Designation: E2359/E2359M – 13

Standard Test Method for Field Pull Testing of an In-Place Exterior Insulation and Finish System Clad Wall Assembly[1]

This standard is issued under the fixed designation E2359/E2359M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers a procedure to determine the resistance of a section of the exterior insulation and finish system (EIFS) to outward loads imposed on an existing exterior wall assembly that has been in place on the building for an unspecified period of time. It is destructive in nature within the localized areas tested and requires appropriate repair of the EIFS cladding and sheathing once the test procedure has been completed. This test procedure utilizes mechanical methods to obtain information, which may be helpful in evaluating the natural application of negative wind loads on the EIFS assembly. Some variability of results should be anticipated within the wall assembly tested due to differences in installation procedures, exposure, or abuse subsequent to application.

1.2 This test method is suitable for use on cladding assemblies that have been in place a short time (new construction), as well as for longer periods in order to evaluate detrimental effects on the EIFS lamina, insulation attachment, substrate integrity, and attachments after exposure to weather and other environmental conditions. It is not intended to evaluate the performance of structural framing. Test results on any particular building may be highly variable depending on specimen location and condition, and are subject to interpretation by the test specifier.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.4 *This standard may involve hazardous materials, operations, or equipment. This standard does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.*

NOTE 1—Due to variations in exposure and construction assemblies, field specimens selected for testing utilizing this test method may experience sudden failure and release of the imposed loads. See Note 7 for further information.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D3665 Practice for Random Sampling of Construction Materials

E631 Terminology of Building Constructions

E2110 Terminology for Exterior Insulation and Finish Systems (EIFS)

E2128 Guide for Evaluating Water Leakage of Building Walls

2.2 *American Society of Civil Engineers (ASCE):*[3]

SEI/ASCE 7-05, Minimum Design Loads for Buildings and Other Structures

3. Terminology

3.1 For general terminology regarding EIFS and building in general, see Terminology E2110 (for EIFS terms) and Terminology E631 (for buildings in general).

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *face delamination, n*—failure mode by which the face of the sheathing loses bond or delaminates from the sheathing core, either partially or fully.

3.2.2 *fastener pull-out from stud, n*—failure mode by which fastener releases from the substrate.

3.2.3 *fastener pull-through, n*—failure mode by which the head of the fastener pulls through the sheathing, insulation, or substrate.

3.2.4 *lamina release, n*—failure mode by which the EIFS base coat and finish coat release their bond to the underlying thermal insulation board layer.

[1] This test method is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.58 on Exterior Insulation and Finish Systems (EIFS).

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American Society of Civil Engineers (ASCE), 1801 Alexander Bell Dr., Reston, VA 20191, http://www.asce.org.

3.2.5 *thermal insulation board failure, n*—cohesive failure within the thermal insulation board.

4. Significance and Use

4.1 The purpose of this test method is to assess the installation adequacy and the overall effects of service-related deterioration (moisture, etc.) on the EIFS wall assembly as opposed to small localized areas of degradation. Resistance to pull testing as determined by this test is used as one of the factors in evaluating the EIFS assembly on a specific project. The values obtained by this test method are not purported to be representative of the actual wind load capacity or other structural properties of a specific EIFS clad wall installation, but may be helpful in assessing such load capacities.

4.2 Since this test is used for field evaluation of existing facilities, load results obtained from this test must be interpreted based on sound engineering practice, applicable building regulations, and codes having jurisdiction. It is the discretion of the test specifier to directly utilize the results derived by this test method, or else to utilize the test results with an appropriate factor of safety to obtain acceptable working loads for each project.

4.3 This method is intended for use on test specimens occurring or installed on existing buildings. The loss of outward wind load resistance of an EIFS wall assembly after exposure to moisture and other weather conditions may compromise the ability of the cladding or other wall components to perform adequately in place. This test method does not provide any means by which the test results may be generalized to the larger wall area. Such efforts should be based on experience and engineering judgement.

4.4 The manner in which the test load is applied may affect the load capacity obtained from using this test method. A discussion of various load application techniques and their effects is given in Appendix X1.

5. Apparatus

5.1 Electronic rebar locator or metal detector sensitive enough to locate metal studs or fasteners of the underlying structural framing through the EIFS assembly.

5.2 Pull test frame fabricated from metal or wood, as required, with capability of applying a concentric pull force to the test module and distributing reaction force on adjacent wall components. Pull test frame shall be provided, as a minimum, with a worm-gear winch and a nylon strap or wire rope capable of applying load to test module in controlled manner with incrementally increasing load intensities. Alternative means of applying a consistent load using electro-servo motors or hydraulic units are also acceptable, provided they are capable of applying consistent, uniform load. It is intended that the pull test frame be easily transportable and relocated so that it can be readily used on saw-horses, scaffolding, or a swing-stage. An example of an acceptable test frame is shown in Fig. 1.

5.3 Electronic load cell with digital force gage having a capacity of at least 4450 N [1000 lbf.], and an accuracy of ±2 %.

5.4 610 mm by 610 mm [24 in. by 24 in.] wooden pull test modules comprised of 19 mm [¾ in.] thick plywood bonding panels (one for each specimen intended for testing), and one 19 mm [¾ in.] thick plywood bolting panel, which is moved from specimen-to-specimen. As each specimen is prepared for testing the bonding panels and bolting panels shall be fastened together using twelve (12) 5.5 mm ((#12) or [0.215 in.]) diameter by 38 mm [1½ in.] long wood screws or lag bolts installed in a prescribed pattern. See Figs. 2-5. Adhere one 19 mm [¾ in.] thick bonding panel to the surface of the EIFS in place at each specimen location. For testing purposes, temporarily fasten the bolting panel at each adhered bonding plate in succession with appropriate hardware, immediately prior to testing.

NOTE 2—Screw hole locations for both the bonding panels and the bolting panel must align for proper attachment; use bolting panel as a drilling template to achieve consistent screw locations and alignment on all bonding panels.

5.5 Miscellaneous bolts and connection hardware.

6. Test Specimen

6.1 Sampling locations and number of specimens shall be specified by the user. Primarily, this test method is intended to implement qualitative evaluation techniques that lead to an accumulation of information in an orderly and efficient manner in accordance with procedures prescribed within Guide E2128. If a hybrid method using a combination of qualitative and quantitative evaluation techniques is desired by the test specifier, then a random number generator method may be utilized to establish locations of test specimens required to represent the entire building population. Include additional test specimens at locations of suspected or potential problems, such as below window corners, at wall base, and so forth.

NOTE 3—For the hybrid method using a combination of qualitative and quantitative evaluation techniques, a selection method based on Practice D3665 may be utilized for this purpose.

6.2 Locate metal studs within wall system (or else fastener heads at wood-framed system) using rebar locator or metal detector, and determine elevation or height of the specimen.

6.3 For stud spacing less than 610 mm [24 in.] (on center), mark 610 mm by 610 mm [24 in. by 24 in.] outline on the surface of EIFS that is centered over two adjacent studs. For stud spacing 610 mm [24 in.] and greater, mark an outline on the EIFS surface that is 610 mm [24 in.] high and with a width equal to the stud spacing plus 75 mm [3 in.], which is centered over two adjacent studs. If foam fasteners are present or suspected within the EIFS clad wall assembly, locate the heads of foam fasteners using a rebar locator, then arrange bonding panel in manner that evenly distributes the load across the test specimen and mark the outline on the EIFS surface. At each outline marked on the wall, carefully cut through the EIFS lamina, thermal insulation board, and sheathing substrate, being careful to avoid excessive vibration during specimen preparation that may adversely affect test results. Efforts should also be made to avoid cutting or damaging the wall studs.

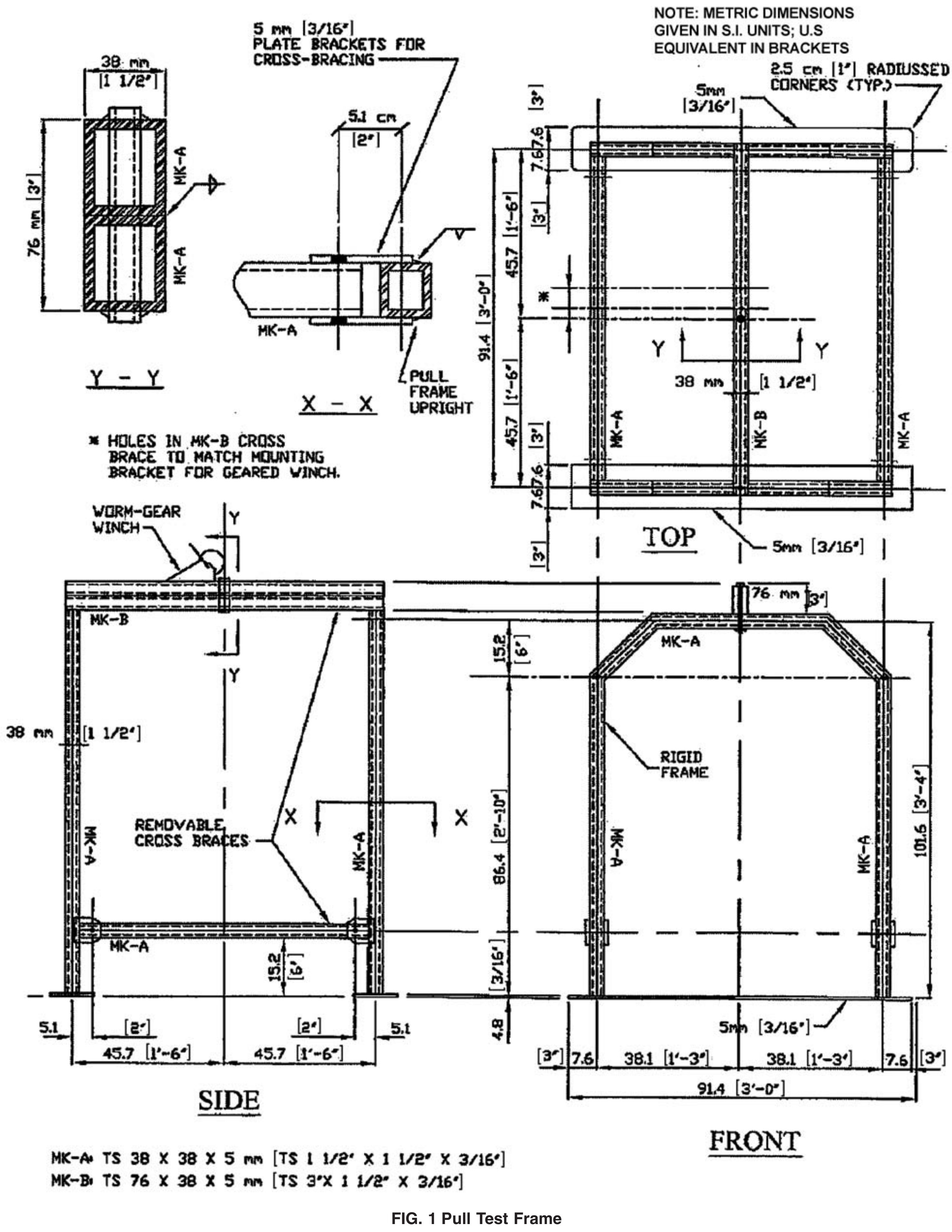

FIG. 1 Pull Test Frame

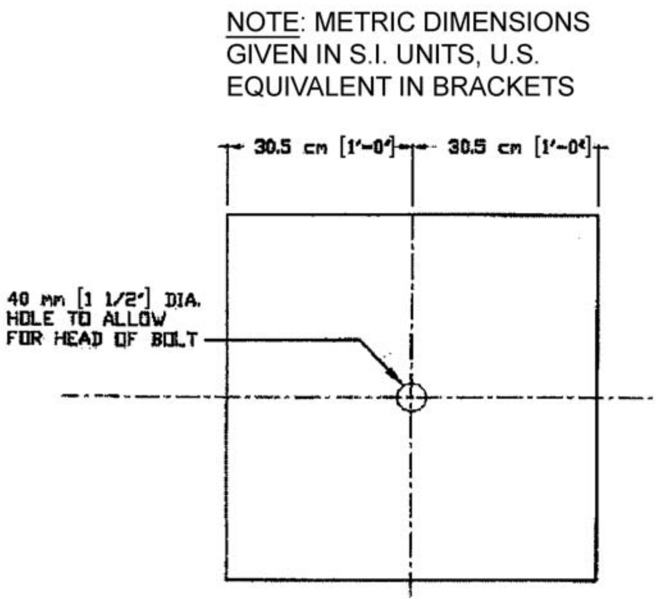

FIG. 2 Bonding panel

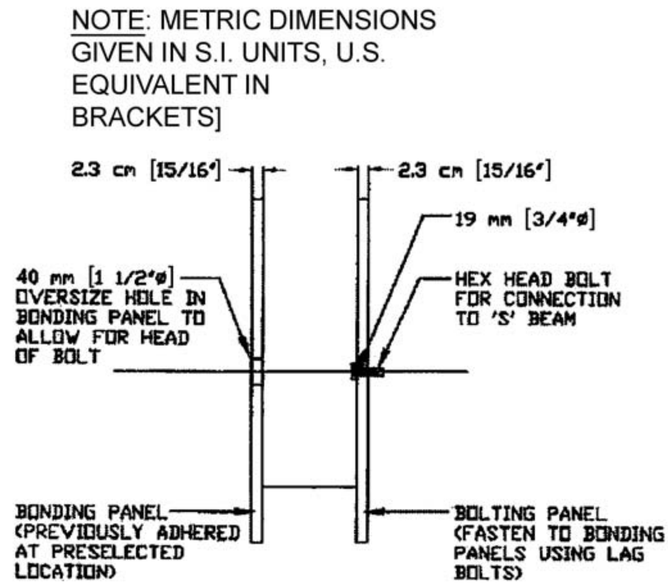

FIG. 4 Plywood Assembly

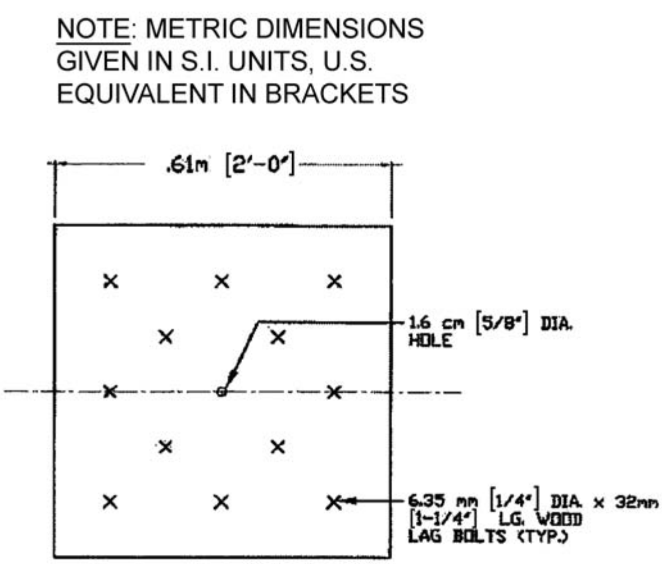

FIG. 3 Bolting Panel

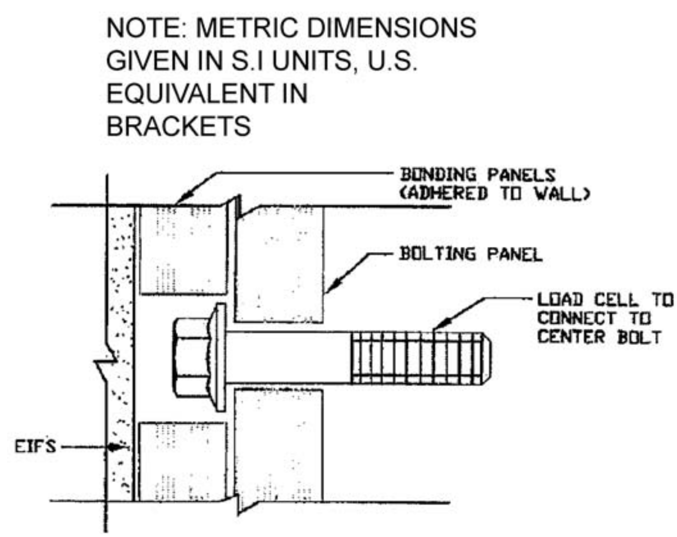

FIG. 5 Detail of Bonding and Bolting Panel with Bolt in Center Hole

NOTE 4—For EIFS cladding applied directly to a masonry substrate, saw blade depth should be set to extend 3 mm [⅛ in.] to 6 mm [¼ in.] into the masonry.

6.4 Adhere one 19 mm [¾ in.] thick, 610 mm [24 in.] square plywood bonding panel to the previously cut EIFS surface (centered) at designated test location using polyester adhesive, adhesive expanding foam, or quick-reaction epoxy cement; temporarily support test module in place on the wall as required. Allow an adequate time for curing of the adhesive considering effect of temperature on cure time of adhesive.

NOTE 5—Alternative adhesives may be used that are not detrimental to the lamina or underlying foam insulation system.

7. Procedure

7.1 Obtain information regarding the cladding assembly design wind pressure (DWP) utilized during original construction of the building, or else otherwise determine an appropriate cladding DWP for comparative purposes using local building codes or SEI/ASCE 7-05 analytical procedures. Establish initial load at approximately ten percent (10 %) of cladding design wind pressure.

7.2 Align the bolting panel, with appropriate pull hardware inserted through center hole, onto the previously adhered bonding panel and securely fasten bolting panel to bonding panel with prescribed screws or lag bolts.

NOTE 6—If required, replace previously used screws with fresh ones as Phillips head slots become worn or damaged.

7.3 Place bearing plates of pull test frame on wall and center over previously adhered bonding panel with bolting panel attached. Fasten wire rope attachment hardware to the test module hardware, with load cell mounted in-line with pull force mechanism in a manner that will measure force loads. See Fig. 6.

NOTE 7—Use saw-horse, scaffolding deck, or swing-stage rails to temporarily support pull test frame until sufficient load is achieved to make test frame self-supporting. Be prepared to re-establish temporary support at end of test, or in case of sudden failure of test specimen.

7.4 Apply previously determined initial load to test module as required to hold pull test frame in place and hold for one minute. Record load from force gage at beginning of load step and at end of load step, prior to going to next load.

7.5 Continue test by applying increasingly higher stepped loadings corresponding to approximately 10 % of the final design wind pressure until the wall assembly fails. Stepped loading increments shall be held for one minute, and loads from force gage recorded at beginning of load step and at end of load step immediately prior to going to next load. Often the specimen may fail transitioning from one sustained load to the next higher step loading increment.

NOTE 8—Once the next load increment is applied, it is common for the load to begin to slowly decrease, due to deformation of thermal insulation board and elongation of test hardware.

NOTE 9—For EIFS cladding applied directly to a masonry substrate, adhesion of the lamina to the foam or foam to the masonry may exceed the capacity of the load cell and force gage. If during load application the maximum capacity of the load measurement device is approached, the load should be temporarily released and the measuring device removed to avoid damage to the unit. A decision should be made by the test specifier whether to retain the specimen on the wall and repair accordingly, or else to continue the test to destruction (without load measurement) and repair the entire opening thus created.

7.6 After completion of pull testing, examine test specimen and opening, and document or record location and spacing of studs within opening, as well as spacing of adjacent studs on both sides of the opening. Also record and document location and spacing of sheathing fasteners, sheathing joints, and thermal insulation board joints. Test administrator should document or record failure mode, whether fastener pull-through, face delamination, lamina release, thermal insulation board debonding, or combination of one or more mode types. Finally, determine whether foam or sheathing exhibits moisture absorption at time of testing using a probe-type moisture meter.

7.7 Remove screws attaching bolting panel to bonding panel of previous specimen. Continue testing by moving bolting panel and pull test frame to each specimen in turn, fastening bolting panel to bonding panel of next specimen immediately prior to testing, then conducting the procedure outlined in 7.2-7.6, above.

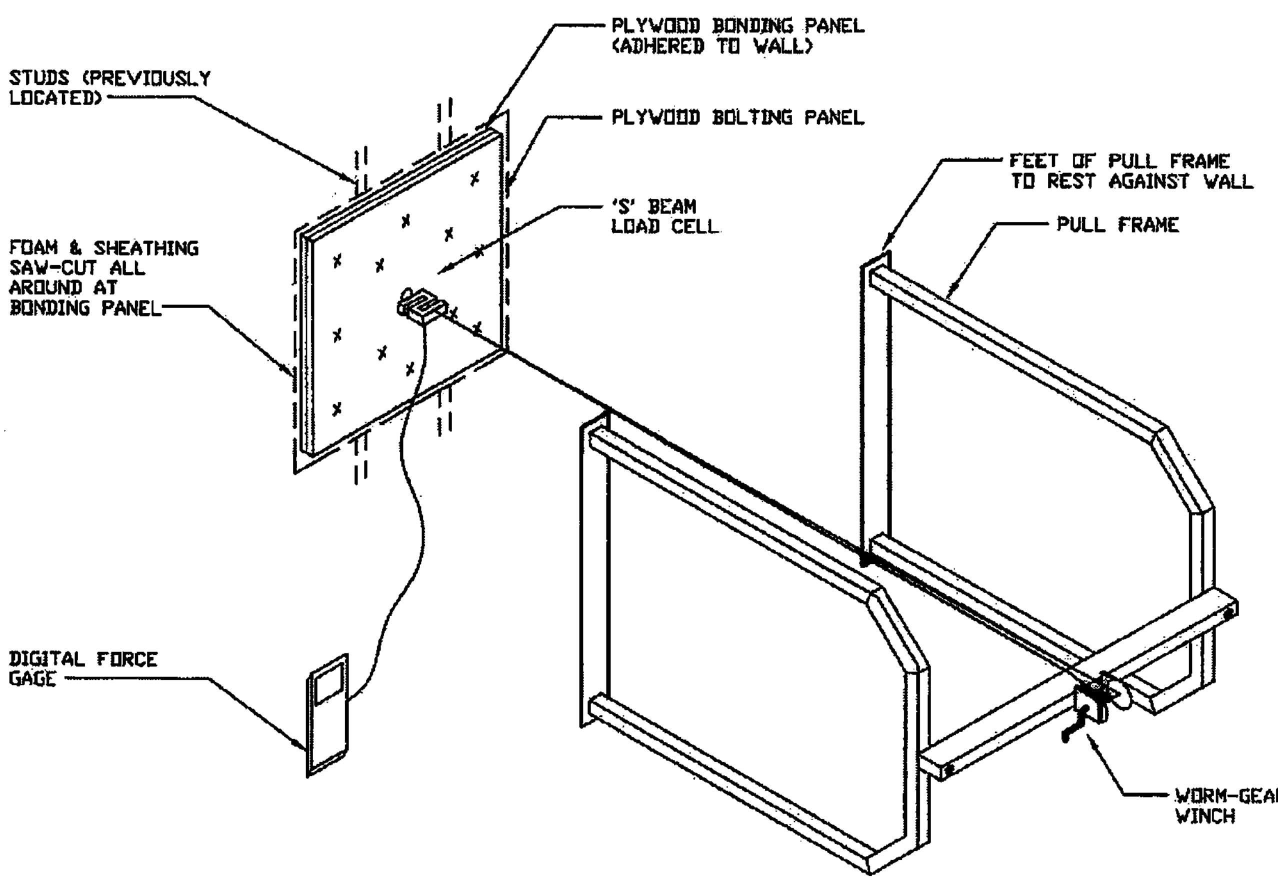

FIG. 6 Test Arrangement Isometric

8. Calculations and Interpretation of Results

8.1 Calculate tributary area of each specimen by multiplying specimen height by specimen theoretical width, which is derived from horizontal spacing of vertical studs plus the dimensions of the two half spaces located on both sides of the specimen opening. Overall tributary area is determined by establishing stud spacing over which the specimen was located and adding half the distance to the studs located on both sides of the specimen (that is, left and right half spaces). See Appendix X2 for illustrative examples.

8.2 Further, calculate test pressure for each individual specimen by dividing the maximum sustained load recorded on the force gauge by the tributary area to obtain force per area.

NOTE 10—Where stud spacing varies, consideration should be given to interpretation of the data with respect to loading per area.

NOTE 11—If failure of specimen occurs due to lamina release from foam or foam release from substrate, then tributary area shall be calculated as the product of the opening height and width (that is, do not include half spaces to right and left of specimen).

NOTE 12—Where fastener spacing varies significantly, or if fastener grouping is substantially off-center, calculations to determine total force as distributed among individual fasteners based on fastener group centroid, or to account for prying resulting from eccentricity, may be appropriate.

8.3 This test method provides a set of instructions for performing one or more specific operations. However, interpretation of the test results for field applications may be highly subjective and will most likely involve consideration of many specific variables. This document cannot replace education or experience and should be used in conjunction with sound engineering practice and professional judgment. Not all aspects of this test method may be applicable in all circumstances. This test method is not intended to represent or replace the standard of care required to fully evaluate the adequacy of a given EIFS clad wall assembly, nor should this method be utilized without consideration of a project's many unique aspects. The word "test method" in the title means only that the procedure has been approved through the ASTM consensus process.

9. Test Report

Provide the following information in the test report:

9.1 The manufacturer of the EIFS materials, if known, and a description of the specific wall assembly or sandwich occurring at each specimen. The date of the original installation, if known, as well as ambient conditions at the time of test, what the time delay was between preparation of specimens and testing procedure, and whether inclement weather was experienced between preparation of specimens and testing.

9.2 Description of test equipment and arrangement, as well as specimen location, size, stud spacing, test results, and so forth.

9.3 Selection criteria for specimen locations, as well as precise description of the location of each specimen within the overall cladding.

9.4 Test results of each specimen, reported in pascal [psf]. Test specifier shall determine whether to include step load results or just final results.

9.5 Description of failure mode, specimen configuration, and any unusual features or conditions exhibited by the specimen, including presence or evidence of corrosion, water stains, moisture absorption (as determined by moisture meter), visible deterioration, and so forth. Also note and describe evidence of failure other than that occurring within the EIFS assembly.

9.6 Sketch of opening, showing overall size, stud spacing within opening, stud spacing to both sides of opening, fastener spacing, fastener locations, location of sheathing joints and insulation joints, and any other pertinent observations or information.

10. Precision and Bias

10.1 No statement is made on the precision or bias of this test method due to the variety of materials, combinations of materials, and installation variables involved in fenestration product design, assembly, and testing. In addition, projects located in differing geographic areas and climatic regions will experience varying severity of exposure, as well as variable exposures within the different elevations and areas of a single building.

11. Keywords

11.1 design wind loads; design wind pressure; DWP; EIFS; exterior insulation and finish system; face delamination; moisture deterioration; negative pressure; pull test; pull test frame; stud spacing; substrate integrity

APPENDIXES

(Nonmandatory Information)

X1. APPLICATION OF TEST LOADS

X1.1 Visually align wire rope for each test pull, apply loads from the pull test frame to the adhered test module that are perpendicular to the wall and concentric to the test module center hole.

X1.2 Application of initial load shall be established swiftly but smoothly, and each incremental step load shall commence at consistent one minute intervals and with step increments that are as uniform as possible (given limitations of load application hardware), and that are as near as possible in magnitude to 10 % of the final anticipated load.

X1.3 Release of load intensity, or load drift, after application of each load increment is not unusual (see Note 8 at 7.5). Continue with test procedure as outlined, recording load increment from force gage at beginning and end of load step as directed. If load drift reduces test load below last previous increment, the next higher increment shall be determined from initial force recorded for that step load, not the final, or drift, load of that step.

X1.4 A worm-gear manual winch is recommended for use for this test procedure. If a manual toothed geared winch is utilized as load application device, the instantaneous peak load experienced as the winch mechanism goes over each tooth of the gear is considered to be inconsequential provided the load application is made quickly and the operator does not linger at the top of the gear tooth. The test method described in this standard requires a record of the maximum sustained load occurring between gear teeth, that is, the normal load position. If a record of the instantaneous peak is desired by the test specifier, then a force gage having a "maximum" capture feature must be used and the maximum peak recorded as an extra step during the one minute load interval.

X2. CALCULATION OF TRIBUTARY AREA (EXAMPLES)

NOTE X2.1—The height and width of the specimen may vary due to field conditions, results of cutting procedures, or other purposeful actions of the test operator to accommodate the field specimen.

X2.1 Example One: Test data indicate that stud spacing at the specimen is 610 mm [24 in.], while the spacing to the left is 597 mm [23½ in.] and to the right is 585 mm [23 in.]. The specimen height is 623 mm [24¼ in.]. The tributary area is: [(610 mm + ((597 mm + 585 mm)/2)) * 623 mm]/1 000 000 = 0.74 m^2. Inch-Pound System: [(24 in. + ((23½ in. + 23 in.)/2) * 24¼ in.)/144] = 7.96 ft^2.

X2.2 Example Two: Test data indicate that stud spacing at the specimen is 407 mm [16 in.], while stud spacings to the left and right are also 407 mm [16 in.]. The specimen height is 610 mm [24 in.]. The tributary area is: [(407 mm + ((407 mm + 407 mm)/2)) * 610 mm]/1 000 000 = 0.50 m^2. Inch-Pound System: [(16 in. + ((16 in. + 16 in.)/2) * 24 in.)/144] = 5.33 ft^2.

X2.3 Example Three: Test data indicate that the stud spacing at the specimen is 610 mm [24 in.], while stud spacing to the left is 305 mm [12 in.] and to the right is 610 mm [24 in.]. The specimen height is 635 mm [25 in.]. The tributary area is: [(610 mm + ((305 mm + 610 mm)/2)) * 635 mm]/1 000 000 = 0.68 m^2. Inch-Pound System: [(24 in. + ((12 in. + 24 in.)/2) * 25 in.)/144] = 7.29 ft^2.

NOTE X2.2—Although this is the actual tributary area for this specimen, a theoretical tributary area of [(610 mm + ((610 mm + 610 mm)/2)) * 635 mm]/1 000 000 = 0.77m^2 could be deduced if it is assumed the left stud spacing is an anomaly. Inch-Pound System: [(24 in. + ((24 in. + 24 in.)/2) * 25 in.)/144] = 8.33 ft^2.

X2.4 Example Four: Foam releases it's bond from substrate for a cut specimen having dimensions 610 mm [(24 in.] wide by 610 [24 in.] high. The tributary area is: [610 mm * 610 mm]/1 000 000 = 0.37 m^2. Inch-Pound System: [(24 in. * 24 in.)/144] = 4.0 ft^2.

X3. EQUIPMENT DIAGRAMS

X3.1 Fig. 1 - Pull Test Frame

X3.2 Fig. 2 - Bonding panel

X3.3 Fig. 3 - Bolting Panel

X3.4 Fig. 4 - Plywood Assembly

X3.5 Fig. 5 - Detail of Bonding and Bolting Panel with Bolt in Center Hole

X3.6 Fig. 6 - Test Arrangement Isometric