ELIMINATING THE POTENTIAL FOR AIR AND MOISTURE INFILTRATION IN STUCCO FACADES AT THE WINDOW-WALL INTERFACE

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Functional performance at the window-wall interface in stucco facades has a significant effect on overall building envelope system performance. While building envelope materials, design and construction have exhibited a number of improvements in recent years including increasingly stringent code requirements, along with the general acceptance of air barriers and vapor protection and the introduction of whole building envelope commissioning, the window-wall interface continues to be a problem.

In 2008, the Western Construction Consultant Association (WESTCON) set out to test commercially available flashing systems for a standard storefront window in a stucco application. Their results were presented at RCI's 2009 Building Envelope Technology Symposium.[1] The WESTCON study began with a literature review, which revealed that there is limited guidance available for flashing aluminum storefront windows that lack attachment flanges. Of the six assemblies tested, two were considered successful, while the others leaked. Based upon the fact that the majority of the assemblies tested experienced problems, a team was assembled to investigate how the connection around the window and/or wall assembly within a stucco façade could be modified to improve leak-free performance. The process began with determining what testing would be required to confirm components incorporated in the design would be compatible and what standards must be met.

A description of product and independent laboratory testing for air infiltration, water-resistance and structural performance as well as vapor permeance and testing protocols will be reviewed in our BEST3 presentation[2] and are summarized here. The presentation includes the evaluation of the ability of drift joints in the test assembly to meet seismic performance requirements by using a modified AAMA racking test with testing showing little difference in air exfiltration and air infiltration rates before and after the racking test.

Stucco facades have problems with proper sealing and flashing window or wall systems within the stucco cladding. The window-wall interface can compromise the integrity of the stucco cladding. A logical solution to remedy these issues is the development of pre-engineered transition assemblies, comprised of finished aluminum and silicone materials, which are assembled and attached to the window and wall assemblies to ensure a durable connection and seal capable of absorbing dynamic movement and wind-loading stresses without pulling apart (see Figure 1). The potential benefits are numerous: reduction or elimination of problems currently faced at the window-wall interface; the ability for the designer to specify one transition assembly flexible enough to be placed in many different locations and under different climactic conditions, and the ability to provide continuity and compatibility of performance layers between adjoining components/assemblies in a structurally sound and durable manner.

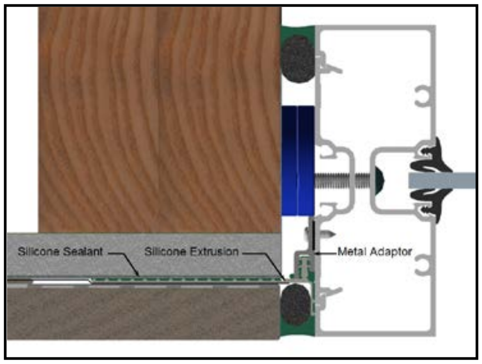

Figure 1. Pre-engineered transition assemblies ensure a durable connection and seal.

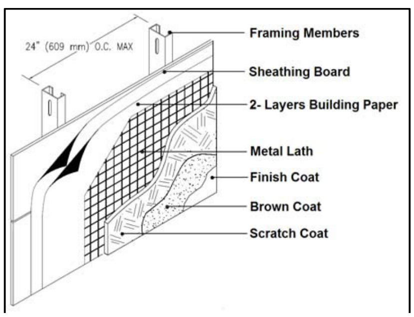

Figure 2. Components comprising a stucco stucco wall assembly

Figure 3. Window head condition in wall assembly

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Stucco facades, as shown in Figure 2, are comprised of a cementitious coating comprised of three layers, a scratch coat, brown coat, and top finish coat, applied over a building paper with a metal lath embedded for structural reinforcement, covering the structure's sheathing. The building paper's function is to create a drainage plane behind the plaster, while the two layers of paper rely on flashing moisture to the bottom of the wall. Fasteners used in mounting the plaster's casing bead (J-molding) and metal lath penetrate the building paper as shown in Figure 3, allowing air/moisture access. The building paper is designed to flash moisture; however, air pressure differential can draw in air and moisture through these penetrations.

DEFINED WALL PERFORMANCE STANDARDS

A typical laboratory test standard for wall performance would be ASTM E331[3], "*Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference.* Since a large percentage of stucco wall construction is done in California, particular attention was given to West Coast standards where the original WESTCON testing was conducted. The California building code goes beyond basic requirements by extending exposures from 15 minutes to two hours.

The California Building Code, Section 1403 Performance Requirements:

2.1. Exterior wall envelope test assemblies shall include at least one opening, one control joint, one wall/eave interface and wall sill. All tested openings and penetrations shall be representative of the intended end-use configuration.

2.2. Exterior wall envelope test assemblies shall be at least 4 feet by 8 feet (1219 mm by 2438 mm) in size.

2.3. Exterior wall envelope assemblies shall be tested at a minimum differential pressure of 6.24 pounds per square foot (psf) (0.297 kN/m²).

2.4.1. Exterior wall envelope assemblies shall be subjected to a minimum test exposure duration of 2 hours.

Many states currently are mandating air barriers in their building codes. As a result, the team felt the test assembly should also comply with ASHRAE 90.1-2010**,** which establishes 0.2 L/s.m² at 75 Pa (0.04 cfm/ft² at 1.57 lb_f/ft^2) as the maximum allowable assembly air leakage as tested in accordance to ASTM E2357 procedures. This test method requires two 8-foot x 8-foot test specimens to be constructed for comparison. One is an opaque wall (specimen-1), while the second (specimen-2) has prescribed window, pipe, ductwork and electrical-box penetrations.

DEFINED COMPONENT PERFORMANCE STANDARDS

Plaster facades are required to use two layers of Grade D 60-minute building paper as an isolation sheet between the plaster and wall sheathing. The following tests were conducted to confirm compatibility with this wall component.

Stain/Adhesion Testing

A three-month stain/adhesion evaluation test was conducted using a silicone extrusion with silicone sealant in direct contact with a Grade D building paper. The test specimens were conditioned at 100°F and 100%RH. Test specimens were evaluated for adhesion and compatibility every month for three months. The test specimens showed no change in adhesion and no staining (color change) to the silicone sealant or silicone extrusion.

The Grade D building paper was placed as a single or double sheet on top of the dry or wet coating in a horizontal position. A common pre-mix concrete was used as the “stucco” and applied on top of the building paper to a 0.5 inch thickness. Each assembly was then cured for 7 days at 75°F and ~50%RH. The wet air barrier membrane exhibited good adhesion to a single layer of the building paper. The cured coating exhibited a very small amount of adhesion to the building paper due to its uneven nature, adhering primarily at the high points.

The exterior sheathing was coated with a fluid-applied synthetic vapor-permeable air barrier. The coating was applied at 70 wet mils and cured to a thickness of 35 mils. A film thickness gauge is used to check the coating thickness. Once cured (less than 24 hours), the surface ~~will~~ provides a clean durable surface for the bonding of the silicone extrusion in the transition assembly to the surface with silicone sealant. The fluid-applied synthetic vapor-permeable air barrier coating was tested in accordance with ASTM D 1970-09 procedures for self-sealability. The test assembly was modified by applying a fluid-applied synthetic vapor-permeable air barrier applied over an exterior gypsum board and allowed to cure. Mechanical fasteners used to support the metal lath, J-Channel and staples for the building paper, were driven into and through the assembly. After the sealant was allowed to cure, deionized water was used to cover the fasteners and the assembly was placed in a refrigeration unit for three days. No water leakage was detected within the assembly.

The Window-Wall Connection

For the window penetration in the test specimen, a center-glazed storefront system was chosen. This was the first time an actual window unit was used as a test specimen for an ASTM E 2357[5] test.

When installing a storefront system in a typical stucco façade, the exterior sealant bead is bonded to the metal casing (J-channel) around the rough opening. As noted in WESTCON’s testing, moisture can migrate behind the plaster coating and casing bead thus bypassing the exterior sealant. Flashing techniques can reduce and potentially prevent moisture from gaining access around the window penetration, but are not designed to prevent air infiltration.

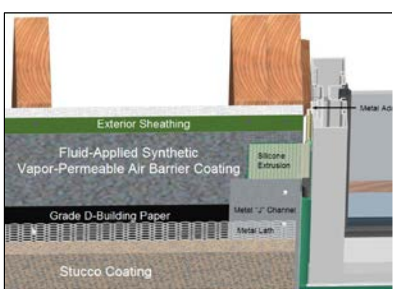

Figure 4. Stucco cross-section at window jamb

To allow a connection to be made behind the stucco coating, as shown in Figure 4, a continuous snap-in pocket filler was utilized in the storefront system. This filler allowed a metal adaptor to be mechanically attached to the prefabricated window unit. Once the unit was properly positioned and shimmed in the rough opening, silicone sealant was applied along the adaptor and window frame. The silicone extrusion was inserted into the adaptor and the excess sealant under the short leg of the silicone extrusion bonded the leg to the window frame and was able to seal the metal-to-metal gap. The silicone extrusion was able to span the rough opening joint like a window nailing flange but flexible to span the gap unsupported to seal the window unit to the air barrier coating.

The window was factory fabricated and sealed. The ends of the vertical mullions were sealed with backer rod and silicone sealant. This allowed the metal adaptor to span over the end of the vertical mullion at the head condition to provide a bonding surface for the silicone extrusion.

This window system was sealed into a typical sill pan with end caps. The sill pan was sealed to the rough opening with silicone sealant. The metal adaptor was stopped short of the sill pan end cap. The dart of the silicone extrusion was removed to allow the gasket to be adhered to the sill pan's end cap and sealant bead under the sill pan.

Prior to installing the ¼-inch monolithic glass, measurements were taken of the glazing pockets and glass thickness. The top load EPDM gaskets were installed on either side of the glazing pocket to allow the insertion of the edge pressure gauge to measure the lip seal pressure of these gaskets. Based upon the measured glass thickness, the gaskets obtained an instantaneous edge pressure reading of ~4 pli. No silicone sealant was used as corner seals in this instance to help reduce the infiltration of air and water as would generally be recommended.

After seismic performance testing, the test specimen was tested in accordance with ASTM E 331 *Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference* of 300 Pa (6.24 psf) infiltration for 2 hours with no water infiltration. Some fasteners missed the structural support and the fluid-applied synthetic vapor-permeable air barrier coating sealed these from the exterior.

After the water test, specimen-2 was retested for air infiltration. Then the test specimen-2 along with the opaque specimen-1 were tested in accordance with ASTM E 2357 *Standard Test Method for Determining Air Leakage of Air Barrier Assemblies. The test results for specimen 2 are contained in Tables 1-4.*

The assembly configured and tested by the team performed at a level far superior to ASHRAE and Air Barrier Association of America (ABAA) standards requirements for an air barrier system. This assembly achieved these results even though it went beyond the normal specimen design to include a real world window (dry glazed with no sealant) and drift joint, which was subjected to simulated seismic racking.

Table 1. Air Infiltration (Before loading sequence)

Pressure	Total Leakage	Tare (cfm)	Specimen	Leakage Rate (L/s•m²)	(cfm/ft²)
25 Pa (0.52 psf)	0.058	0	0.058	0.005	0.001

50 Pa (1.04 psf)	0.098	0	0.098	0.008	0.002
75 Pa (1.57 psf)	0.144	0	0.144	0.011	0.002
100 Pa (2.09	0.168	0	0.168	0.013	0.003
150 Pa (3.13	0.229	0	0.229	0.018	0.004
250 Pa (5.22	0.339	0	0.339	0.027	0.005
300 Pa (6.27	0.397	0	0.397	0.031	0.006

Table 2. Air Exfiltration (Before loading sequence)

Pressure	Total Leakage	Tare (cfm)	Specime n	Leakage Rate (L/s•m²)	(cfm/ft²)
25 Pa (0.52 psf)	0.072	0	0.072	0.006	0.001
50 Pa (1.04 psf)	0.102	0	0.102	0.008	0.002
75 Pa (1.57 psf)	0.139	0	0.139	0.011	0.002
100 Pa (2.09	0.179	0	0.179	0.014	0.003
150 Pa (3.13	0.249	0	0.249	0.020	0.004
250 Pa (5.22	0.331	0	0.331	0.026	0.005
300 Pa (6.27	0.381	0	0.381	0.030	0.006

Title of Test	Pressure	Test Results
Deformation (10 Seconds)	± 100 Pa (± 2.09 psf)	No Damage
	± 200 Pa (± 4.18 psf)	No Damage
	± 300 Pa (± 6.27 psf)	No Damage
	± 400 Pa (± 8.36 psf)	No Damage
	± 500 Pa (± 10.45 psf)	No Damage
Deformation (60 minute load)	± 600 Pa (± 12.54 psf)	No Damage
Cyclic Loading (2000 cycles)	± 800 Pa (± 16.72 psf)	No Damage
Gust Loading (3 second	± 1200 Pa (± 25.06 psf)	No Damage

Table 3. Air Infiltration (After loading sequence)

Pressure	Total Leakage	Tare (cfm)	Specime n	Leakage Rate (L/s•m²)	(cfm/ft²)
25 Pa (0.52 psf)	0.068	0	0.068	0.005	0.001
50 Pa (1.04 psf)	0.124	0	0.124	0.010	0.002
75 Pa (1.57 psf)	0.162	0	0.162	0.013	0.003
100 Pa (2.09	0.197	0	0.197	0.016	0.003
150 Pa (3.13	0.275	0	0.275	0.022	0.004
250 Pa (5.22	0.419	0	0.419	0.033	0.007
300 Pa (6.27	0.467	0	0.467	0.037	0.007

Table 4. **Air Exfiltration (After loading sequence)**					
Pressure	**Total Leakage**	**Tare (cfm)**	**Specime n**	**Leakage Rate (L/s•m²)**	**(cfm/ft²)**
25 Pa (0.52 psf)	0.064	0	0.064	0.005	0.001
50 Pa (1.04 psf)	0.122	0	0.122	0.010	0.002
75 Pa (1.57 psf)	0.170	0	0.170	0.013	0.003
100 Pa (2.09	0.211	0	0.211	0.017	0.003
150 Pa (3.13	0.259	0	0.259	0.021	0.004
250 Pa (5.22	0.423	0	0.423	0.034	0.007
300 Pa (6.27	0.459	0	0.459	0.036	0.007

The two test specimens will be joined with a door and another wall to create a small out-building with a roof for long-term exposure. After a period of time, the structure will be dismantled and the walls retested for comparison. Prior to the out-building construction, specimen-2 (with window) was retested ~~to~~ in accordance with ASTM E 331[5] @ 600 Pa (12.5 psf) for 15 minutes with no water leakage, which surpasses the storefront manufacturer's minimum performance requirements.

CONCLUSION

The development of pre-engineered transition assemblies which were flexible, durable, could simplify the detailing and that could provide clear proof of a secure bond was key to the design of a leak-free, airtight wall assembly. These assemblies could not only eliminate problems currently faced at the window-wall interface but enable the designer to specify one transition assembly flexible enough to be placed in many different locations based upon the configuration of the window or wall system and under different climactic conditions. When used in conjunction with a compatible air barrier system, they could also ensure continuity and compatibility of performance layers between adjoining components/assemblies in a structurally sound and durable manner for a wall assembly that could meet today's most stringent standards and those anticipated in the future.

This wall assembly was put to all of today's tests and beyond. The results surpassed expectations, providing a solution that eliminates trial and error, uncertainty and interpretation on the job while providing critical data that will enable the design team to make sound decisions and provide long-term sustainability.

References

[1] *Presentation by the Western Construction Consultant Association (WESTCON) at RCI Inc.'s 2009 Building Envelope Technology Symposium, October 26-27, in San Diego, CA.*
[2] *Eliminating the Potential for Air and Moisture Infiltration in Stucco Facades at the Window-Wall Interface, to be presented at the BEST3 conference, April 2-4, 2012, Atlanta, GA.*
[3] *ASTM E331, "Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference," (2009)*
[4] *ASTM E2357 - 11 Standard Test Method for Determining Air Leakage of Air Barrier Assemblies*

[5] *ASTM E331, "Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference," (2009).*