Brampton Brick), and many consultants (e.g., Clayford Grimm) do not endorse the use of waterproof sealers.

Unfortunately, this stance may well eliminate products and applications which actually do work effectively and hence exclude possible solutions to moisture problems.

The first-generation of waterproofing coatings often caused serious problems, primarily because their use allowed very little drying. A second generation of more "breathable" (more vapour permeable) waterproofing coatings, usually silicones, continued to exhibit problems by trapping water in the cladding in some circumstances. A third generation of penetrating waterproofing sealers, usually silane and siloxane based, is now available which promise major benefits (e.g. reduced freeze-thaw risk, reduction of rain penetration).

Proposed Research Project

A pair of meetings were held at the offices of Canada Brick to discuss the possibility of a research and demonstration project to study the characteristics of effective sealers for masonry walls. The University of Waterloo, Canada Brick and Brampton Brick organised the meeting. Representatives of various manufacturers of waterproofing, water repellents, and sealers were present at the meeting or expressed an interest. These included CPD, Tristar, Sternson, Harris Specialty, Dow-Corning, Drizoro, DRE Industries, WR Meadows, and Gemite.

The goal of the project is to provide firm recommendations for sealer properties that consultants and manufacturers can demand from manufacturers and use with confidence. Achieving this goal will likely require the development of better test methods and physical understanding of the way various products work. The durability of these desirable properties will be a secondary goal.

It was discussed and generally agreed that the important issue is not one of stopping water absorption/penetration, since most products are effective in this role, but of assessing how the sealers affect drying. The future performance of a treated wall depends on how well it allows drying of incidental sources of moisture such as leakage around windows and joints, exfiltration condensation, or water directed by flashing into other parts of the wall. Simple vapour permeance tests are not sufficient evidence that water-repellent sealers or coatings in fact allow drying. The sealer industry currently uses non-standard proprietary test methods that are unlike any other building product vapour permeance tests.

Research Plan and Methodology

The research plan is somewhat flexible, and depends on both participant interest and funding. For this reason, a phased approach with a number of distinct tasks has been chosen. An outline of several major tasks is listed below. This is merely a first attempt, so changes are both expected and input welcome.

Task 1 - Initial Exploration

Task 1A - Review

Much of the literature has already been reviewed in the past (most of it relating to concrete bridge deck sealers), so this does not need to done again. A basic document (less than 20 pages) that summarizes the state of the art and describes what we believe to be desirable sealer properties and how to test them will be prepared as the first deliverable.

Task 1B - Brick Tests

A series of brick-only tests will be conducted. Clay (and concrete bricks) of two types of cold water absorption (high and low) will be tested for vapour permeance (modified ASTM E96) with and without a sealer. Approximately 5 types of sealer and control samples will be considered (a total of 5x2 substrate= 10 samples). The E96 test will be slightly modified to have 100%RH on the inside and about 75% on the exterior (which are much more realistic conditions than wet-cup/dry-cup tests for real walls in much of Canada when drying is needed). Water uptake (to DIN 52617) will also be measured. The same bricks will then be allowed to contact liquid water on their interior side, and the water transmission rate (e.g., drying of a constantly saturated brick) will be measured. The latter test is probably a fairly realistic replication of a problem wall.

Task 2: Brickwork Tests and Computer Extrapolation

Task2A - Wallette Tests

A similar series of tests will then be conducted on 16"x16" wallettes, made of the same type of bricks as used in Task 1 with type N mortar. Four sealers plus a control have been budgeted for (a total of 5x2 = 10 samples). This set of tests will indicate the importance of mortar joints, and provide a snapshot of how one might expect a wall to perform. If there is little difference between the brick and wallette tests, then simple brick tests may become the standard method. It is not likely to be so simple, since it is well known that almost all liquid water penetrates through the joints and it is believed that a significant proportion of vapour moves out the same way.

Only one sample of each combination will be tested. It is assumed that the brick companies will prepare and deliver the samples. The sealers will be applied by BEG.

A detailed self-standing report describing the test set-up results, and implications will be prepared.

Task 2B - computer model extrapolation

The data from the Task 1B and 2A tests will be used initially to rank performance and gain some idea of the maximum drying rates (and hence of the maximum allowable amount of moisture from other moisture sources like leaks and condensation). A one-dimensional computer model, widely verified in numerous field studies of masonry and concrete walls (WUFI Pro), will be used to demonstrate the impact of insulation level, driving rain exposure, water absorption, and orientation, imperfect air barriers, etc for five different but representative Canadian climates. The number of freeze-thaw cycles while above 93% of saturation could be used as a performance measure in the modelling.

A total of about 25 detailed simulations will be run, e.g., five different wall assemblies in five climates, plus exploratory simulations to assess the impact of orientation, etc.

A self-standing report documenting the assumptions and results will be prepared.

Task 2C - optional long-term study

After testing, the wallettes could be installed in an exposed outdoor location (a sloped southeast orientation is recommend) with insulation and vapour barrier behind them for a certain length of time (1,3,5, 7, 10 years seem like appropriate time intervals). The tests of Task 2A would be repeated at these future dates and changes in performance noted.

Task 3: Field Verification and Demonstration

Finally, to confirm and relate lab and computer work to real applications, a full-scale controlled field verification and demonstration project should be undertaken. Three full-scale 4’x8’ brick veneers (two sealed and one not), in the UW Beghut test facility so that they are exposed to the outdoor weather. The veneers would have their weight (and hence their moisture content) constantly measured by the use of a precision load cell.

Experience from previous projects has shown that a plot of moisture content of a full-scale real life wall is a powerful demonstration tool, especially when compared to a normal or typical wall that the building industry understands.

After initial proof that the sealer prevents rain absorption (via supplemental rain wetting and ASTM E514 tests), both walls would be *wetted from the interior side*, and the drying of the veneer measured in real time, in winter and spring weather. The Beghut includes extensive instrumentation for measuring weather (temp, RH, rain, wind, driving rain, driving rain deposition, solar radiation, solar radiation on the wall, etc.). The results can be compared to the results of WUFI simulations to validate the model.

The water repellence of the wall will be measured again after 1-year exposure through the use of rain penetration tests.

Task 4: Freeze-Thaw Testing

Since much of the concern with sealers relates to their effect on the freeze-thaw resistance of the masonry, a task related to assessing the freeze-thaw resistance should be included.

In this task four treated samples and a control of two types of bricks would be tested in a uni-directional freeze-thaw apparatus (i.e., freezing would start from the outside face and move inward just as in real walls). All of the brick samples would be tested with the same amount of water applied to the interior side, while the treated exterior face would be exposed to typical cold-weather atmospheric humidity. Replication would be undertaken.

Task 5: Guideline Development and Dissemination

A final report (based on at least Tasks 1 and 2), intended as a record document of the work, will be produced that outlines all the testing, results, and interpretation in such a way that replication of the work is easily possible. The report will also contain recommendations for the type of testing and the range of properties seen as desirable.

A short report (intended for manufacturers and test labs) will be prepared describing what testing procedures should be followed to generate useful test data for assessing sealers for cold climate masonry walls, along with recommended performance targets for the sealers.

A technical note (4-6 pages) for practitioners that provides recommendations on assessing a masonry wall, when to choose sealers, what properties are relevant, and how to ensure that the sealers are properly applied and maintained.