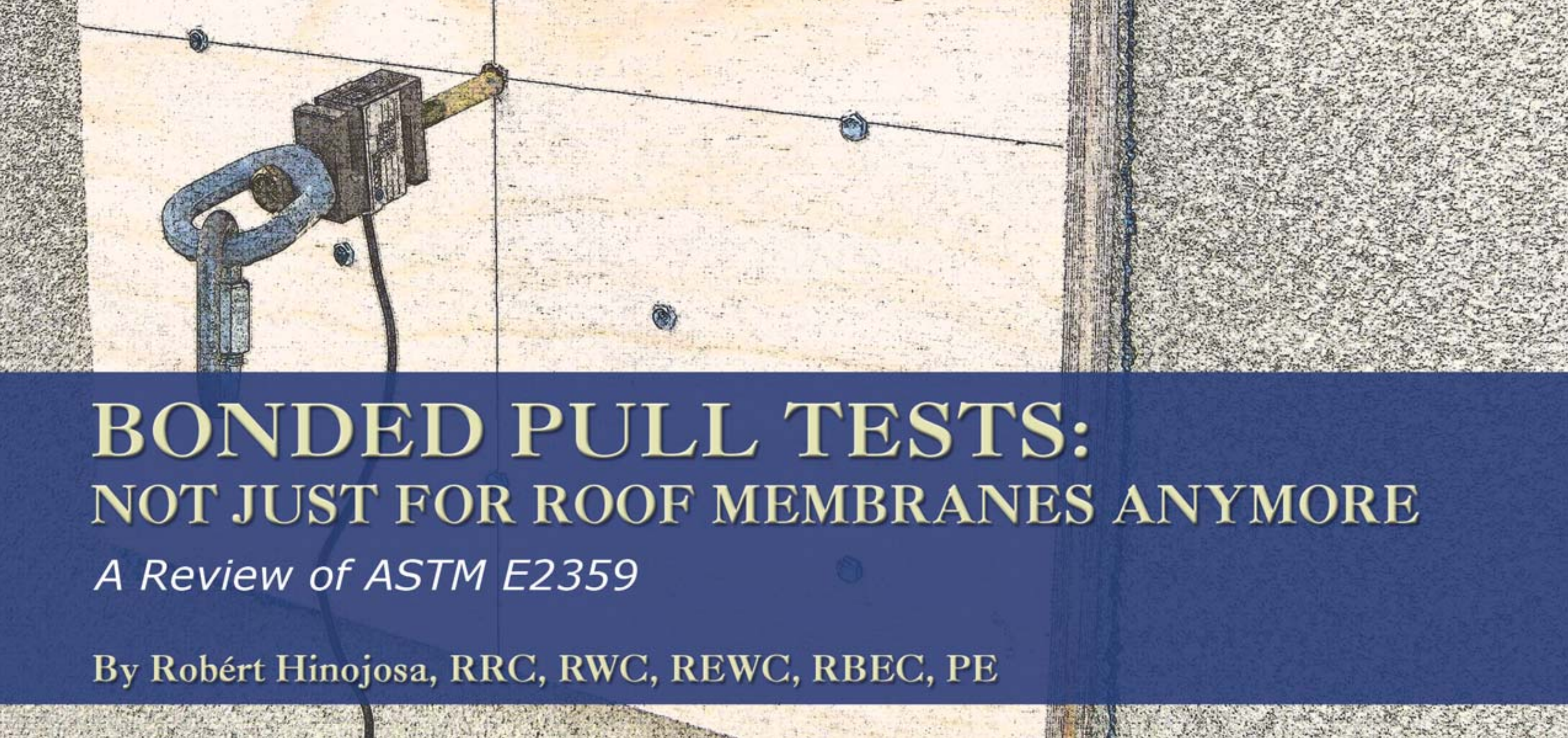

BONDED PULL TESTS: NOT JUST FOR ROOF MEMBRANES ANYMORE

A Review of ASTM E2359

By Robért Hinojosa, RRC, RWC, REWC, RBEC, PE

Those of us who have been involved in building envelope consulting for any period of time have either performed, observed, or read about the bonded pull test for roof membranes. These tried-and-true tests are some of the best ways to perform a roof test in the field to measure the uplift and negative pressure capacity of a roof system. What about the vertical surface of the building envelope and the outward or negative load capacities of these systems? While the construction of many exterior cladding systems prevents this type of test, an exterior insulation and finish system (EIFS) is built in such a way that a bonded pull test can be performed that will accurately evaluate the outward load capacities of the EIFS system. The results of such procedures can be helpful in determining the negative wind load capacities of EIFS assemblies.

INTRODUCTION

Several of the bonded testing procedures for roofs include those covered in FM Global Property Loss Prevention Data Sheet 1-52; ANSI FM 4474, *American National Standard for Evaluating the Simulated Wind Uplift Resistance of Roof Assemblies Using Static Positive and/or Negative Differential Pressures*; and the Florida Building Code's Roofing Testing Application Standard (TAS) 124. Presently, all these standards are fairly similar in procedure and purpose. They assist in determining if the roof system in the three different zones of a roof can withstand the code-required calculated wind uplift pressure of that particular building in its respective zone.

Design wind pressures for a building based on code are typically calculated utilizing the American Society of Civil Engineers' ASCE 7, *Minimum Design Loads for Buildings and Other Structures.* ASCE 7 assists in calculating the negative pressures for Zones 1, 2, and 3 on the roof, as well as positive and negative pressures for Zones 4 and 5 on the exterior walls.

In designing and specifying different components for exterior wall systems, it is important for designers to ensure that these components can withstand code-required loads. Whether the component is the curtain wall, windows, sliding glass doors, or exterior wall cladding (including EIFS), different field tests may be required during installation (or many years after a system is installed) to evaluate the performance of or detrimental effects to these building components. ASTM E2359, *Standard Test Method for Field-Pull Testing of an In-Place Exterior-Insulation-and-Finish-System-Clad Wall Assembly,* is the most valuable method for determining the resistance of a section of EIFS.

FRAME AND APPARATUS

The first part of this procedure requires having or constructing a pull test frame. Similar to the roof-bonded pull tests, a frame is required to pull the test specimen away from the wall. The most common roof frame is a tripod with a winch and load cell at the top that pulls the roof specimen from the roof upward to simulate the negative uplift pressure the system could undergo. When dealing with a vertical surface, one must also deal with the weight of the frame against gravity and other factors that make the procedure vary slightly.

While the frame for an exterior wall is similar, there are some different considerations than those for a roof frame. The pull-test frame for the ASTM E2359 procedure is typically constructed and fabricated from metal (wood is also acceptable by the standard) and must be able to apply a concentric force to the test specimen while distributing the reaction force to the adjacent wall components. This is typically done with flat plates on the exterior of the frame that are outside the size of the test specimen. ASTM E2359 (*Figure 1*) shows a detailed view of a typical frame. The frame should also be constructed and provided with a worm-gear-style winch with a strap or cable to apply the load in a controlled manner to the specimen. This is measured with a load cell and digital load force gauge so that the loads can be measured and recorded throughout the test procedure.

Once the components of the frame are constructed and ready for use, a specimen must be adhered to the EIFS wall in such a way that it can be connected to the pull test frame, winch, and load cell to perform the bonded pull tests. This process is completed by using 2- x 2-ft. wooden panels comprised of ¾-in.-thick plywood. These panels must be precut prior to performing the procedure, with one required for each pull test performed, as the plywood will be bonded to the EIFS wall and will become a part of the

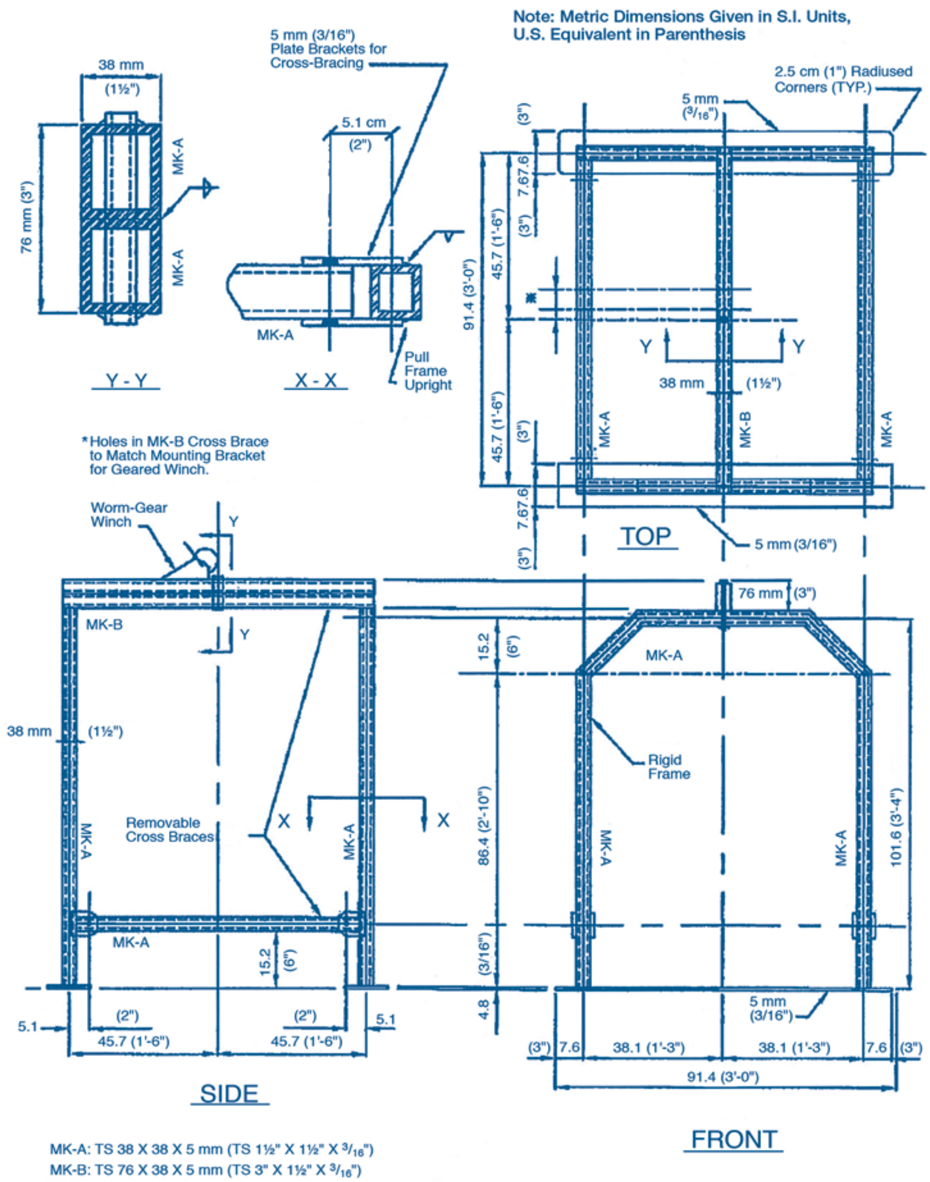

Figure 1 – Pull test frame.

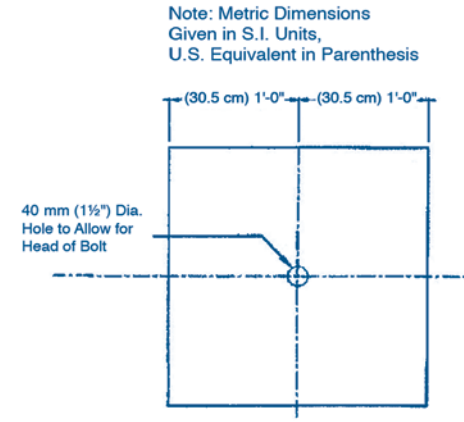

Figure 2 – Bonding panel.

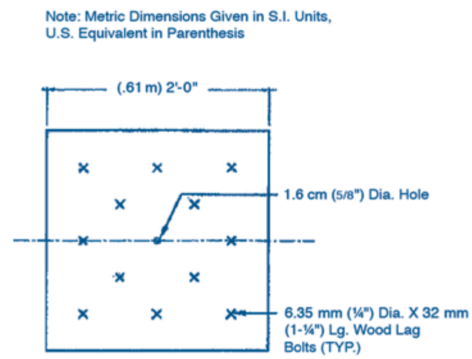

Figure 3 – Bolting panel.

Photo 1 – Plywood panel bonded to EIFS wall.

sample once the test is performed. The plywood is adhered or bonded to the surface of the EIFS wall with polyester adhesive, adhesive expanding foam, or quick-reaction epoxy cement. In addition, another ¾-in. plywood bolting panel will need to be cut and will move from test location to test location. This second panel is connected to the plywood panel once it is adhered to the EIFS wall by fastening twelve #12 screws, 1½ in. long, in a prescribed pattern (see *Figures 2* and *3* from ASTM E2359).

TEST PROCEDURE

To begin the process, use a metal detector or rebar locater to locate the metal studs within the wall assembly. For typical stud spacing that is going to be less than 24 in., the specimen panel will be spaced and centered over two adjacent studs. If fasteners were used to secure the foam in the EIFS, locate the heads of the foam fasteners and arrange the specimen panel so that it will evenly distribute the load across the specimen. Once the location where the panel will be adhered to the wall is determined, outline the area. At the outlines, the EIFS will need to be cut through the lamina, insulation board, and underlying sheathing. A reciprocating saw works best to cut through the EIFS without damaging the studs. If the EIFS is applied directly to a masonry substrate, a circular saw can be used. It should be noted

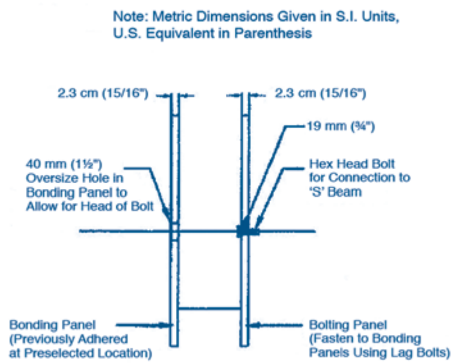

Figure 4 – Plywood assembly.

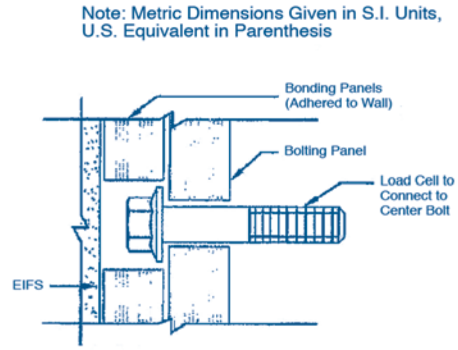

Figure 5 – Detail of bonding and bolting panel with bolt in center hole.

that if the EIFS is applied to a masonry substrate, the saw blade should be set at a depth to extend ⅛ in. to ¼ in. into the masonry.

Once the location is marked and cut, adhere one of the 2- by 2-ft. panels to the wall with the selected adhesive (*Photo 1*). Sintolit Transparent Solid polyester, two-component, knife-grade adhesive has been found to work the best for bonding the plywood panel to the EIFS. While there are different types of expanding foam adhesives, this author finds that often the plywood panels need to be additionally secured to the exterior wall with fasteners or other means while the foam sets. The weight of the plywood panel often overcomes the initial hold of the adhesive before setting up. After installation of the bonding panel to the wall, a precut bolting panel can be installed using the fasteners in the prescribed pattern shown above. It can be seen from *Figures 2* and *3* that a 1½-in.-diameter hole allows for the head of the bolt to be installed in the bonding panel, and a ⅝-in.-diameter hole is installed in the bolting panel so that the load cell can be connected to the center bolt (see *Figures 4* and *5* and *Photo 2*).

Once the panel is set, the frame can be installed and the load cell connected to the center bolt to start applying pressure. The pressure for the test should be the cladding design wind pressure (DWP) that was utilized during original construction, or the DWP should be calculated using the appropriate building code or ASCE 7. The frame should be installed centrally around the test panels. It should be installed in such a manner that the load cell is mounted in line so that the winch and wire attachment can provide a concentric load to properly measure a force load (see *Figure 6* and *Photos 3* and *4*). The frame can be heavy and can affect the test due to its weight on the test specimen, so it is often required (as described in Note 7 of the test standard) that a sawhorse, swing-stage rails, or extra personnel be used to hold the frame until enough load is achieved to make the frame self-supporting (see *Photo 5*).

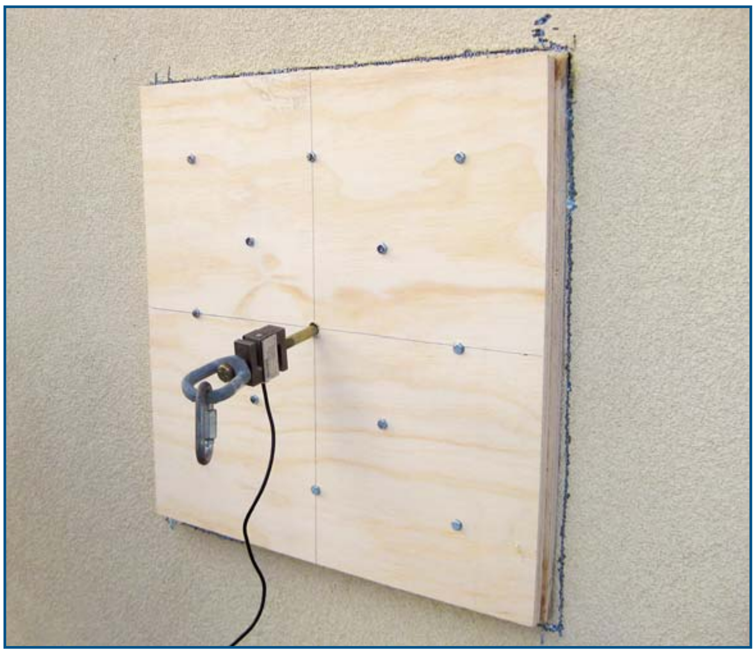

Photo 2 – Test panel fastened to bonded plywood panel with force gauge in place.

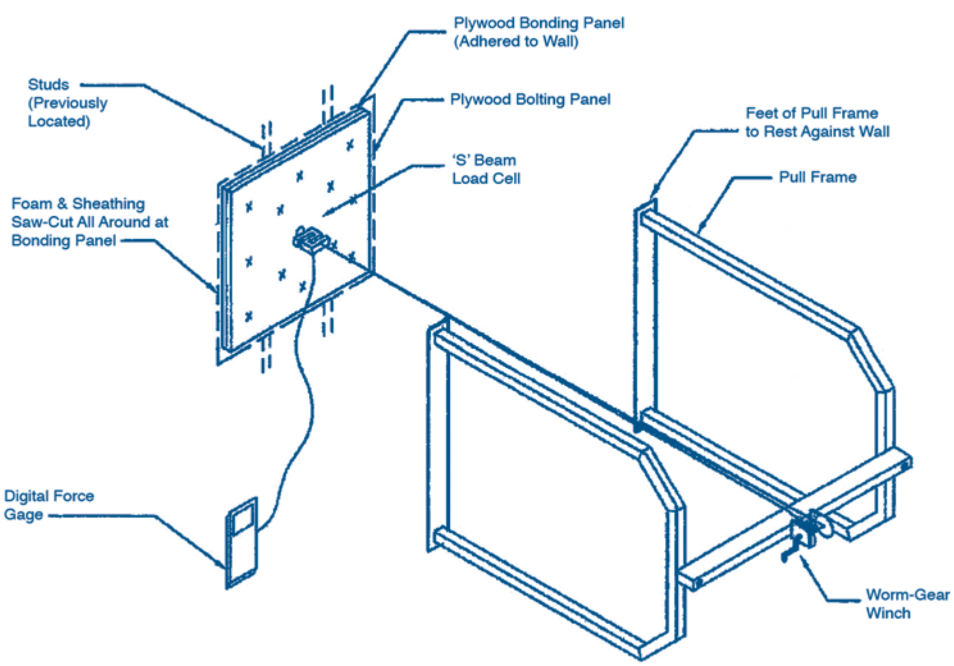

Figure 6 – Test arrangement isometric.

To start the test, an initial load of approximately 10% of the cladding DWP should be applied. This load should be held for one minute with recordings of the loads applied at the beginning of the load step, at the end of the load step, and then after the minute prior to going to the next load. The test procedure should be continued by applying increasingly higher steps with each one 10% of the DWP until the specimen fails. As stated above, the loads from the force gauge should be recorded at the beginning of the loading, at the end of the loading, and after the one-minute hold prior to going to the next load.

Once the specimen fails, the failure method should be documented. The standard defines five different types of failure methods:

1) Face delamination, which occurs

when the face of the sheathing loses bond or delaminates from the sheathing core;

2) Fastener pull-out from the stud, which occurs when the fastener releases from the substrate;

3) Fastener pull-through, which occurs when the head of the fastener pulls through the sheathing, insulation, or substrate;

4) Lamina release, which occurs when the EIFS base coat and finish coat release from the underlying thermal insulation board; and

5) Thermal insulation board failure, which is cohesive failure within the thermal insulation board (*Photo 6*).

Photo 3 – Pull test frame installed against wall.

Photo 4 – Pull test frame centered to provide outward pressure on bonded panel.

INTERPRETATION OF THE RESULTS

The final load recorded from the force gauge is the failure load applied on the specimen. Once the specimen has failed and been removed and the failure load is recorded, the tributary area of the specimen should be calculated. The overall tributary area is calculated by measuring the stud spacing over which the speci-

Photo 5 – Test procedure in process. Additional personnel used to hold the frame in place until the load is applied.

Photo 6 – Test specimen after pull test exposing the metal stud framed wall.

men was applied and then measuring and adding half the distance to the studs on either side of the specimen opening. This theoretical width is multiplied by the height of the specimen to calculate the tributary area. This process should be performed for each of the specimens that are tested on the project. To calculate the test pressure for each specimen, divide the maximum sustained load recorded on the force gauge by the theoretical tributary area to obtain the force per area.

Example: Testing is performed on a specimen with a failure load of 304 lbs. A test specimen is taken with the height being 24 in. and the stud spacing being 16 in. The tributary area is (height x theoretical width):

Width = 16 in. + (16 in./2) + (16 in./2) = 32 in.

Tributary Area = [(24 in. x 32 in.)/144] = 5.33 sq. ft.

Force Per Area = (304 lbs./5.33 sq. ft.) = 57.4 p.s.f.

Interpretation of these results as described in the standard can be highly subjective. The test standard does not claim to "replace education or experience and should be used in conjunction with sound engineering practice and professional judgment." In the example above, the test specimen was taken in Zone 4 of a new building in Tulsa, OK, where the calculated DWP for Zone 4 was a negative 39 p.s.f. For this example, it was concluded that the test specimen was able to withstand the DWP for this project.

CONCLUSION

As many of us read and understand this standard, we are reminded of the bonded pull tests that we have seen or done numerous times throughout our careers working on roofs. Those types of procedures could possibly have been the inspiration for ASTM E2359. While many types of exterior cladding systems cannot be analyzed in this fashion, an EIFS wall typically can. As designers, we need to ensure that we are specifying products and systems that have been tested and certified to meet the code-required loads to which we are bound. In addition, in evaluating building failure or performance of in-place assemblies, these types of evaluation procedures can be very valuable in helping with forensic studies and surveys.

The ASTM E2359 procedure can be performed on new and existing construction and will evaluate the entire assembly of the EIFS to determine the failure method of the system to help pinpoint the source and reason for the failure. A thorough knowledge of the standard and EIFS should be understood before attempting to perform this test procedure. While it should be used in conjunction with experience and education to determine outward load capacities, this test standard is the most valuable tool for assistance in determining the negative wind load capacities of an EIF system.

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