Masonry Veneer Manufacturers Association

TECHNICAL BULLETIN

Water Penetration Testing of an Adhered Masonry Veneer Wall Assembly

INTRODUCTION

This investigation explored the effect of simulated wind-driven rain conditions on various wall assemblies related to adhered masonry veneer cladding. The assemblies included the field of the wall, a penetration (window), a wall/eave interface, a wall sill (foundation termination), and a control joint. The parameters investigated were double-layer combinations of the water-resistive barrier (WRB), different lath fastening schedules, and the effect of a cracked scratch coat.

The testing protocol was to evaluate "layers" of the wall assembly, starting with the inner-most layer of WRB and lath, followed by the scratch coat layer, and, if necessary, a final layer of adhered masonry veneer. The intent was to understand the minimum application of materials that prevented water penetration, knowing that additional layers would only improve the performance.
The testing ultimately showed that the combination of WRB, lath, & scratch coat proved effective at preventing water penetration, and the addition of adhered masonry veneer was unnecessary.

EXPERIMENTAL APPROACH

A common, laboratory-based test for building water penetration is ASTM E 331 – *Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference*. This test involves the placement of a pressurized, wetted condition on the exterior side of the wall assembly, which simulates wind-driven rain, and the observation of water penetration on the interior side of the wall assembly (i.e., the sheathing-framing interface).

The pressure differential, water flow rate, test duration, and wall assemblies were derived from the 2006 International Residential Code, Section R703.1. It specifies that a wall assembly must pass ASTM E 331 at a pressure of 6.24 lb/ft^2 for a 2-hour duration. ASTM E 331 requires a minimum water flow rate of 5 gal/ft^2-hr. The pressure differential of 6.24 lb/ft^2 is equivalent to a 50 mph wind, and the water flow rate of 5 gal/ft^2-hr is equivalent to 8 inches of rain per hour, which creates a continuous film of water on the surface. Section R703.1 also states that the wall assemblies to be tested shall include an opening, a control joint, a wall/eave interface and a wall sill.

WALL CONSTRUCTION

Framing & Sheathing (without window) – Each wall assembly was 4' wide by 8' high and constructed from 2x4 wood framing spaced 16" on center (Fig. 1). The framing was sheathed with four pieces of APA-rated 1/2" oriented-strand board (OSB) – two were 32" by 48" and two were 16" by 48". These sheathing sections were secured to the wood studs in a staggered pattern with an 1/8" gap between the sheets to simulate a typical offset stacking joint (Fig. 1).

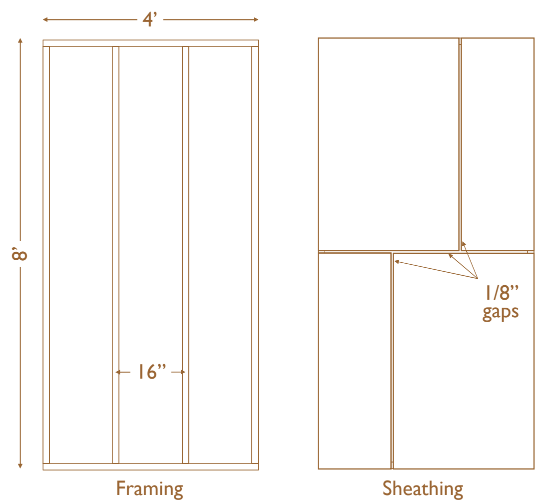

Fig. 1 – Framing & sheathing configurations.

Framing & Sheathing (with window) – The wall assemblies with windows were also 4' wide by 8' high and constructed from 2x4 wood framing per the American Wood Council recommendations to accommodate a 24" wide by 36" high window (Fig. 2). The framing was sheathed with four pieces of APA-rated 1/2" oriented-strand board (OSB) separated by a 1/8" gap as shown in Fig. 2.

WRB – Two double-layer combinations of WRB were explored: (1) a double-layer of No. 15 felt (ASTM D 226, Type 1), and (2) an inner-most layer of spun-bonded polyolefin housewrap (compliant with ICC-ES AC38, Acceptance Criteria for Water-Resistive Barriers) with an outer-most layer of No. 15 felt. In the case of No. 15 felt, a vertical seam was located in the center of the wall for one of the courses, and the felt lapped 6" at this seam. All other courses of felt were continuous across the width. The fastener type was a staple with 3/8" crown

(T50) and 3/8" length and spaced 16" on center both horizontally and vertically, In the case of the housewrap, there was a single horizontal joint that was lapped 6" and taped per the manufacturer's recommendation. The fastener type was capped staples and spaced 16" on center both horizontally and vertically

Lath – Galvanized, self-furred, expanded metal lath (2.5-lb.) was installed over the WRB using 16-gauge staples with 1" crowns and 1-1/2" length. Two lath fastening schedules were explored: (1) into framing, and (2) into and between framing, located 6" on center vertically in both cases.

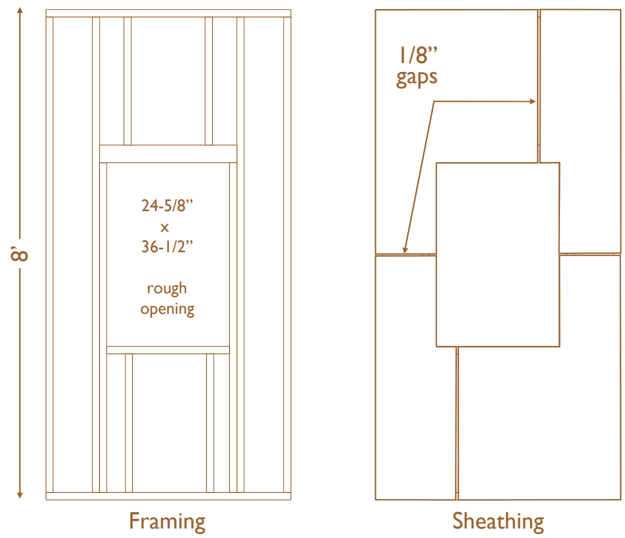

Fig. 2 – Framing & sheathing configurations with a window.

Scratch Coat – Two scratch coat conditions were examined: pristine and distressed, both utilizing premixed Type S mortar installed at a nominal thickness of ½-inch and was allowed to cure for a minimum of 28 days prior to water penetration testing. A repeatable method was needed to induce the distressed condition for simulated aging. An existing impact test method for building materials, albeit for glazing, was adapted for this purpose – namely, ANSI Z 97, *Safety Glazing Materials Used in Buildings - Safety Performance Specifications and Methods of Test*. This method utilizes a 100 lb. shot bag, drawn back to achieve an 18" vertical drop. The shot bag impacted a 2x4 stud on the wall's interior, which supported the upper vertical seam in the OSB (Fig. 3). Impact to the wall's exterior was avoided out of concern for potential spalling of the scratch coat, which would have been overly aggressive and non-prototypic.

Window – The installation method for the window depended on which WRB combination was used. The details are outlined below for each of the two WRB combinations. The features common to both installations were:

Fig. 3 – Photo showing impact of shot bag on wall's interior to create cracks in the scratch coat.

- The window type was a 24" wide by 36" high (nominal) vinyl picture window with an integral flange that was located mid-span of the wall.
- A pan flashing was constructed from a flexible, butyl rubber self-adhered flashing.
- On the interior, backer rod was installed in the joint between the frame of the window and the rough framing, followed by a bead of sealant around the entire window to create an air seal and back dam for the pan flashing at the sill.
- A galvanized sheet metal Z-type head flashing was mechanically fastened at the head of the window with the 3-1/2" vertical leg located beneath both layers of the WRB.
- Casing bead (No. 66) was used at the window jambs and sill; it was set back 3/8" from the window to allow for backer rod and caulk. Weeped casing bead was used at the window head, also set back 3/8" from the head flashing, but no backer rod or caulk was used at this location.

Window with double-layer of No. 15 felt: The installation of the window preceded the installation of the water-resistive barrier. The pan flashing was aligned with the inside edge of the sill, extended 6" vertically up each jamb, 3" down the exterior face of the OSB, and was mechanically fastened at the fanned edges with staples. A piece of No. 15 felt (44" wide by 24" high apron) was placed under the window and beneath the pan flashing to allow for subsequent shingle-like placement of the water-resistive barrier. The window was then nail-fastened along with a continuous bead of caulk between the window flange and the OSB at the jambs and head, but not the sill. 4"-wide strips of self-adhered flashing (SAF) were then applied at the jambs, overlapping the entire mounting flange and extending 1" above the top of the rough opening and below the bottom edge of the sill flashing. A 4"-wide strip of SAF was applied at the head, overlapping the mounting flange and extending beyond the outside edges of both jamb flashings. The two layers of No. 15 felt were then installed with only the first layer integrated beneath the apron that was installed with the pan flashing. No sealant, tape or SAF was used in interfacing the window with the double-layer of No. 15 felt.

Window with housewrap & No. 15 felt: The installation of the window followed the installation of the inner-most layer of WRB, which was the housewrap. An "I-Cut" was made in the housewrap at the rough opening, where a horizontal cut was made at the top and bottom of the opening and a vertical cut was made along the centerline of the opening. The flaps were folded into the opening and fastened to the interior framing. Two outward 45 degree slits were cut from the upper corners of the opening, each 8" long, to create access for flashing of the window head. The pan flashing was aligned with the inside edge of the sill, extended 6" vertically up each jamb, 3" down the exterior face of the housewrap, and was mechanically fastened at the fanned edges with staples. The window was then nail-fastened along with a continuous bead of caulk between the window flange and the housewrap at the jambs and head, but not the sill. 4"-wide strips of self-adhered flashing (SAF) were then applied at the jambs, overlapping the entire mounting flange and extending 1" above the top of the rough opening and below the bottom edge of the sill flashing. A 4"-wide strip of SAF was applied at the head, overlapping the mounting flange and extending beyond the outside edges of both jamb flashings. The Z-type head flashing was then installed at the window head and the flap of housewrap was layered on top of it and taped to the adjacent housewrap. The No. 15 felt was applied as the outer-most layer of WRB. No sealant, tape or SAF was used in interfacing the window with this outer-most layer.

Wall / Eave Interface – The top edge of the outer-most layer of WRB was sealed to the sheathing with SAF and covered with 1x6 lumber as blocking and then a 1x8 fascia board (see Figure 4).

Wall Sill (foundation termination) **–** The bottom edge of the wall was terminated with a foundation weep screed (No. 7), and both layers of WRB lapped over the weep screed flange (see Figure 5). No sealant, tape or SAF was used in interfacing of the weep screed with the sheathing or the interfacing of the WRB with the weep screed.

Control Joint – This was accomplished with an M-type expansion joint (Figure 6) located over the WRB and coincident with each seam in the OSB – one 4-foot horizontal section and two 4-foot vertical sections. No sealant was applied between the expansion joint and the underlying WRB or to any intersections in the expansion joints.

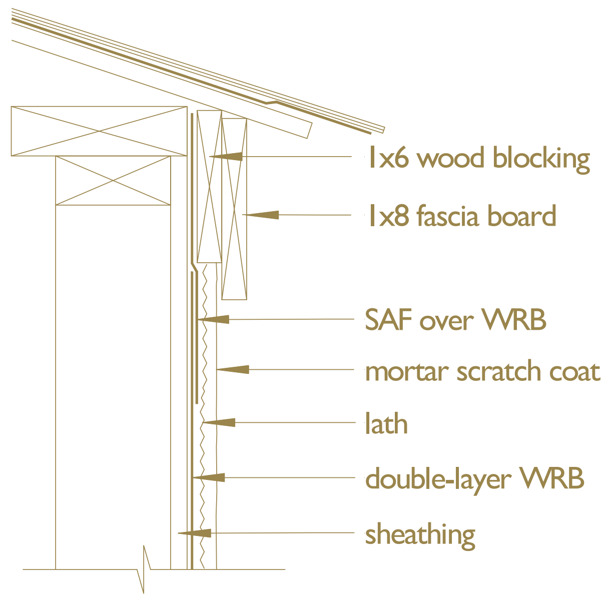

Fig. 4 – Wall/eave interface detail.

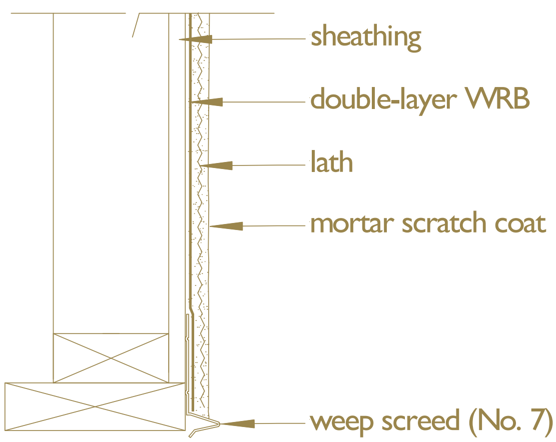

Fig. 5 – Wall sill detail.

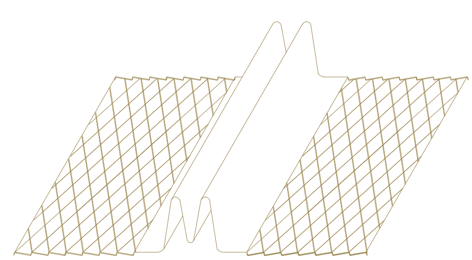

Fig. 6 – M-type expansion joint.

RESULTS

Testing began with the field-of-the-wall assembly comprised of layers of WRB and lath, followed by the additional layer of a scratch coat. Testing then shifted to the various penetrations and terminations (window, wall/eave interface, wall sill & expansion joint), all comprised of WRB, lath and scratch coat.

The test details and results are summarized in Table 1.

Field of Wall: *WRB + Lath*
Two assemblies were tested, evaluating the WRB combination – (1) a double-layer of No. 15 felt and (2) an inner-most layer of spun-bonded polyolefin housewrap with an outer-most layer of No. 15 felt. Both assemblies involved lath fastening into framing, carefully located to ensure the fasteners penetrated the framing.

Test Result: Within minutes of initiating the test, water was observed pooling around the horizontal seam in the OSB and spilled over into a stud cavity on both assemblies. Green dye was subsequently added to the water to aid in identification of the leak source. The lath and layers of WRB were systematically removed from the test wall. It was concluded that water ran through the WRB at the lath fasteners along the vertical seams in the sheathing (Fig. 7). The vertical seams in the sheathing coincide with the framing members (Fig. 1), which are also the lath fastening locations. This common field scenario co-locates penetrations in the WRB with a direct path to the interior wall cavity, creating an opportunity for water to penetrate. No water penetration was observed at lath fastening locations that did not coincide with a sheathing gap.

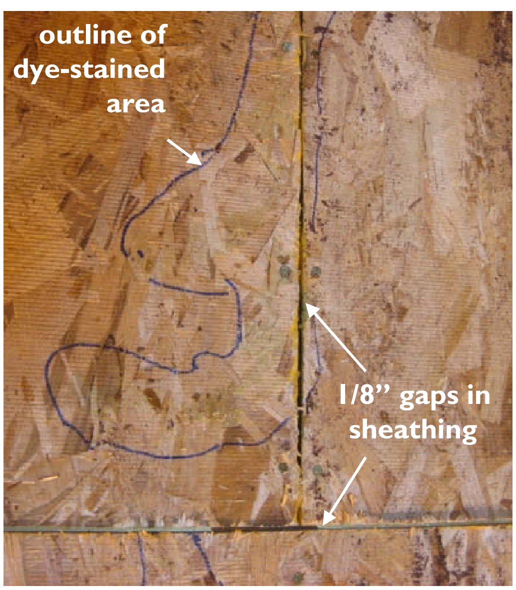

Fig. 7 – Photo of sheathing after water penetration test with WRB & lath only.

Field of Wall: *WRB + Lath + Pristine Scratch Coat*
Four assemblies were tested to evaluate the WRB combination and the lath fastening schedule with the scratch coat present. Two assemblies had a double-layer of No. 15 felt – one with the lath fastened into framing only and another with the lath fastened into and between framing. Two assemblies had an inner-most layer of spun-bonded polyolefin housewrap with an outer-most layer of No. 15 felt – one with the lath fastened into framing only and another with the lath fastened into and between framing. All four assemblies were finished with a nominal ½-inch scratch coat.

Test Result: No water was observed on the interior of any of these four assemblies for the 2-hour test duration.

Field of Wall: *WRB + Lath + Distressed Scratch Coat*
The fact that water penetration was observed with no scratch coat and was absent with a pristine scratch coat begged the question of what would happen when there were cracks in the scratch coat, as would occur upon aging. The same four assemblies were subjected to the impact described previously, which induced cracks in the scratch coat throughout each of the wall assemblies. Figure 8 shows a typical assembly, where the cracks have been highlighted with a marker. The length of visible cracks per unit area for each of the four field-of-the-wall assemblies was 4.9, 7.8, 7.8, and 9.3 inches of crack per square foot of wall area.

Test Result: No water was observed on the interior of any of these four assemblies for the 2-hour test duration.

Window
Two wall assemblies were tested to evaluate the two different WRB combinations. Both assemblies had the lath fastened into and between framing and were finished with a nominal ½-inch scratch coat, which had natural cracks located throughout.

Test Result: No water was observed on the interior of either of these assemblies for the 2-hour test duration.

Wall / Eave Interface
Two wall assemblies were tested to evaluate the two different WRB combinations. Both assemblies had the lath fastened into and between framing and were finished with a nominal ½-inch scratch coat, which had natural cracks located throughout.

Test Result: No water was observed on the interior of either of these assemblies for the 2-hour test duration.

Wall Sill (foundation termination)
Two wall assemblies were tested to evaluate the two different WRB combinations. Both assemblies had the lath fastened into and between framing and were finished

with a nominal ½-inch scratch coat, which had natural cracks located throughout.

Test Result: No water was observed on the interior of either of these assemblies for the 2-hour test duration.

Control Joint

Two wall assemblies were tested to evaluate the two different WRB combinations. Both assemblies had the lath fastened into and between framing and were finished with a nominal ½-inch scratch coat, which had natural cracks located throughout.

Test Result: No water was observed on the interior of either of these assemblies for the 2-hour test duration.

CONCLUSIONS

This study shows the influence that layers of the wall assembly have on the resistance to wind-driven rain. It shows that the introduction of cladding fasteners into framing members can create a path for water penetration at seams in the sheathing. However, the testing demonstrated the presence of a scratch coat, even when distressed, prevents water penetration from wind-driven rain, despite the compromised WRB at the sheathing seams. This study also shows no water penetration for different combinations of water-resistive barriers, different lath fastening schedules, and for various penetrations and terminations in the wall assembly.

This testing was conducted by Architectural Testing, Incorporated and can be referenced from their report numbers shown in Table 1.

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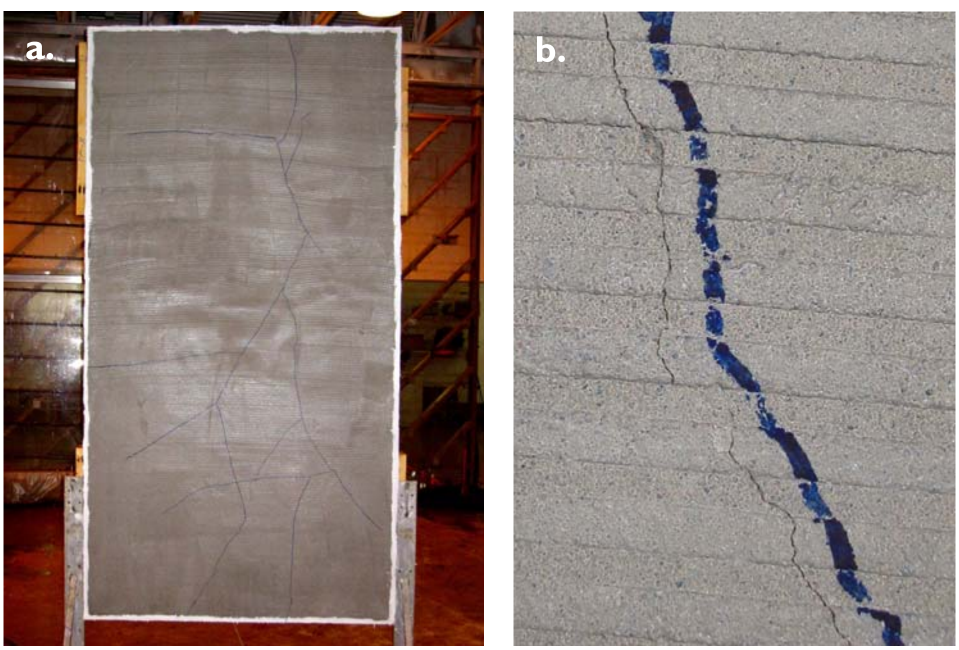

Fig. 8 – Photo showing induced scratch coat cracking (typical) for the entire panel (a) and a close-up view (b).

Table 1 – Summary of water penetration testing.

Test Method: ASTM E 331-00 - *Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference.*

Test Conditions:
pressure difference: 6.24 lb/ft^2
water flow rate: 5.0 U.S. gal/ft^2·h
duration: 2 hours

Report Number	Description of Wall Assembly				Test Result
	Wall Detail	WRB Combinations	Lath Fasteners	Scratch Coat	
74202.01-201-44	field of wall	(1) No. 15 + No. 15 (2) housewrap + No. 15	(1) into framing	none	(1) Fail* (2) Fail* *Water penetrated at fasteners located at sheathing gaps for both wall assemblies.
74202.02-201-44	field of wall	(1) No. 15 + No. 15 (2) housewrap + No. 15	(1) into framing (2) into & between framing	pristine	(1) Pass (2) Pass (3) Pass (4) Pass
74202.03-201-44	field of wall	(1) No. 15 + No. 15 (2) housewrap + No. 15	(1) into framing (2) into & between framing	cracked (deliberate)	(1) Pass (2) Pass (3) Pass (4) Pass
78473.01-201-44	window roof eave wall sill weep	(1) No. 15 + No. 15	(1) into & between framing	cracked (natural)	(1) Pass
78473.04-201-44	window roof eave wall sill weep	(1) housewrap + No. 15	(1) into & between framing	cracked (natural)	(1) Pass
78473.02-201-44	expansion joint wall sill weep	(1) No. 15 + No. 15	(1) into & between framing	cracked (natural)	(1) Pass
78473.03-201-44	expansion joint wall sill weep	(1) housewrap + No. 15	(1) into & between framing	cracked (natural)	(1) Pass