WATER-RESISTIVE BARRIERS:

How do they compare?

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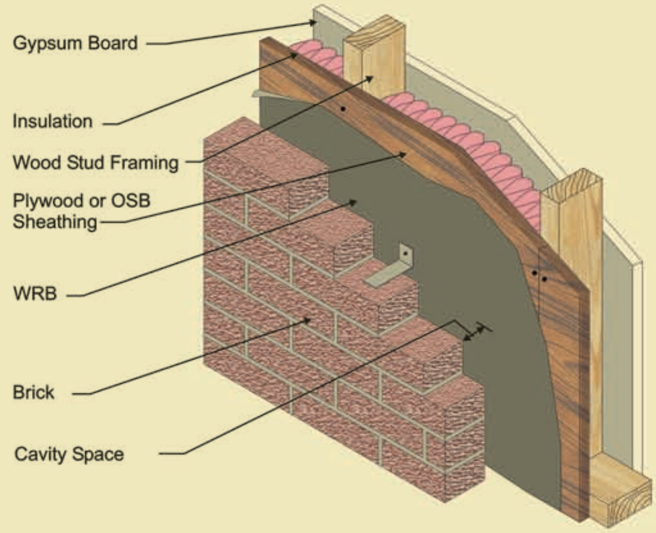

Figure 1A. Typical brick veneer installation over wood frame construction.

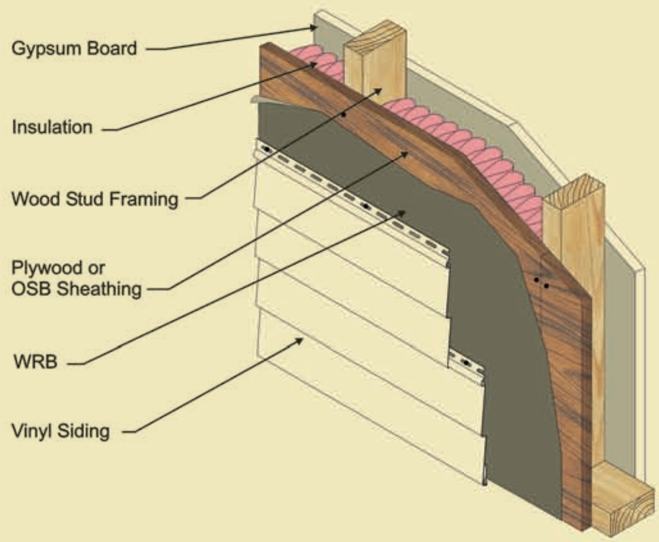

Figure 1B. Typical vinyl siding installation over wood frame construction.

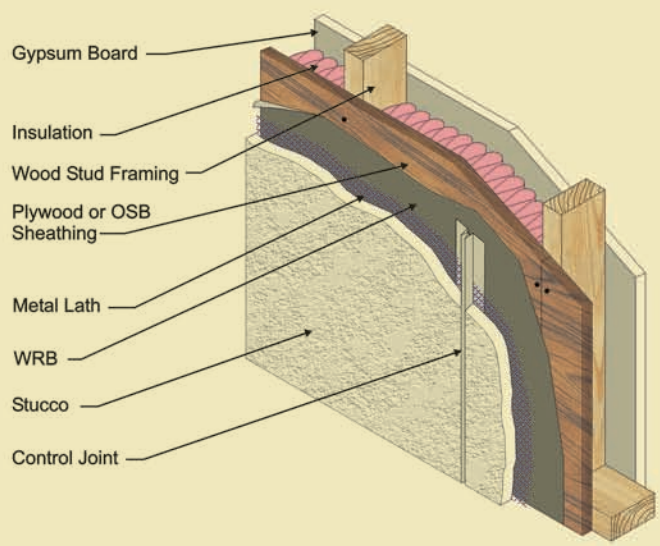

Figure 1C. Typical traditional stucco application over wood frame construction.

BACKGROUND

In general, the description of any building, whether a high-rise or a warehouse, can be simplified into two basic components: 1) the building structure, which gives the building its overall shape and resists forces from sources such as wind, snow, people, furniture (live loads), and the weight of fixed building components (dead loads); and 2) the building envelope, which separates the indoor and outdoor environments, keeping the weather outside and conditioned air inside.

The building envelope can be further broken down into two primary components: A) the roof; and B) the exterior walls. As part of the building envelope, exterior walls have the task of protecting the building structure and interior space from precipitation, wind, and other climatic conditions. To accomplish this, many exterior wall installations incorporate a water-resistive barrier (or WRB) and flashing materials behind the wall cladding to protect the structure and wall components. In drainage wall designs, the WRB and flashing are relied upon to collect water that penetrates the wall cladding and drains it back to the exterior. Common wall-covering materials include brick and stone masonry; aluminum, steel, vinyl, and wood siding; stucco; and EIFS (refer to *Figures 1A*, *1B*, and *1C* for common arrangements).

The WRBs used in exterior wall construction have changed significantly over the past several decades, both in the variety of materials available for use and in related building code requirements. Prior to this time, the WRB material most commonly referred to in building codes and used in construction was known as No. 15 asphalt felt, which is currently defined as Type I asphalt-saturated felt in ASTM D-226, *Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing.*[1] Advances in the construction polymer field beginning in the 1960s brought new polymeric WRB products to the market as substitutes for No. 15 asphalt felt (refer to *Figure 2*). This left building code authorities with a need to develop acceptance criteria for evaluating the equivalency of these alternative materials.

Figure 2. Commercial construction project using polymeric WRB behind brick veneer.

Figure 3. Example of exterior wall sheathing damage due to water penetration through a polymeric WRB.

The authors contend that the current standards have not caught up with the technology of polymeric WRBs, commonly referred to as "housewraps." This leaves an information gap that has resulted in confusion among design professionals and the construction industry at large regarding the in-service performance of, and equivalency among, various WRB products. During a recent field investigation of exterior wall water intrusion problems, concerns were raised regarding the water resistance capabilities of a polymeric WRB installed over the wall sheathing and behind the exterior siding of a residential building. On this project, water damage to the exterior wall wood sheathing and framing was found at numerous locations (see *Figure 3*). While some water-damaged areas corresponded with conditions often associated with common paths of water entry (such as poor flashing installation and poor integration of the WRB with other wall components), other locations of water damage did not. In fact, the investigation identified locations of water damage behind the WRB material where it was installed continuously, free from any penetrations that might allow water to bypass it. The damage appeared to be associated solely with water penetrating through the protective WRB material. This finding prompted the authors to examine WRB building code provisions and test methods and to perform independent laboratory testing to study WRB performance.

Building Code Requirements

The 2003 International Building Code[2] (IBC) has been adopted in many jurisdictions across the country and appears to provide representative code language regarding WRBs. Section 1400 of the 2003 IBC states, "A minimum of one layer of No. 15 asphalt felt, complying with ASTM D-226 for Type I felt, shall be attached to the sheathing with flashing as described in Section 1405.3, in such a manner as to provide a continuous, water-resistive barrier behind the exterior veneer." It also states, "Materials used for construction of exterior walls shall comply with the provisions of this section. Materials not prescribed herein shall be permitted, provided that any such alternative has been approved.” Section 104 provides guidance on the approval of alternative materials, such as polymeric WRBs, by stating, “An alternative material, design, or method of construction shall be approved where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method, or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability, and safety.”

The authors’ interpretation of the code sections cited above suggests the IBC standard WRB material can be defined as ASTM D-266 Type I asphalt-saturated felt or alternate material with equal or better ability to prevent water penetration. Unfortunately, the ASTM standard is limited to dimensional and physical requirements and does not address water resistance performance, leaving the user with no stated criteria to assess water performance equivalency of new products, or to compare them with the code-specified D-266 Type I asphalt-saturated felt.

The apparent dead-end in WRB penetration performance criteria is addressed by a document entitled, *Acceptance Criteria for Water-Resistive Barriers*,[3] also known as AC38, which is published by the same organization that publishes the IBC (International Code Council, Inc., also known as ICC). Although this document is not directly referenced by the code, its stated purpose is “to establish requirements for recognition of water-resistive barriers in ICC Evaluation Service, Inc. evaluation reports under the 2003 International Building Code (IBC), the 2003 International Residential Code (IRC), the 1999 BOCA National Building Code (BNBC), the 1999 Standard Building Code (SBC), and the 1997 Uniform Building Code (UBC).”

AC38 groups WRB materials into three categories: paper-based, felt-based, and polymeric-based barriers. Felt-based WRBs are defined as “asphalt-saturated organic felts that comply with ASTM D-226 and are intended for use as water-resistive barriers.” This definition is the same as that provided by the ICB and offers no additional information regarding water resistance performance. Water resistance test data are not included in the information required to be submitted for approval of felt-based materials as WRBs.

Paper-based WRBs are defined as “building papers composed predominantly of sulfate pulp fibers that comply with UBC Standard 14-1 and that are intended for use as water-resistive barriers.” UBC Standard 14-1, entitled *Kraft Waterproofing Building Paper*,[4] defines four grades of building paper intended for use as a weather-resistive barrier. The four grades (Grade A – high water-vapor resistance; Grade B – moderate water-vapor resistance; Grade C – water resistant; and Grade D – water-vapor permeable) have increasing water vapor permeability requirements and decreasing water resistance requirements, but no test methods are specified for either property. AC38 clarifies the testing requirements by prescribing ASTM D-779, *Standard Test Method for Water Resistance of Paper, Paperboard, and other Sheet Materials by the Dry Indicator Method*[5] as the test method for water resistance.

Polymeric-based WRBs are defined by AC38 as “proprietary polymeric sheet materials for use as water-resistive barriers.” Water resistance test data are required to be included in the information submitted for approval of polymeric-based WRBs. Water resistance of polymeric WRBs can be deter-

Figure 4. Demonstration of three different hydrostatic heads prescribed by AC38 for water resistance testing of Grade D WRBs. From left to right: 55 cm (AATCC 127), 1 inch (CCMC), and negligible head (ASTM D-779).

Table 1 - AC38 WRB Grade D Barrier Water Resistance Test Requirements

WRB Type	Test Method	Test Pressure	Test Duration
Felt-based	No test required	N/A	N/A
Paper-based	ASTM D-779	Negligible	10 minutes
Polymeric Based, Grade D	CCMC 07102 or AATCC 127	5.2 psf 112 psf	2 hours 5 hours

mined by one of three specified test methods: ASTM D-779; the Canadian Construction Materials Centre (CCMC) Technical Guide for Sheathing, Membrane, Breather-Type, *Water Ponding Test*[6]; or a modified version of the American Association of Textile Chemists and Colorists (AATCC) Test Method 127 *Water Resistance: Hydrostatic Pressure Test*[7]. AC38 further indicates that the ASTM D-779 test method is not applicable to Grade D barriers (a term associated with paper-based WRBs).

Comparison of the requirements for the three WRB categories quickly reveals an apparent gap in the logic used by AC38 to determine the equivalency of non-felt-based WRB materials with IBC standard ASTM D-266 Type I asphalt-saturated felt. The paper-based and polymer-based WRBs must be tested for water resistance while no such requirement exists for felt-based WRB, leaving no direct link to performance equivalency of alternate materials. Furthermore, different water resistance test methods are prescribed for paper-based WRBs and polymeric house wraps.

WRB Water Resistance Testing

Review of the three water resistance test methods prescribed by AC38 brings further confusion to the issue of performance equivalency. ASTM D-779 involves bringing one side of the WRB in contact with water and measuring the elapsed time for liquid water penetration to occur.

A common method of performing this test involves floating a small boat made from the product on water, resulting in a negligible pressure differential across the test specimen. In order to meet the minimum standard for a Grade D barrier, the product must resist water penetration for ten minutes. The CCMC 07102 test subjects the test specimen to a column of water one inch high for a period of two hours, producing a pressure differential of approximately 5.2 psf. A passing grade is assigned to products with no water penetration observed.

The modified version of the AATCC 127 test specified by AC38 subjects the test specimen to a 55-cm-high column of water for five hours, producing a differential pressure of approximately 112 psf. As with the CCMC 07102 test, successful WRB materials will have no water penetration observed during the prescribed test period. A summary of the AC38 water resistance test requirements for Grade D barriers is presented in *Table 1* and *Figure 4*. The authors believe the wide-ranging differences in the AC38 water resistance test requirements demonstrate a failure to provide a rational approach to assessing or approving alternate WRB materials.

A separate problem beyond the current differences in the AC38 water resistance test requirements is that the prescribed test methods only address water transport mechanisms related to liquid flow due to gravity and hydrostatic pressure. Field

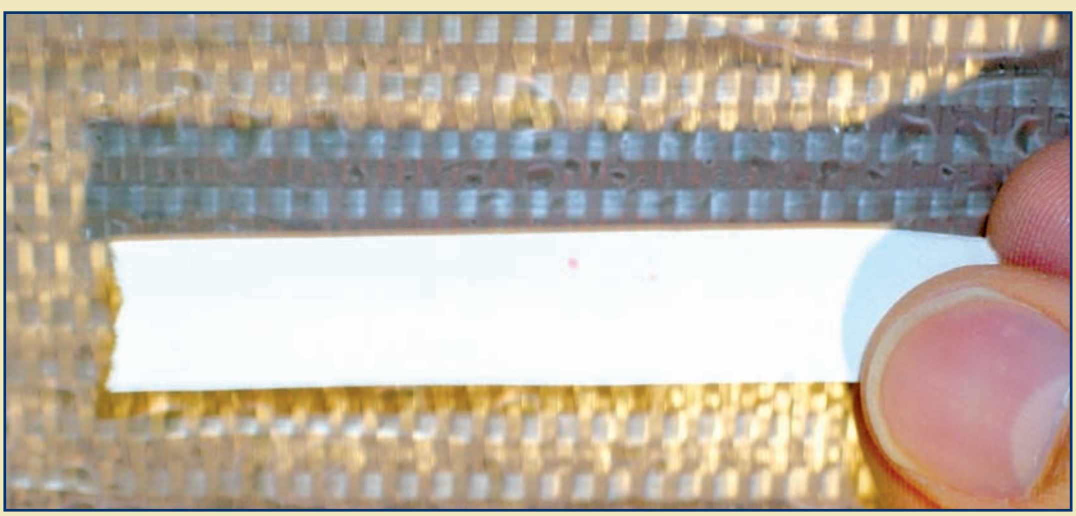

Figure 5. Water-indicating paper is being held approximately 1/2 inch from the back of a perforated WRB during direct water spray testing. Bright pink spots on the water-indicating paper show moisture penetration.

investigations of building water intrusion problems by the authors and others[8] have identified additional factors, such as capillary suction and surface tension properties, that can also affect WRB moisture resistance performance. By ignoring these behaviors, AC38 neglects critical real-world moisture transport mechanisms that affect the in-service performance of WRBs. As a result, some WRB products that meet the requirements of AC38 and have been approved for use may not perform satisfactorily in the built environment.

To address some of the potential in-service conditions ignored by AC38, the authors subjected five commercially available WRBs to two new tests devised to simulate potential service conditions not addressed by the existing standard test methods. The tested products included asphalt-saturated paper and felt as well as coated, non-coated, and perforated varieties of polymeric house wraps (Grade D WRBs).

Figure 6. Water droplet on the "interior" side of a coated polymeric WRB during direct water spray testing.

The first new test procedure simulated rain exposure of building framing materials during construction. The WRB test materials were mounted over an 8-foot length of wood stud wall, 8 feet high, constructed without sheathing. In order to focus the test on the performance of WRB products and not installation issues, no exposed fasteners were installed in the test area. Water was applied directly onto the exterior face of the WRB for 15 minutes with a spray rack calibrated according to ASTM E-331, *Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtainwalls by Uniform Static Air Pressure Difference*,[9] while the rear or "interior" side of the specimen was checked for water penetration.

Figure 7. Water penetration is evident on the wood test frame after removal of the WRB at the completion of the 15-minute direct water spray test.

Figure 8. Modified spray test setup utilizing reduced water spray onto a polyethylene sheet. Water runoff was allowed to wet the WRB for 30 minutes.

Water penetrated the perforated polymeric WRB almost immediately upon application of the test spray. Fine water drops passing through the material could be felt in the air by an observer positioned on the "interior" side of the test specimen and were visibly detected as bright pink spots on water-indicating paper held approximately 1/2 inch from the back of the WRB (refer to *Figure 5*).

Water also penetrated the coated polymeric product during the spray test, with water droplets visible at many locations on the "interior" side of the test specimen (see *Figure 6*). Upon completion of the 15-minute test and removal of the perforated and coated WRB products, water was clearly visible on the face of the wood test frame (refer to *Figure 7*). No water penetration was detected through the non-coated polymeric product or the asphalt-saturated paper and felt materials.

The two polymeric WRB products that failed the direct spray test were re-tested using a modified water spray configuration. This time, instead of having the standard water spray applied directly onto the WRB for 15 minutes, a reduced water spray was applied to a sheet of polyethylene placed over the top portion of the test specimen. The run-off from the polyethylene sheet was allowed to wet the WRB for 30 minutes (refer to *Figure 8*). As with the direct spray test, water penetrated the perforated polymeric product, wetting the wood test frame. No water penetration was detected through the coated polymeric product.

The second new test procedure was designed to simulate the effects of surface contact and capillary moisture movement that can occur in wall designs incorporating cladding materials installed over exterior sheathing and in contact with a WRB. The WRB test materials were sandwiched between a piece of surface-wetted plastic and a sheet of blotter paper. Light pressure was applied to the blotter paper by covering it with a piece of clear plastic. Water passed through the perforated and coated polymeric products almost immediately upon contact with the wet "cladding" (refer to *Figure 9*). No water penetration was detected through the non-coated polymeric product or the asphalt-saturated paper and felt materials.

CONCLUSIONS

1. The 2003 IBC effectively defines asphalt-saturated felt meeting the requirements of ASTM D-266 for Type I felt as the standard for WRB materials used in exterior wall construction.
2. Current building code provisions offer no rational means of assessing the equivalency of alternative WRB products to ASTM D-266 Type I asphalt-saturated felt, which has no prescribed water resistance performance requirement.
3. The three water resistance test methods specified by AC38 vary so significantly in test duration and applied hydrostatic pressure that no meaningful comparison of test data can be made. They fail to address several important moisture transport mechanisms that affect the in-service performance of WRBs. New standardized tests need to be developed.
4. Laboratory tests performed by the authors to simulate potential in-service conditions not addressed by AC38 resulted in water penetration through several commercially available WRB materials that, according to published manufacturer information, passed the requirements of AC38 for Grade D barriers.

REFERENCES

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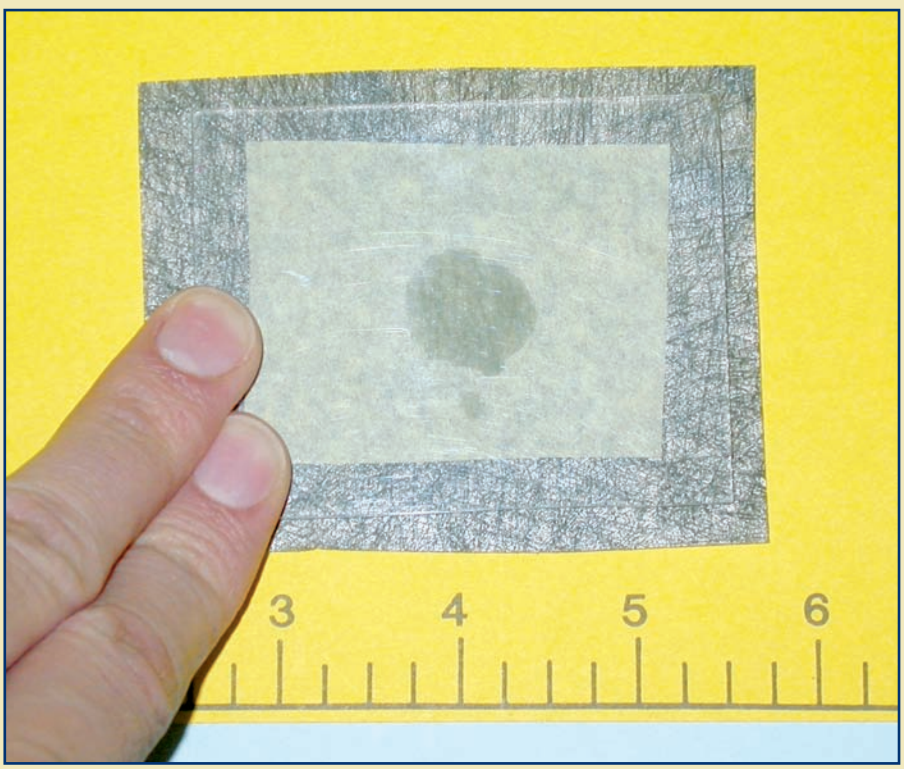

Figure 9. Water penetration through polymeric WRB during test devised to simulate the effects of surface contact and capillary moisture movement.

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