Ballot E06 (13-04) Response, Items 1-7 (E72)

Table of Contents

Item 1:

b) MODIFY SECTION 14.2.2

14.2.1 *Size and Number*—The test specimen shall be 2.4 by 2.4 m (8 by 8 ft) and the framing shall be constructed as shown in Fig. 6 and a minimum of three panels of each construction shall be tested

14.2.2 The average moisture content of framing material shall be between ~~12~~ 6 and 15 % at the time of testing. ~~when the panel is fabricated, and shall not vary by more than 3 % from the initial moisture content when the panel is tested.~~ Immediately after the racking test, the moisture content of all framing members that receive sheathing perimeter fasteners at the panel boundaries and center stud shall be determined using D4442 or D7438 and reported. The average moisture content for each test frame and the delay between fabrication and testing shall be reported. If the time delay between fabrication and testing exceeds 72 hours, then moisture content of all framing members that receive sheathing perimeter fasteners shall also be determined at the time of fabrication and reported.

Vote

Negative

Comment

Part (b):

Section 14.2.1 should be renamed and address only the number of specimens to test. The remaining language then be moved to Section 14.2.1.1, as that section addresses a specific ("standard") frame for the explicit purpose of evaluating the sheathing material on a relative basis (per the scope). Requiring size and framing details is inconsistent with the flexibility of Section 14.2.1.2. The concept is limiting tests to only products that have a nominal size of 4'x8', installed with the panel's long length oriented vertically. This also may cause conflict with Section 14.2.2 which requires installation as specified by the manufacture.

Section 14.2.2 should move the requirement of moisture content (first sentence) to section 14.2.1.1. Again, section 14.2.1.2 allows for varying the framing and is unnecessarily being prescribed values.

Suggested Language

14.2 *Test Specimens:*

14.2.1 ~~*Size and* Number—The test specimen shall be 2.4 by 2.4 m (8 by 8 ft) and the framing shall be constructed as shown in Fig. 6 and a~~ A minimum of three panels of each construction shall be tested. ~~Frames shall be newly constructed for each test. All individual framing members shall be continuous.~~

14.2.2 *Moisture Content* – ~~The average moisture content of framing material shall be between 12 6 and 15 % at the time of testing. when the panel is fabricated, and shall not vary by more than 3 % from the initial moisture content when the panel is tested.~~ Immediately after the racking test, the moisture content of all framing members that receive sheathing perimeter fasteners ~~at the panel boundaries and center stud~~ shall be determined using D4442 or D7438 and reported. The average moisture content for each test frame and the delay between fabrication and testing shall be reported. If the time delay between fabrication and testing exceeds 72 hours, then moisture content of all framing members that receive sheathing perimeter fasteners shall also be determined at the time of fabrication and reported.

Item 2:

Proposal

b) MODIFY SECTION 14.1

14.1 Scope—This test method measures the resistance of panels, having a ~~standard~~ wood frame, and sheathed with sheet materials such as structural insulating board, plywood, gypsum board, transite, and so forth, to a racking load such as would be imposed by winds blowing on a wall oriented at 90° to the panel. It is intended to provide a reliable, uniform procedure for determining the resistance to racking load provided by these sheet materials as commonly employed in building construction. Since a standard frame is employed, the relative performance of the sheathing is the test objective.

c) MODIFY SECTIONS 14.2.1.1 AND 14.2.1.2:

14.2 *Test Specimens*:

14.2.1 *Size and Number*—The test specimen shall be 2.4 by 2.4 m (8 by 8 ft) and the framing shall be constructed as shown in Fig. 6 and a minimum of three panels of each construction shall be tested. Frames shall be newly constructed for each test. All individual framing members shall be continuous. The moisture content of framing material shall be between 12 and 15 % when the panel is fabricated, and shall not vary by more than 3 % from the initial moisture content when the panel is tested.

14.2.1.1 *Sheathing Material Evaluation* - ~~If the test is used to evaluate the sheathing material, the~~ The frame shall be constructed as nearly like the frames shown in Fig. 6 as possible. ~~using~~ No. 1 Douglas-fir Larch or Southern Pine lumber conforming to NIST Voluntary Product Standard PS20 shall be used. The stud spacing and size of the stud at the vertical panel joint shall be permitted to vary as necessary to reflect the manufacturer's specified test condition or standardized requirements. Any deviations from the framing scheme depicted in Fig. 6 shall be reported.

Note X: A common situation where the 14.2.1.1 framing provisions apply would be for product qualification and evaluation of sheathing products where design values have already been established. In those instances, the sheathing performance and variation is the primary interest.

14.2.1.2 *Sheathing and Sheathing-to-Framing Attachment Design Shear Evaluation Without the Involvement of Anchorage* - ~~If the test is used to evaluate design shear resistance of the wall assembly without the involvement of anchorage details, the~~ The framing shall be constructed in accordance with Fig. 6 except that the framing materials (size and specific gravity), stud spacing, and sheathing fastener ~~nail~~ size and spacing shall conservatively represent the range of applications that use the same design shear or racking resistance ~~value~~. The oven-dry specific gravity of the framing materials that receive perimeter sheathing fasteners at the panel boundaries and center stud shall be determined in accordance with D2395 and reported. The average framing specific gravity for any test assembly shall not exceed the targeted average by more than 0.03.

Note Y: The framing details of 14.2.1.2 apply in instances where the racking test is used to evaluate the racking resistance of the sheathing and sheathing-to-framing attachment for the establishment of design loads. This may include evaluation for sheathing, fastener, or framing products to be used in engineered or braced wall applications. In these instances, the goal is to ensure that the interaction between the framing, sheathing fastener, and sheathing is representative of the end use condition.

Vote

Negative

Comment

Part (b), modification of the scope: The text has been modified to remove the word 'standard' from the first sentence, implying the test is for any wood frame. The last sentence then states that 'Since a standard wood frame is employed, the relative performance of the sheathing is the test objective.' These two sentences are now in conflict. The assumption is that the word standard was removed from the first sentence to accommodate section 14.2.1.2 which allows for framing variations. It seems the scope needs to be reworked to explicitly address the objective when using a standard frame (Section 14.2.1.1) and the objective when using a specific frame (Section 14.2.1.2). The standard appears to have two different objectives, and these differences need to be clearly defined (both in the scope and throughout).

Part (c):
Section 14.2.1 should be renamed and address only the number of specimens to test. The remaining language then be moved to Section 14.2.1.1, as that section address a specific ("standard") frame for the explicit purpose of evaluating the sheathing material on a relative basis (per the scope). (See comments on item 1)

The first sentence of Section 14.2.1.1 mentions 'frames' shown in Figure 6, which should be modified to 'frame'.

Section 14.2.1.2 should remove 'design shear' from the section title, and include 'or influence of boundary conditions' after anchorage (*Sheathing and Sheathing-to-Framing Attachment ~~Design Shear~~ Evaluation Without the Involvement of Anchorage or Influence of Boundary Conditions)*. Following the wording of the current scope and being consistent with the naming of Section 14.2.1.1, the testing is to determine resistance, and to evaluate performance. The reference to 'the same design shear' should then also be removed from the first sentence of this section. Also, as mentioned above, the framing details of Figure 6 should not be required in this test.

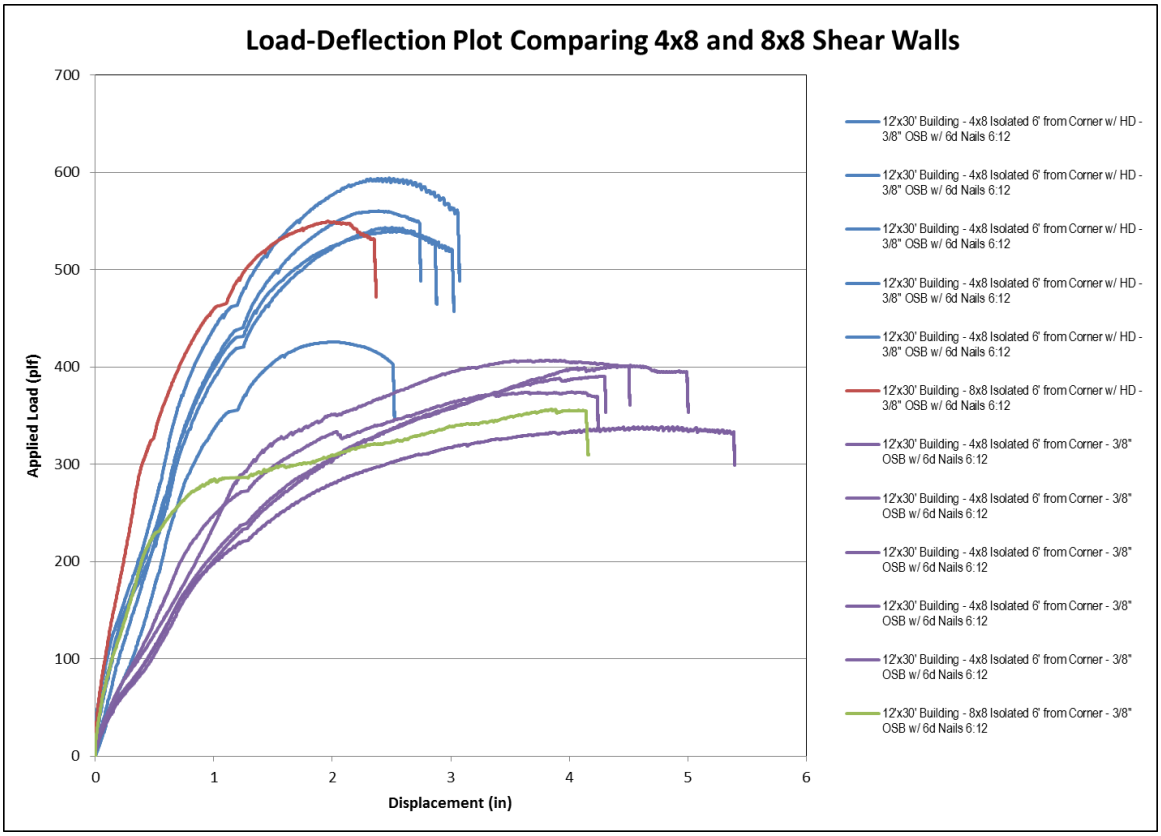
Note Y: Language discussing 'the establishment of design loads' is both incorrect (values should replace loads) and unnecessary and should be removed. Also, the sentence '… the goal is to ensure that the interaction between the framing, sheathing fastener, and sheathing is representative of the end use condition'. The implication, along with the current title that ends with 'without the involvement of anchorage' is that using threaded rods to restrain the load edge of the frame is, or can be used, to represent the end use condition is false. If a Note Y is to exist, the language should be modified.

ASTM E72 has never been a standard that has had as its scope anything other than to evaluate the relative performance of sheathing materials.

If this standard is going to be changed so that it is now providing design value all the “due allowance conditions” will need to be defined in this standards so that there can be sound correlation between the test results and real world resistance performance. This “due allowance”

detailing and correlation modeling will by definition need to be justified by test data that shows how this is done and the approaches used standardized as well.

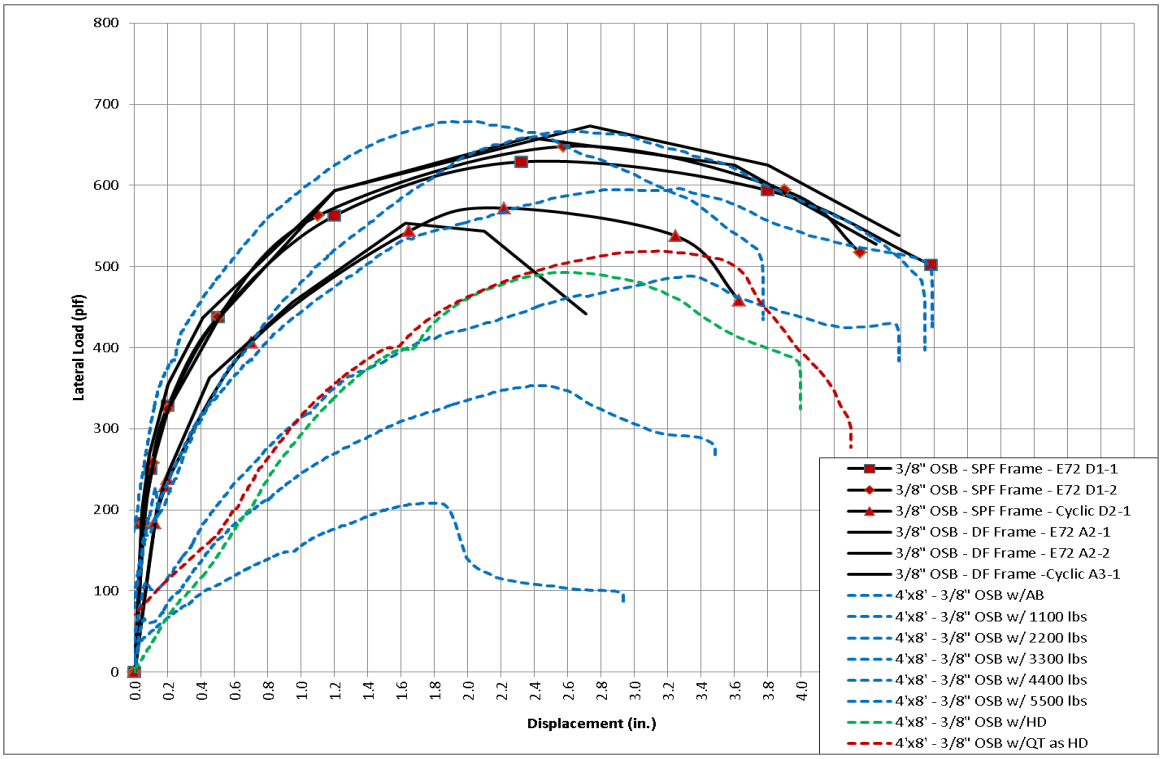
Please see the graph below demonstrating both the lack of need of a prescribed 8x8 wall and the effects of true end-use boundary conditions can have on the performance of a wall. The graphic illustrates the plf load-deflection of a wall using single 4'x8' panels, and two abutting 4'x8' panels. It also includes tests with anchor bolts, and with hold-downs.



The effects of the threaded rods, furthermore, have dramatic effect on the performance of a sheathed wall. Without commentary on the effect tension rods have on the performance, stating that tests using the threaded rods are representative of end use conditions is incorrect. The graphic below graphic compares E72 testing by Weyerhaeuser plotted against tests that replace the tension rod with an applied vertical load[1]. Vertical loads incremented at 1100lb, starting at 0, up to 5500lb. There also is a comparative test

[1] The Weyerhaeuser data and Gruber data were attached documents. The Gruber work can also be found here: http://digitalcommons.wayne.edu/cgi/viewcontent.cgi?article=1441&context=oa_dissertations&sei-redir=1&referer=http%3A%2F%2Fwww.google.com%2Furl%3Fsa%3Dt%26rct%3Dj%26q%3Dreliability%2520and%2520effect%2520of%2520partially%2520restrained%2520wood%2520shear%2520walls%26source%3Dweb%26cd%3D2%26ved%3D0CFEQFjAB%26url%3Dhttp%253A%252F%252Fdigitalcommons.wayne.edu%252Fcgi%252Fviewcontent.cgi%253Farticle%253D1441%2526context%253Doa_dissertations%26ei%3DvmCuT_69OYnnggfT2s2yCQ%26usg%3DAFQjCNFP3fqAMNSpltoROhDkK0BpIn96tg#search=%22reliability%20effect%20partially%20restrained%20wood%20shear%20walls%22

using a hold-down. The work by Gruber establishes ASTM E72 is inappropriate for formulation of nominal unit shear design values.



It is clear from the above graph that use of the tension rods results in over-prediction of performance when compared to use of anchorage bolts only (lowest blue line, approximately 200plf ultimate load) and compared to hold-downs (green and red line).

Use of the prescribed frame and fixture may be relevant for relative WSP sheathing/fastener interface evaluation, but it is not satisfactory to apply the concept to Section 14.2.1.2 through Note Y.

If Section 14.2.1.2 is intended to be used as the basis for design values, language must be included as stated above so all of the "due allowance conditions" are defined in this standard to provide sound correlation between the test results and real world resistance performance. It is clear different boundary conditions will result in different performance characteristics. Requiring the test report include all the details of framing and anchorage could be satisfactory.

Suggested Language

14. Racking Load—Evaluation of Sheathing Materials on a ~~Standard~~ Wood Frame

NOTE 2 – This standard has been used to evaluate design shear resistance of ~~wall assemblies~~ sheathing materials without the involvement of anchorage details. If the test objective is to measure the performance of the complete wall, Practice E564 is recommended.

14.1 Scope – This test method measures the resistance of panels, having a ~~standard~~ wood frame, and sheathed with sheet materials such as structural insulating board, plywood, gypsum board, transite, and so forth, to a racking load such as would be imposed by winds blowing on a wall oriented at 90° to the panel. ~~It is intended to provide a reliable, uniform procedure for determining the resistance to racking load provided by these sheet materials as commonly employed in building construction. Since a standard frame is employed, t~~The relative performance of the sheathing is the test objective for tests using a standard frame. Evaluation of the racking resistance of sheathing and sheathing-to-fastener connection without the involvement of anchorage or influence of boundary conditions is the objective when a non-prescribed wood frame is used.

14.1.1 This test is conducted with ~~standardized~~ framing, loading procedures, and method of measuring deflection, as detailed in the method to ensure reproducibility. Provision is made for following the sheathing manufacturers' recommendations for attaching the sheathing to the frame, and for reporting the behavior of the specimen over its entire range of use.

14.2 *Test Specimens:*

14.2.1 ~~*Size and* Number—The test specimen shall be 2.4 by 2.4 m (8 by 8 ft) and the framing shall be constructed as shown in Fig. 6 and a~~ A minimum of three panels of each construction shall be tested. ~~Frames shall be newly constructed for each test. All individual framing members shall be continuous.~~

14.2.2 *Moisture Content* – ~~The average moisture content of framing material shall be between 12~~ 6 ~~and 15 % at the time of testing~~. ~~when the panel is fabricated, and shall not vary by more than 3 % from the initial moisture content when the panel is tested.~~ Immediately after the racking test, the moisture content of all framing members that receive sheathing perimeter fasteners ~~at the panel boundaries and center stud~~ shall be determined using D4442 or D7438 and reported. The average moisture content for each test frame and the delay between fabrication and testing shall be reported. If the time delay between fabrication and testing exceeds 72 hours, then moisture content of all framing members that receive sheathing perimeter fasteners shall also be determined at the time of fabrication and reported.

14.2.3 *Size*

14.2.~~1~~3.1 *Sheathing Material Evaluation* – ~~If the test is used to evaluate the sheathing material, the~~ The test specimen shall be 2.4 by 2.4 m (8 by 8 ft) and the framing shall be constructed as shown in Fig. 6. Frames shall be newly constructed for each test. All individual framing members shall be continuous. The frame shall be constructed as nearly like the frame~~s~~ shown in Fig. 6 as possible ~~using~~ No. 1 Douglas-fir Larch or Southern Pine lumber conforming to NIST voluntary Product Standard PS20 shall be used. The stud spacing and size of the stud at the vertical panel joint shall be permitted to vary as necessary to reflect the manufacturer's specified test condition or standardized requirements. Any deviations from the framing scheme depicted in Fig. 6 shall be reported. The average moisture content of framing material shall be between ~~12~~ 6 and 15 % at the time of testing.

Note X: A common situation where the 14.2.~~1~~3.1 framing provisions apply would be for product qualification and evaluation of sheathing products where design values have already been established. In those instances, the relative sheathing performance and variation is the primary interest.

14.2.~~1~~3.2 *Sheathing and Sheathing-to-Framing Attachment ~~Design Shear~~ Evaluation Without the Involvement of Anchorage or Influence of Boundary Conditions* - ~~If the test is used to evaluate design shear resistance of the wall assembly without the involvement of anchorage details, the~~ The framing shall be constructed ~~in accordance with Fig. 6 except~~ such that the framing materials (size and specific gravity), stud spacing, and sheathing fastener ~~nail~~ size and spacing ~~shall~~ conservatively represent the range of applications that use the same ~~design shear or~~ racking resistance ~~value~~. The oven-dry specific gravity of the framing materials that receive perimeter sheathing fasteners at

the panel boundaries ~~and center stud~~ shall be determined in accordance with D2395 and reported. The average framing specific gravity for any test assembly shall not exceed the targeted average by more than 0.03.

Note Y: The framing details of 14.2.3~~1~~.2 apply in instances where the racking test is used to evaluate the racking resistance of the sheathing and sheathing-to-framing attachment ~~for the establishment of design loads~~. This may include evaluation for sheathing, fastener, ~~or~~ framing products, or boundary conditions to be used in engineered or braced wall applications~~. In these instances, the goal is to ensure that the interaction between the framing, sheathing fastener, and sheathing is representative of the end use condition.~~

Item 3:

Proposal

MODIFY SECTION 14.2.2 AND ADD NOTE X:

14.2.2 *Application of Sheathing*—The method of applying the sheathing shall be ~~exactly~~ as specified by the manufacturer and include at least one centered vertical sheathing joint. ~~The spacing of fasteners shall be as recommended.~~ Sheathing fasteners shall be installed using the minimum edge distance recommended by the manufacturer along all four sheathing edges. The number of fasteners installed along each edge shall be equal to the length of the sheathing edge, divided by the specified fastener spacing, plus one. Spacing between the sheathing corner fastener and the next adjacent fastener is permitted to be less than the recommended spacing to accommodate the required edge distance. Sheathing ~~F~~fasteners shall be driven through the sheathing into only the outside stud of each corner post shown in Fig. 6. ~~The importance of the attachment of sheathing to the framing cannot be overemphasized. Slight differences in edge clearances, angle of fastener, and amounts of penetration of heads of fasteners into the sheathing have appreciable effects on the results of test.~~ Unless otherwise specified, fasteners shall be driven perpendicular to the surface of the sheathing. ~~with the center of each fastener the specified distance from the edge of the sheathing.~~ Sheathing ~~F~~fasteners shall be driven so that the head of the fastener contacts the surface of the sheathing but not so deep as to crush the surface, unless specified differently by the manufacturers.

Note X: Differences in edge distance, angle of fastener, and amount of fastener head penetration into the sheathing may impact the results of the tests and should be consistently installed in accordance with the manufacturer's installation instructions.

Vote

Negative

Comment

The requirement that fasteners be installed using the minimum edge distance recommended by the manufacturer along all four sheathing edges would require a 3/8" minimum edge distance when following SDPWS. This is not typically the spacing used in field construction for studs that are 92-5/8" with 4-1/2" of top and bottom plates. The test results, however, are likely conservative.

Inclusion of language requiring a center vertical sheathing joint in this section is unnecessary. Details of framing should remain in section discussing frame construction, as remain a detail of a 'standard' wall used for the relative performance of sheathing material.

Suggested Language

14.2.4~~2~~ *Application of Sheathing*—The method of applying the sheathing shall be ~~exactly~~ as specified by the manufacturer ~~and include at least one centered vertical sheathing joint.~~ ~~The spacing of fasteners shall be as recommended.~~ Sheathing fasteners shall be installed using the minimum edge distance recommended by the manufacturer along all four sheathing edges. The number of fasteners installed along each edge shall be equal to the length of the sheathing edge, divided by the specified fastener spacing, plus one. Spacing between the sheathing corner fastener and the next adjacent fastener is permitted to be less than the recommended spacing to accommodate the required edge distance. Sheathing ~~F~~fasteners shall be driven through the sheathing into only the outside stud of each corner post shown in Fig. 6. ~~The importance of the attachment of sheathing to the framing cannot be overemphasized. Slight differences in edge clearances, angle of fastener, and amounts of penetration of heads of fasteners into the sheathing have appreciable effects on the results of test.~~ Unless otherwise specified, fasteners shall be driven perpendicular to the surface of the sheathing. ~~with the center of each fastener the specified distance from the~~

~~edge of the sheathing.~~ Sheathing ~~F~~fasteners shall be driven so that the head of the fastener contacts the surface of the sheathing but not so deep as to crush the surface, unless specified differently by the manufacturers.

Note X: Differences in edge distance, angle of fastener, and amount of fastener head penetration into the sheathing may impact the results of the tests and should be consistently installed in accordance with the manufacturer's installation instructions.

Item 4:

Proposal

a) MODIFY SECTION 14.3:

14.3 *Apparatus*—The apparatus shall be assembled as shown in Fig. 7. In-plane lateral load shall be applied and measured by any suitable means capable of the precision specified by practice E4~~of a testing machine, or a dynamometer attached to cables that load the specimen, or in linkage with a hydraulic jack used to apply load.~~ The essential parts of the testing apparatus, exclusive of the loading ~~frame~~apparatus, are as described in 14.3.1–14.3.5. The test report shall include a detailed diagram of the test setup.

14.3.1 *Base and Loading Fixtures~~rame~~*—The test panel shall be attached to ~~a~~ timber or steel base and loading fixtures~~plate~~. The base fixture ~~that~~ is in turn attached rigidly to the base of the ~~loading~~ test frame. ~~in such a manner that w~~When the panel is racked, the sheathing shall freely rotate without ~~will not~~ bearing on the base fixture, loading fixture, or any other portion of the test frame. Th~~is~~e base and loading fixtures ~~member~~ may be of any convenient cross section, but ~~it~~ shall be at least as long as the panel and not greater in width than the thickness of the frame, 89 mm (31/2 in.). Means shall be provided to bolt or otherwise attach the ~~sole~~ top and bottom plates of the test panel firmly to ~~this member~~ the base and loading fixtures. For illustrative purposes, two bolts are shown in Fig. 7. More may be used if required. The attachment between the test panel and the loading fixtures shall be reported.

Note x: In special applications, when the sheathing bears upon a wood plate or floor surface in application (such as in structural insulated panel walls), representative details may be provided between the wall panel and the test frame fixtures.

14.3.2 *Hold-Down*—A hold-down shall be provided as shown in Fig. 7 to rigidly overcome the tendency of one end of the panel to rise as the racking load is applied. Plates and rollers shall be provided between the ~~test specimen~~loading fixture and the hold-down so that the top of the specimen can deflect horizontally with respect to the bottom without ~~unnecessary~~ interference from the hold-down. Because the amount of tension in the rods of the hold-down may have an effect on the results of the test, nuts on the hold-down rods shall be tightened prior to load application so that the total force in each rod does not exceed 90 N (20 lbf) at the beginning of test as determined by previous calibration.

14.3.3 *Loading Apparatus*—Load shall be applied to the specimen in shear through ~~an 89 by 89 mm (3.5 by 3.5 in.) timber firmly bolted to the upper plates of the panel~~ a horizontal compressive force applied to the loading fixture. ~~Loading shall be a compressive force against the end of the timber attached to the upper plate. When a testing machine is used, pulleys and cables may be used to transmit the vertical movement of the tension head of the machine to the horizontal movement in the specimen.~~

14.3.4 *Lateral Guides*—Lateral guides shall be provided so that the specimen will deflect in a plane. The rollers should be bearing-supported to reduce friction to a minimum. The lateral guides shall be firmly attached to the loading frame. Plates for the rollers shall be provided. ~~may be up to 300 mm (12 in.) in length as required.~~

b) MODIFY FIGURE 7:

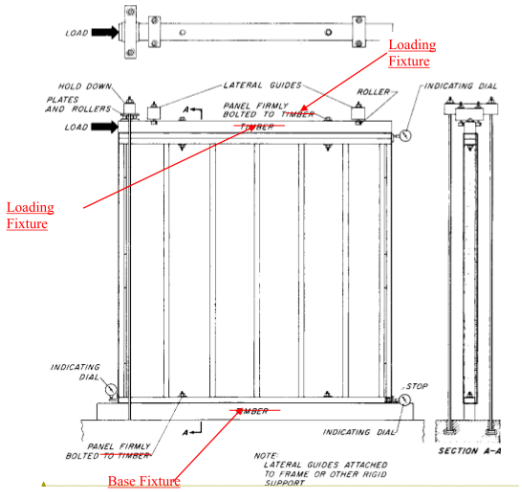


FIG. 7 Racking Load Assembly

Vote

Negative

Comment

Section 14.3.2 should address the impact of the hold-down. The section title language should also be modified to make it clear the hold down is restraining the full wall, from the base through to the top-plate. A hold down attachment tying the exterior stud only through to the base may significantly alter the performance of the wall. Additionally, requirements should be in place to measure the amount of vertical force in the hold-down rods, as a means to quantify the degree of restraint actually provided.

In Section 14.3.3, guidance should be provided regarding the size of the top and base fixture. Past work has been done which shows there are effects, particularly with stiffness, that result from different fixture devices.

Suggested Language

14.3 *Apparatus*—The apparatus shall be assembled as shown in Fig. 7. In-plane lateral load shall be applied and measured by any suitable means capable of the precision specified by practice E4~~of a testing machine, or a dynamometer attached to cables that load the specimen, or in linkage with a hydraulic jack used to apply load.~~ The essential parts of the testing apparatus, exclusive of the loading ~~frame~~apparatus, are as described in 14.3.1–14.3.5. The test report shall include a detailed diagram of the test setup.

14.3.1 *Base and Loading Fixtures~~rame~~*—The test panel shall be attached to ~~a~~ timber or steel base and loading fixtures~~plate~~. The base fixture ~~that~~ is in turn attached rigidly to the base of the ~~loading~~ test frame. ~~in such a manner that w~~When the panel is racked, the sheathing shall freely rotate without ~~will not~~ bearing on the base fixture, loading fixture, or any other portion of the test frame. Th~~is~~e base and loading fixtures ~~member~~ may be of any convenient cross section, but ~~it~~ shall be at least as long as the panel and not greater in width than the thickness of the frame, 89 mm (31/2 in.). Means shall be provided to bolt or otherwise attach the ~~sole~~ top and bottom plates of the test panel firmly to ~~this member~~ the base and loading fixtures. For illustrative purposes, two bolts are shown in Fig. 7. More may be used if required. The attachment between the test panel and the loading fixtures shall be reported.

Note x: In special applications, when the sheathing bears upon a wood plate or floor surface in application (such as in structural insulated panel walls), representative details may be provided between the wall panel and the test frame fixtures.

14.3.2 *Top-plate Restraining Hold-Down*—

14.3.2.1 When the relative performance of the sheathing material is the objective, a~~A~~ top-plate restraining hold-down shall be provided as shown in Fig. 7 to rigidly overcome the tendency of one end of the panel to rise as the racking load is applied. Plates and rollers shall be provided between the ~~test specimen~~loading fixture and the hold-down so that the top of the specimen can deflect horizontally with respect to the bottom without ~~unnecessary~~ interference from the hold-down. Because the amount of tension in the rods of the hold-down may have an effect on the results of the test, nuts on the hold-down rods shall be tightened prior to load application so that the total force in each rod does not exceed 90 N (20 lbf) at the beginning of test as determined by previous calibration. A load measuring device shall be attached to measure the vertical amount of load imparted to the hold-downs during the test.

14.3.2.2 When the evaluation of the racking resistance of the sheathing and sheathing-to-framing attachment is the objective, restraining boundary conditions shall be used to meet requirements of the test. The anchorage method shall be reported. Procedures should be followed to prevent interference of the anchorage system from the horizontal deflection and loading of the test panel assembly. For instances when a hold-down is utilized, a load measure device shall be utilized to measure the vertical amount of load imparted during the test.

14.3.3 *Loading Apparatus*—Load shall be applied to the specimen in shear through ~~an 89 by 89 mm (3.5 by 3.5 in.) timber firmly bolted to the upper plates of the panel~~ a horizontal compressive force applied to the loading fixture. ~~Loading shall be a compressive force against the end of the timber attached to the upper plate. When a testing machine is used, pulleys and cables may be used to transmit the vertical movement of the tension head of the machine to the horizontal movement in the specimen.~~

14.3.4 *Lateral Guides*—Lateral guides shall be provided so that the specimen will deflect in a plane. The rollers should be bearing-supported to reduce friction to a minimum. The lateral guides shall be firmly attached to the loading frame. Plates for the rollers shall be provided. ~~may be up to 300 mm (12 in.) in length as required.~~

Item 5:

Proposal

b) MODIFY SECTION 14.3.5 AND ADD NOTE X:

14.3.5 ~~*Deflection*~~ *Displacement Measuring Devices*—linear displacement measuring devices, ~~indicating dials, or scales and wires,~~ shall be provided to measure the displacement of the different parts of the panel during test. ~~The readings shall be recorded to the nearest 0.25 mm (0.01 in.).~~ The deflection measurement devices shall be Class "B" or higher when evaluated in accordance with Practice E2309. The locations and sign conventions of the ~~deflection~~ displacement measuring devices shall be as shown ~~in the lower left, lower right, and upper right corners of the side view of the test assembly~~ in Fig. 7. The devices are used to measure: the lateral displacement of the centerline of the top plate (Δ_1) and the bottom plate (Δ_2), and the vertical displacement at the center of the tension stud (Δ_3) and the compression stud (Δ_4). ~~The device at the lower left, which is attached to the stud, measures any rotation of the panel, the device at the lower right measures any slippage of the panel, and the device at the upper right measures the total of the other two plus the deformation of the panel. Therefore, the horizontal deflection of the panel at any load is the reading of the device at the upper right less the sum of the readings of the other two.~~

Note X: Δ_1 provides a gross horizontal displacement measurement for the racking test specimen that includes lateral movement from specimen shear deformation, rigid body rotation, and rigid body translation Δ_2, Δ_3 , and Δ_4 provide displacement measurements used to analytically determine the assembly deformation that excludes movement from rigid body rotation and translation.

c) MODIFY SECTION 14.5.1:

14.5.1 *Deformation*—For each ~~dial, or other~~ measuring device, calculate the movement under each racking load as the difference between the readings when load is applied and the initial readings at the start of the test. Calculate set readings as the difference between the readings when the load is removed and the initial readings. Calculate and report the horizontal deformation of the test specimen as:

$$\Delta_h = \Delta_1 - \Delta_2 - (\Delta_3 - \Delta_4)$$

Where:

Δ_h is the horizontal deformation of the assembly that excludes movement from rigid body rotation and translation, mm (in.)

Δ_1 is the horizontal displacement of the top plate, mm (in.)

Δ_2 is the horizontal displacement of the bottom plate, mm (in.)

Δ_3 is the vertical displacement of the tension stud, mm (in.)

Δ_4 is the vertical displacement of the compression stud, mm (in.)

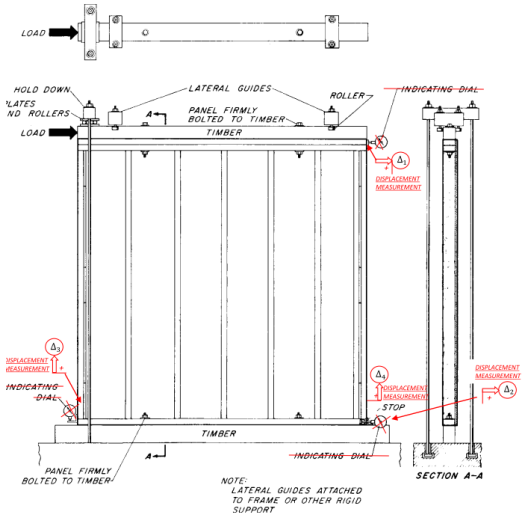


FIG. 7 Racking Load Assembly

Vote

Affirmative

Item 6:

Proposal

a) MODIFY SECTION 14.4:

14.4 *Procedure*: The racking load shall be applied using a series of stages that are a function of the targeted allowable seismic design load. The targeted allowable seismic design load shall be determined based upon experience, calculation, or standardized product requirements. The panel shall be loaded at a uniform rate using a minimum of three stages, with the final stage loading the panel to failure. Loads and displacements are measured and recorded through all stages at a frequency of not less than once every 20 seconds.

14.4.1 *Loading Rate*—Load shall be applied ~~Apply the load~~ continuously throughout test at a uniform rate of racking load or fixture displacement ~~motion of the loading device used~~. The ~~recommended~~ speed of testing shall be such that the peak load in the first stage shall be achieved ~~the loading to 3.5 kN (790 lbf) total load shall be completed~~ in not less than 2 minutes~~. from the start of the test. The loading to 7.0 to 10.5 kN (1570 to 2360 lbf) total load and to failure shall employ the same rate of travel of the loading~~ The same load or displacement rate shall be used for subsequent stages. Report ~~device as for the loading to 3.5 kN. Give~~ the speed of testing used ~~in the report of test~~. The unloading portion of each stage shall take place in 30 seconds or less.

14.4.2 *Loading Procedure*—Load the specimen ~~in~~ using a minimum of the three mandatory stages outlined below. Additional preliminary stages shall be permitted.

14.4.2.1 *First Stage*- Load the specimen to a load level not less than the targeted allowable seismic design racking strength. Unload the specimen. Allow the specimen to relax for 5 ± 1 minutes.

14.4.2.2 *Second Stage* - Load the specimen to not less than twice the targeted allowable seismic design racking strength. Unload the specimen. Allow the specimen to relax for 5 ± 1 minutes.

14.4.2.3 *Third Stage* – Load the specimen beyond the maximum (peak) load to failure or to the point where the measured post-peak racking resistance represents 80% of the maximum load, whichever occurs first. If this condition cannot be achieved by the test apparatus, the report shall indicate that the test was prematurely terminated at the maximum capability of the test equipment.

~~to 3.5, 7.0, and 10.5 kN (790, 1570, and 2360 lbf) total load at a uniform rate.~~

~~14.4.2.1 To provide data to meet performance requirements, other values of total load may be included in the test procedure. Use the same rate of loading as for the loadings specified and indicate additional loadings evaluated and the results obtained in the report.~~

~~14.4.2.2 After the load of 3.5 kN (790 lbf) is placed on the specimen, remove all of the load and any residual deflection (set) in the panel noted. Then load the specimen to 7.0 kN (1570 lbf) and again remove the load and note any additional set; after this increase the loading to 10.5 kN (2360 lbf), remove the load again, and note the set. Apply load continuously for each of the increment loads specified above and obtain load-deflection data. Obtainthese data for at least each 900 N (200 lbf) of loading. Obtain deflections during the loading cycle and, if desired, during the unloading cycle as well.~~

~~14.4.2.3 After the specimen is loaded as specified to 3.5, 7.0, and 10.5 kN (790, 1570, and 2360 lbf) load it again to failure or until the total deflection of the panel becomes 100 mm (4 in.). Obtain readings of deflection for the same intervals of load as were used for the other loadings.~~

b) MODIFY SECTION 14.5.2:

14.5.2 *Data Presentation*—Report the targeted load levels for each stage, peak loads and corresponding deformations ~~deflections~~ measured during each load stage. Report the ~~at 3.5, 7.0, and 10.5 kN (790, 1570, and 2360 lbf) and the~~ set after loading to these amounts. Present the load-deflection curves obtained ~~during loading to failure~~

~~and to 3.5, 7.0, and 10.5 kN~~ in the form of a graph ~~as prescribed in Section 6~~. Include maximum (peak) load, the interpolated load corresponding to a horizontal deformation of 5 mm (0.2 in.), the post-peak deflection at 80% of the maximum (peak) load and any observations on the behavior of the panel during test and at failure. Express residual deflections (sets) as percentages of the deflections that produced the sets as well as in millimeters or inches. If the specimen fails, describe the visible failure. If the specimen has been subjected to any special conditioning prior to test, describe this treatment in detail. Describe in the report the sheathing used, the method of applying the sheathing, the type and spacing of fasteners, and the method and rate of loading employed.

Vote

Negative

Comment

Section 14.4.2 requires the load increments to be a product of targeted allowable seismic design racking strength. This is not a cyclic test, nor has any mention (other than new language proposed in Section 14.4) been made in the standard addressing seismic loading or effects. The loading stages should rather reflect fractions of the expected ultimate load strength. This concept is further conflicted, as the existing scope of work for the standard clearly mentions use the standard is used to measure the resistance of panels "… to a racking load such as would be imposed by *winds blowing on a wall*…". Seismic design is best left in the domain of ASTM E2126.

The requirement in section 14.5.2 that the load at 5mm of horizontal deformation be reported is unnecessary. Reporting of the loads at each stage and corresponding deformation is sufficient. Any other load or deformation data required for external, product specific purposes can be calculated. Mandating a value be reported that has otherwise been unmentioned in the standard should be left to the test agency.

Suggested Language

14.4 *Procedure*: The racking load shall be applied using a series of stages that are a function of the targeted ~~allowable seismic design load~~ ultimate load. The targeted ~~allowable seismic design~~ load shall be determined based upon experience, calculation, or standardized product requirements. The panel shall be loaded at a uniform rate using a minimum of three stages, with the final stage loading the panel to failure. Loads and displacements are measured and recorded through all stages at a frequency of not less than once every 20 seconds.

14.4.1 *Loading Rate*—Load shall be applied ~~Apply the load~~ continuously throughout test at a uniform rate of racking load or fixture displacement ~~motion of the loading device used~~. The ~~recommended~~ speed of testing shall be such that the peak load in the first stage shall be achieved ~~the loading to 3.5 kN (790 lbf) total load shall be completed~~ in not less than 2 minutes~~. from the start of the test. The loading to 7.0 to 10.5 kN (1570 to 2360 lbf) total load and to failure shall employ the same rate of travel of the loading~~ The same load or displacement rate shall be used for subsequent stages. Report ~~device as for the loading to 3.5 kN. Give~~ the speed of testing used ~~in the report of test~~. The unloading portion of each stage shall take place in 30 seconds or less.

14.4.2 *Loading Procedure*—Load the specimen ~~in~~ using a minimum of the three mandatory stages outlined below. Additional preliminary stages shall be permitted.

14.4.2.1 *First Stage*- Load the specimen to a load level not less than 1/3 the targeted ~~allowable seismic design racking strength~~ ultimate load. Unload the specimen. Allow the specimen to relax for 5 ± 1 minutes.

14.4.2.2 *Second Stage* - Load the specimen to not less than ~~twice~~ 2/3 the targeted ~~allowable seismic design racking strength~~ ultimate load. Unload the specimen. Allow the specimen to relax for 5 ± 1 minutes.

14.4.2.3 *Third Stage* – Load the specimen beyond the maximum (peak) load to failure or to the point where the measured post-peak racking resistance represents 80% of the maximum load, whichever occurs first. If this condition cannot be achieved by the test apparatus, the report shall indicate that the test was prematurely terminated at the maximum capability of the test equipment.

14.5.2 *Data Presentation*—Report the targeted load levels for each stage, peak loads and corresponding deformations ~~deflections~~ measured during each load stage. Report the ~~at 3.5, 7.0, and 10.5 kN (790, 1570, and 2360 lbf) and the~~ set after loading to these amounts. Present the load-deflection curves obtained ~~during loading to failure and to 3.5, 7.0, and 10.5 kN~~ in the form of a graph ~~as prescribed in Section 6~~. Include maximum (peak) load, ~~the interpolated load corresponding to a horizontal deformation of 5 mm (0.2 in.)~~, the post-peak deflection at 80% of the maximum (peak) load and any observations on the behavior of the panel during test and at failure. Express residual deflections (sets) as percentages of the deflections that produced the sets as well as in millimeters or inches. If the specimen fails, describe the visible failure. If the specimen has been subjected to any special conditioning prior to test, describe this treatment in detail. Describe in the report the sheathing used, the method of applying the sheathing, the type and spacing of fasteners, and the method and rate of loading employed. Describe in the report the loading fixture, base fixture, and anchorage method used. If a hold-down was utilized, report the vertical load in the hold-down at the load levels of each stage, at ultimate load, and at the post-peak deflection at 80% of the maximum (peak) load.

Item 7:

Proposal

ADD NEW SECTION X3 TO NON-MANDATORY APPENDIX:

X3. RACKING LOAD ASSEMBLY TESTS

X3.1 *General Conditions* - The racking load assembly testing of Section 14 is often used for the evaluation of sheathing products and attachment schemes. While it is recognized that a wide range of wall configurations and anchorage conditions exist in application, for the purpose of sheathing and sheathing attachment review, this historic test method purposefully combines a 1:1 aspect ratio wall specimen with a vertical panel joint, rigid anchorage, and full overturning restraint.

X3.1.1 *Vertical Joint* - A vertical panel joint is included in the specimen because such joints typically exist in application and often represent weak-links in the assembly. The panel joints typically require the smallest sheathing fastener edge distances to occur at a location where the entire shear load must be transferred between sheathing panels and through the framing attachment. This interface commonly limits the wall capacity and, therefore, must be included as part of the test assembly. Tests of assemblies without this joint may overestimate the sheathing system's capabilities.

X3.1.2 *Anchorage and Overturning Restraint.* It is acknowledged that a wide range of in-plane wall racking anchorage conditions exist in application. These applications may range from a lightly-anchored prescriptive braced wall panel that does not support gravity loads to a similar prescriptive wall assembly that supports significant gravity loads that provide overturning restraint or even an engineered shear wall with rigid anchorage. However, it is not the intent of the racking test method of this standard to replicate any specific application condition. The goal is to provide a consistent basis where the capacity of the sheathing and sheathing attachment can be evaluated without the confounding influence of an anchorage failure. The fully-restrained boundary condition selected for the racking test ensures that the full potential of the sheathing and attachment is consistently evaluated. This provides a benchmark for comparison between sheathing and attachment alternatives that addresses the entire range of potential anchorage conditions that may exist in application. Using a lesser degree of anchorage for the test would serve to introduce anchorage and/or framing-related failure modes that limit the usefulness of the review to the specific assembly and boundary conditions tested. For example, a racking test comparison made between sheathing alternatives using a lightly-restrained condition may result in anchorage failure for both products. Such a review would not necessarily address their relative performance in other applications where more restraint is provided and higher loads governed by the sheathing or sheathing attachment are typically achieved. For these reasons, the fully-restrained condition has been historically used for the baseline comparison. If the goal of the test program is to include anchorage conditions as a specific parameter to be evaluated, then standardized wall assembly test methods such as E564 or E2126 may be more appropriate.

Vote

Negative

Comment

Outside of the first sentence of X3.1, this commentary is only valid in the context of Section 14.2.1.1 *Sheathing Material Evaluation*. Even then, there is conflict of intentions between this commentary, and the scope of the standard (addressed in ballot Item 2b) and the proposed note for section 14.2.1.1 (in ballot Item 2c). This commentary addresses the use of the standard for *relative* comparison of sheathing. The proposed Note X of Ballot Item 2 clarifies that walls tested using Section 14.2.1.1 are only to establish the relative sheathing performance for materials that already have a design load. Section 14.2.1.2, as proposed, is intended to be used for the

establishment of design values. Section 14.2.1.2 should allow for true boundary conditions for testing, but then contradictory or prescriptive requirements are applied in the following locations that prevent such testing from occurring:

- Section 14.2.1 requiring specific dimensions, which should be applied only to the relative performance testing
- Language proposed in Item 1 requiring a vertical sheathing joint, which may be at odds with non-standard panel sizes or orientation and manufacturer's installation instructions.
- Note Y of proposed Item 2. The commentary of this proposal clearly indicates boundary conditions have an effect on performance and this variable is being removed to provide relative comparisons of the sheathing material. The proposed note, by inclusion of 'representative of end use conditions', gives the implication that use of threaded rods is representative of end use conditions. Language in other locations of the standard, particularly Section 14.3, 14.3.1, 14.3.2, and 14.3.3 essentially disallow testing truly representative boundary conditions.
- As mentioned in the bullet above, Section 14.3 puts requirements on the apparatus, frame, hold-downs, and loading apparatus to the degree that no realistic test is conducted.

The language of this commentary, without some modifications and drastic modifications to other ballot items, essentially prevents the establishment of true design values. Rather, it allows only for the relative comparison of sheathing material in unrealistic, forced laboratory conditions. Without allowing for true boundary condition testing, design values should never be included anywhere within the standard and the language throughout should be modified to only adhere to the concept of relative performance. The fact building codes and other agencies have wrongly used this standard for creation of design loads should be of no concern, and if anything, corrected by removing all conflicting language.

Suggested Language

X3. RACKING LOAD ASSEMBLY TESTS for Sheathing Material Evaluation

X3.1 *General Conditions* - The racking load assembly testing of Section 14.2.3.1 is ~~often~~ used for the relative evaluation of sheathing materials.~~products and attachment schemes.~~ While it is recognized that a wide range of wall configurations and anchorage conditions exist in application, for the purpose of relative sheathing material ~~and sheathing attachment~~ review, this historic test method purposefully combines a 1:1 aspect ratio wall specimen with a vertical panel joint, rigid anchorage, and full overturning restraint.

X3.1.1 *Vertical Joint* - A vertical panel joint is included in the specimen because such joints typically exist in application and ~~often~~ may represent weak-links in the assembly. The panel joints typically require the smallest sheathing fastener edge distances to occur at a location where the entire shear load must be transferred between sheathing panels and through the framing attachment. This interface commonly limits the ~~wall~~ sheathing material capacity and, therefore, must be included as part of the test assembly. Tests of assemblies for comparison of relative performance without this joint may overestimate the sheathing ~~system's~~ material's capabilities.

X3.1.2 *Anchorage and Overturning Restraint.* It is acknowledged that a wide range of in-plane wall racking anchorage conditions exist in application. These applications may range from a lightly-anchored prescriptive braced wall panel

that does not support gravity loads to a similar prescriptive wall assembly that supports significant gravity loads that provide overturning restraint or even an engineered shear wall with rigid anchorage. However, it is not the intent of the racking test method of this standard for sheathing material evaluation to replicate any specific application condition. The goal is to provide a consistent basis where the capacity of the sheathing material ~~and sheathing attachment~~ can be evaluated without the confounding influence of an anchorage failure. The fully-restrained boundary condition selected for the racking test ensures that the full potential of the sheathing material ~~and attachment~~ is consistently evaluated. ~~This provides a benchmark for comparison between sheathing and attachment alternatives that addresses the entire range of potential anchorage conditions that may exist in application.~~ Using a lesser degree of anchorage for the test ~~would~~ could serve to introduce anchorage and/or framing-related failure modes that limit the usefulness of the relative comparison of sheathing material. ~~review to the specific assembly and boundary conditions tested. For example, a racking test comparison made between sheathing alternatives using a lightly restrained condition may result in anchorage failure for both products. Such a review would not necessarily address their relative performance in other applications where more restraint is provided and higher loads governed by the sheathing or sheathing attachment are typically achieved. For these reasons, the fully-restrained condition has been historically used for the baseline comparison. If the goal of the test program is to include anchorage conditions as a specific parameter to be evaluated, then standardized wall assembly test methods such as E564 or E2126 may be more appropriate.~~ If the test objective is to measure the performance of a wall assembly for the purpose of assigning a design shear resistance, Practice E564 is recommended.

Suggested Language if Using Both Objectives

14. Racking Load—Evaluation of Sheathing Materials on a ~~Standard~~ Wood Frame

NOTE 2 – This standard has been used to evaluate design shear resistance of ~~wall assemblies~~ sheathing materials without the involvement of anchorage details. If the test objective is to measure the performance of the complete wall, Practice E564 is recommended.

14.1 Scope – This test method measures the resistance of panels, having a ~~standard~~ wood frame, and sheathed with sheet materials such as structural insulating board, plywood, gypsum board, transite, and so forth, to a racking load such as would be imposed by winds blowing on a wall oriented at 90° to the panel. ~~It is intended to provide a reliable, uniform procedure for determining the resistance to racking load provided by these sheet materials as commonly employed in building construction. Since a standard frame is employed, t~~ The relative performance of the sheathing is the test objective for tests using a standard frame. Evaluation of the racking resistance of sheathing and sheathing-to-fastener connection without the involvement of anchorage or influence of boundary conditions is the objective when a non-prescribed wood frame is used.

14.1.1 This test is conducted with ~~standardized~~ framing, loading procedures, and method of measuring deflection, as detailed in the method to ensure reproducibility. Provision is made for following the sheathing manufacturers' recommendations for attaching the sheathing to the frame, and for reporting the behavior of the specimen over its entire range of use.

14.2 *Test Specimens:*

14.2.1 ~~*Size and Number*—The test specimen shall be 2.4 by 2.4 m (8 by 8 ft) and the framing shall be constructed as shown in Fig. 6 and a~~ A minimum of three panels of each construction shall be tested. ~~Frames shall be newly constructed for each test. All individual framing members shall be continuous.~~

14.2.2 *Moisture Content* – ~~The average moisture content of framing material shall be between 12 6 and 15 % at the time of testing. when the panel is fabricated, and shall not vary by more than 3 % from the initial moisture content when the panel is tested.~~ Immediately after the racking test, the moisture content of all framing members that receive sheathing perimeter fasteners ~~at the panel boundaries and center stud~~ shall be determined using D4442 or D7438 and reported. The average moisture content for each test frame and the delay between fabrication and testing shall be reported. If the time delay between fabrication and testing exceeds 72 hours, then moisture content of all framing members that receive sheathing perimeter fasteners shall also be determined at the time of fabrication and reported.

14.2.3 *Size*

14.2.~~1~~3.1 *Sheathing Material Evaluation* – ~~If the test is used to evaluate the sheathing material, the~~ The test specimen shall be 2.4 by 2.4 m (8 by 8 ft) and the framing shall be constructed as shown in Fig. 6. Frames shall be newly constructed for each test. All individual framing members shall be continuous. The frame shall be constructed as nearly like the frame~~s~~ shown in Fig. 6 as possible. ~~using~~ No. 1 Douglas-fir Larch or Southern Pine lumber conforming to NIST voluntary Product Standard PS20 shall be used. The stud spacing and size of the stud at the vertical panel joint shall be permitted to vary as necessary to reflect the manufacturer's specified test condition or standardized requirements. Any deviations from the framing scheme depicted in Fig. 6 shall be reported. The average moisture content of framing material shall be between ~~12~~ 6 and 15 % at the time of testing.

Note X: A common situation where the 14.2.~~1~~3.1 framing provisions apply would be for product qualification and evaluation of sheathing products where design values have already been established. In those instances, the relative sheathing performance and variation is the primary interest.

14.2.1~~3~~.2 *Sheathing and Sheathing-to-Framing Attachment ~~Design Shear~~ Evaluation Without the Involvement of Anchorage or Influence of Boundary Conditions* - ~~If the test is used to evaluate design shear resistance of the wall assembly without the involvement of anchorage details, the~~ The framing shall be constructed ~~in accordance with Fig. 6 except~~ such that the framing materials (size and specific gravity), stud spacing, and sheathing fastener ~~nail~~ size and spacing ~~shall~~ conservatively represent the range of applications that use the same ~~design shear or~~ racking resistance ~~value~~. The oven-dry specific gravity of the framing materials that receive perimeter sheathing fasteners at the panel boundaries ~~and center stud~~ shall be determined in accordance with D2395 and reported. The average framing specific gravity for any test assembly shall not exceed the targeted average by more than 0.03.

Note Y: The framing details of 14.2.3~~1~~.2 apply in instances where the racking test is used to evaluate the racking resistance of the sheathing and sheathing-to-framing attachment ~~for the establishment of design loads. This may include evaluation for sheathing, fastener, or~~ framing products, or boundary conditions to be used in engineered or braced wall applications. ~~In these instances, the goal is to ensure that the interaction between the framing, sheathing fastener, and sheathing is representative of the end use condition.~~

14.2.4~~2~~ *Application of Sheathing*—The method of applying the sheathing shall be ~~exactly~~ as specified by the manufacturer ~~and include at least one centered vertical sheathing joint. The spacing of fasteners shall be as recommended.~~ Sheathing fasteners shall be installed using the minimum edge distance recommended by the manufacturer along all four sheathing edges. The number of fasteners installed along each edge shall be equal to the length of the sheathing edge, divided by the specified fastener spacing, plus one. Spacing between the sheathing corner fastener and the next adjacent fastener is permitted to be less than the recommended spacing to accommodate the required edge distance. Sheathing ~~F~~fasteners shall be driven through the sheathing into only the outside stud of each corner post shown in Fig. 6. ~~The importance of the attachment of sheathing to the framing cannot be overemphasized. Slight differences in edge clearances, angle of fastener, and amounts of penetration of heads of fasteners into the sheathing have appreciable effects on the results of test.~~ Unless otherwise specified, fasteners shall be driven perpendicular to the surface of the sheathing. ~~with the center of each fastener the specified distance from the edge of the sheathing.~~ Sheathing ~~F~~fasteners shall be driven so that the head of the fastener contacts the surface of the sheathing but not so deep as to crush the surface, unless specified differently by the manufacturers.

Note X: Differences in edge distance, angle of fastener, and amount of fastener head penetration into the sheathing may impact the results of the tests and should be consistently installed in accordance with the manufacturer's installation instructions.

14.3 *Apparatus*—The apparatus shall be assembled as shown in Fig. 7. In-plane lateral load shall be applied and measured by any suitable means capable of the precision specified by practice E4~~of a testing machine, or a dynamometer attached to cables that load the specimen, or in linkage with a hydraulic jack used to apply load.~~ The essential parts of the testing apparatus, exclusive of the loading ~~frame~~apparatus, are as described in 14.3.1–14.3.5. The test report shall include a detailed diagram of the test setup.

14.3.1 *Base and Loading Fixtures~~rame~~* —The test panel shall be attached to ~~a~~ timber or steel base and loading fixtures~~plate~~. The base fixture ~~that~~ is in turn attached rigidly to the base of the ~~loading~~ test frame. ~~in such a manner that w~~When the panel is racked, the sheathing shall freely rotate without ~~will not~~ bearing on the base fixture, loading fixture, or any other portion of the test frame. Th~~is~~e base and loading fixtures ~~member~~ may be of any convenient cross section, but ~~it~~ shall be at least as long as the panel and not greater in width than the thickness of the frame, 89 mm (31/2 in.). Means shall be provided to bolt or otherwise attach the ~~sole~~ top and bottom plates of the test panel firmly to ~~this member~~ the base and loading fixtures. For illustrative purposes, two bolts are shown in Fig. 7. More may be used if required. The attachment between the test panel and the loading fixtures shall be reported.

Note x: In special applications, when the sheathing bears upon a wood plate or floor surface in application (such as in structural insulated panel walls), representative details may be provided between the wall panel and the test frame fixtures.

14.3.2 *Top-plate Restraining Hold-Down*—

14.3.2.1 When the relative performance of the sheathing material is the objective, a~~A~~ top-plate restraining hold-down shall be provided as shown in Fig. 7 to rigidly overcome the tendency of one end of the panel to rise as the racking load is applied. Plates and rollers shall be provided between the ~~test specimen~~loading fixture and the hold-down so that the top of the specimen can deflect horizontally with respect to the bottom without ~~unnecessary~~ interference from the hold-down. Because the amount of tension in the rods of the hold-down may have an effect on the results of the test, nuts on the hold-down rods shall be tightened prior to load application so that the total force in each rod does not exceed 90 N (20 lbf) at the beginning of test as determined by previous calibration. A load measuring device shall be attached to measure the vertical amount of load imparted to the hold-downs during the test.

14.3.2.2 When the evaluation of the racking resistance of the sheathing and sheathing-to-framing attachment is the objective, restraining boundary conditions shall be used to meet requirements of the test. The anchorage method shall be reported. Procedures should be followed to prevent interference of the anchorage system from the horizontal deflection and loading of the test panel assembly. For instances when a hold-down is utilized, a load measure device shall be utilized to measure the vertical amount of load imparted during the test.

14.3.3 *Loading Apparatus*—Load shall be applied to the specimen in shear through ~~an 89 by 89 mm (3.5 by 3.5 in.) timber firmly bolted to the upper plates of the panel~~ a horizontal compressive force applied to the loading fixture. ~~Loading shall be a compressive force against the end of the timber attached to the upper plate. When a testing machine is used, pulleys and cables may be used to transmit the vertical movement of the tension head of the machine to the horizontal movement in the specimen.~~

14.3.4 *Lateral Guides*—Lateral guides shall be provided so that the specimen will deflect in a plane. The rollers should be bearing-supported to reduce friction to a minimum. The lateral guides shall be firmly attached to the loading frame. Plates for the rollers shall be provided. ~~may be up to 300 mm (12 in.) in length as required.~~

14.3.5 ~~*Deflection*~~ *Displacement Measuring Device*~~s~~—linear displacement measuring devices, ~~indicating dials, or scales and wires,~~ shall be provided to measure the displacement of the different parts of the panel during test. ~~The readings shall be recorded to the nearest 0.25 mm (0.01 in.).~~ The deflection measurement devices shall be Class "B" or higher when evaluated in accordance with Practice E2309. The locations and sign conventions of the ~~deflection~~ displacement measuring devices shall be as shown ~~in the lower left, lower right, and upper right corners of the side view of the test assembly~~ in Fig. 7. The devices are used to measure: the lateral displacement of the centerline of the top plate (Δ_1) and the bottom plate (Δ_2), and the vertical displacement at the center of the tension stud (Δ_3) and the compression stud (Δ_4). ~~The device at the lower left, which is attached to the stud, measures any rotation of the panel, the device at the lower right measures any slippage of the panel, and the device at the upper right measures the total of the other two plus the deformation of the panel. Therefore, the horizontal deflection of the panel at any load is the reading of the device at the upper right less the sum of the readings of the other two.~~

Note X: Δ_1 provides a gross horizontal displacement measurement for the racking test specimen that includes lateral movement from specimen shear deformation, rigid body rotation, and rigid body translation Δ_2, Δ_3 , and Δ_4 provide displacement measurements used to analytically determine the assembly deformation that excludes movement from rigid body rotation and translation.

14.4 *Procedure*: The racking load shall be applied using a series of stages that are a function of the targeted ~~allowable seismic design load~~ ultimate load. The targeted ~~allowable seismic design~~ load shall be determined based upon experience, calculation, or standardized product requirements. The panel shall be loaded at a uniform rate using a minimum of three stages, with the final stage loading the panel to failure. Loads and displacements are measured and recorded through all stages at a frequency of not less than once every 20 seconds.

14.4.1 *Loading Rate*—Load shall be applied ~~Apply the load~~ continuously throughout test at a uniform rate of racking load or fixture displacement ~~motion of the loading device used~~. The ~~recommended~~ speed of testing shall be such that the peak load in the first stage shall be achieved ~~the loading to 3.5 kN (790 lbf) total load shall be completed~~ in not less than 2 minutes~~. from the start of the test. The loading to 7.0 to 10.5 kN (1570 to 2360 lbf) total load and to failure shall employ the same rate of travel of the loading~~ The same load or displacement rate shall be used for subsequent stages. Report ~~device as for the loading to 3.5 kN. Give~~ the speed of testing used ~~in the report of test~~. The unloading portion of each stage shall take place in 30 seconds or less.

14.4.2 *Loading Procedure*—Load the specimen ~~in~~ using a minimum of the three mandatory stages outlined below. Additional preliminary stages shall be permitted.

14.4.2.1 *First Stage*- Load the specimen to a load level not less than 1/3 the targeted ~~allowable seismic design racking strength~~ ultimate load. Unload the specimen. Allow the specimen to relax for 5 ± 1 minutes.

14.4.2.2 *Second Stage* - Load the specimen to not less than ~~twice~~ 2/3 the targeted ~~allowable seismic design racking strength~~ ultimate load. Unload the specimen. Allow the specimen to relax for 5 ± 1 minutes.

14.4.2.3 *Third Stage* – Load the specimen beyond the maximum (peak) load to failure or to the point where the measured post-peak racking resistance represents 80% of the maximum load, whichever occurs first. If this condition cannot be achieved by the test apparatus, the report shall indicate that the test was prematurely terminated at the maximum capability of the test equipment.

~~to 3.5, 7.0, and 10.5 kN (790, 1570, and 2360 lbf) total load at a uniform rate.~~

~~14.4.2.1 To provide data to meet performance requirements, other values of total load may be included in the test procedure. Use the same rate of loading as for the loadings specified and indicate additional loadings evaluated and the results obtained in the report.~~

~~14.4.2.2 After the load of 3.5 kN (790 lbf) is placed on the specimen, remove all of the load and any residual deflection (set) in the panel noted. Then load the specimen to 7.0 kN (1570 lbf) and again remove the load and note any additional set; after this increase the loading to 10.5 kN (2360 lbf), remove the load again, and note the set. Apply load continuously for each of the increment loads specified above and obtain load-deflection data. Obtainthese data for at least each 900 N (200 lbf) of loading. Obtain deflections during the loading cycle and, if desired, during the unloading cycle as well.~~

~~14.4.2.3 After the specimen is loaded as specified to 3.5, 7.0, and 10.5 kN (790, 1570, and 2360 lbf) load it again to failure or until the total deflection of the panel becomes 100 mm (4 in.). Obtain readings of deflection for the same intervals of load as were used for the other loadings.~~

14.5 *Calculations and Report:*

14.5.1 *Deformation*—For each ~~dial, or other~~ measuring device, calculate the movement under each racking load as the difference between the readings when load is applied and the initial readings at the start of the test. Calculate set readings as the difference between the readings when the load is removed and the initial readings. Calculate and report the horizontal deformation of the test specimen as:

$$\Delta_h = \Delta_1 - \Delta_2 - (\Delta_3 - \Delta_4)$$

Where:

Δ_h is the horizontal deformation of the assembly that excludes movement from rigid body rotation and translation, mm (in.)

Δ_1 is the horizontal displacement of the top plate, mm (in.)

Δ_2 is the horizontal displacement of the bottom plate, mm (in.)

Δ_3 is the vertical displacement of the tension stud, mm (in.)

Δ_4 is the vertical displacement of the compression stud, mm (in.)

14.5.2 *Data Presentation*—Report the targeted load levels for each stage, peak loads and corresponding deformations ~~deflections~~ measured during each load stage. Report the ~~at 3.5, 7.0, and 10.5 kN (790, 1570, and 2360 lbf) and the~~ set after loading to these amounts. Present the load-deflection curves obtained ~~during loading to failure and to 3.5, 7.0, and 10.5 kN~~ in the form of a graph ~~as prescribed in Section 6~~. Include maximum (peak) load, ~~the interpolated load corresponding to a horizontal deformation of 5 mm (0.2 in.),~~ the post-peak deflection at 80% of the maximum (peak) load and any observations on the behavior of the panel during test and at failure. Express residual deflections (sets) as percentages of the deflections that produced the sets as well as in millimeters or inches. If the specimen fails, describe the visible failure. If the specimen has been subjected to any special conditioning prior to test, describe this treatment in detail. Describe in the report the sheathing used, the method of applying the sheathing, the type and spacing of fasteners, and the method and rate of loading employed. Describe in the report the loading fixture, base fixture, and anchorage method used. If a hold-down was utilized, report the vertical load in the hold-down at the load levels of each stage, at ultimate load, and at the post-peak deflection at 80% of the maximum (peak) load.

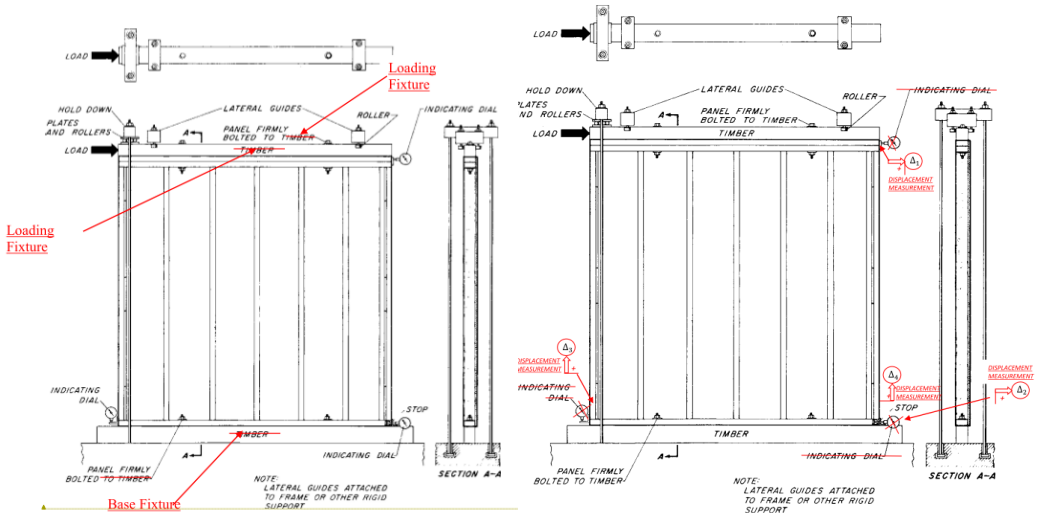


FIG. 7 Racking Load Assembly

FIG. 7 Racking Load Assembly

X3. RACKING LOAD ASSEMBLY TESTS for Sheathing Material Evaluation

X3.1 *General Conditions* - The racking load assembly testing of Section 14.2.3.1 is ~~often~~ used for the relative evaluation of sheathing materials.~~products and attachment schemes.~~ While it is recognized that a wide range of wall configurations and anchorage conditions exist in application, for the purpose of relative sheathing material ~~and sheathing attachment~~ review, this historic test method purposefully combines a 1:1 aspect ratio wall specimen with a vertical panel joint, rigid anchorage, and full overturning restraint.

X3.1.1 *Vertical Joint* - A vertical panel joint is included in the specimen because such joints typically exist in application and ~~often~~ may represent weak-links in the assembly. The panel joints typically require the smallest sheathing fastener edge distances to occur at a location where the entire shear load must be transferred between sheathing panels and through the framing attachment. This interface commonly limits the ~~wall~~ sheathing material capacity and, therefore, must be included as part of the test assembly. Tests of assemblies for comparison of relative performance without this joint may overestimate the sheathing ~~system's~~ material's capabilities.

X3.1.2 *Anchorage and Overturning Restraint.* It is acknowledged that a wide range of in-plane wall racking anchorage conditions exist in application. These applications may range from a lightly-anchored prescriptive braced wall panel that does not support gravity loads to a similar prescriptive wall assembly that supports significant gravity loads that provide overturning restraint or even an engineered shear wall with rigid anchorage. However, it is not the intent of the racking test method of this standard for sheathing material evaluation to replicate any specific application condition. The goal is to provide a consistent basis where the capacity of the sheathing material ~~and sheathing attachment~~ can be evaluated without the confounding influence of an anchorage failure. The fully-restrained boundary condition selected for the racking test ensures that the full potential of the sheathing material ~~and attachment~~ is consistently evaluated. ~~This provides a benchmark for comparison between sheathing and attachment alternatives that addresses the entire range of potential anchorage conditions that may exist in application.~~ Using a lesser degree of anchorage for the test ~~would~~ could serve to introduce anchorage and/or framing-related failure modes that limit the usefulness of the relative comparison of sheathing material. ~~review to the specific assembly and boundary conditions tested. For example, a racking test comparison made between sheathing alternatives using a lightly-restrained condition may result in anchorage failure for both products. Such a review would not necessarily address their relative performance in other applications where more restraint is provided and higher loads governed by the sheathing or sheathing attachment are typically achieved. For these reasons, the fully-restrained condition has been historically used for the baseline comparison. If the goal of the test program is to include anchorage conditions as a specific parameter to be evaluated, then standardized wall assembly test methods such as E564 or E2126 may be more appropriate.~~ If the test objective is to measure the performance of a wall assembly for the purpose of assigning a design shear resistance, Practice E564 is recommended.

Suggested Language if Relative Performance Objective Only

14. Racking Load—Evaluation of Sheathing Materials on a Standard Wood Frame

NOTE 2 – This standard has been used to evaluate design shear resistance of ~~wall assemblies~~ sheathing materials without the involvement of anchorage details. If the test objective is to measure the performance of the complete wall, Practice E564 is recommended.

14.1 Scope – This test method measures the resistance of panels, having a ~~standard~~ standard wood frame, and sheathed with sheet materials such as structural insulating board, plywood, gypsum board, transite, and so forth, to a racking load such as would be imposed by winds blowing on a wall oriented at 90° to the panel. ~~It is intended to provide a reliable, uniform procedure for determining the resistance to racking load provided by these sheet materials as commonly employed in building construction.~~ Since a standard frame is employed, the relative performance of the sheathing is the test objective. The creation of design values for a sheathing material or attachment is not the intention of this standard.

14.1.1 This test is conducted with standardized framing, loading procedures, and method of measuring deflection, as detailed in the method to ensure reproducibility. Provision is made for following the sheathing manufacturers' recommendations for attaching the sheathing to the frame, and for reporting the behavior of the specimen over its entire range of use.

14.2 *Test Specimens:*

14.2.1 *Size and Number*—The test specimen shall be 2.4 by 2.4 m (8 by 8 ft) and the framing shall be constructed as shown in Fig. 6 and a minimum of three panels of each construction shall be tested. Frames shall be newly constructed for each test. All individual framing members shall be continuous.

14.2.2 *Moisture Content* – The average moisture content of framing material shall be between ~~12~~ 6 and 15 % at the time of testing. ~~when the panel is fabricated, and shall not vary by more than 3 % from the initial moisture content when the panel is tested.~~ Immediately after the racking test, the moisture content of all framing members that receive sheathing perimeter fasteners ~~at the panel boundaries and center stud~~ shall be determined using D4442 or D7438 and reported. The average moisture content for each test frame and the delay between fabrication and testing shall be reported. If the time delay between fabrication and testing exceeds 72 hours, then moisture content of all framing members that receive sheathing perimeter fasteners shall also be determined at the time of fabrication and reported.

14.2.~~1~~3 ~~.1~~ *Frame* ~~*Sheathing Material Evaluation* – If the test is used to evaluate the sheathing material, the~~ The frame shall be constructed as nearly like the frame~~s~~ shown in Fig. 6 as possible ~~using~~ No. 1 Douglas-fir Larch or Southern Pine lumber conforming to NIST voluntary Product Standard PS20 shall be used. The stud spacing and size of the stud at the vertical panel joint shall be permitted to vary as necessary to reflect the manufacturer's specified test condition or standardized requirements. Any deviations from the framing scheme depicted in Fig. 6 shall be reported.

~~*Note X: A common situation where the 14.2.1.1 framing provisions apply would be for product qualification and evaluation of sheathing products where design values have already been established. In those instances, the sheathing performance and variation is the primary interest.*~~

~~14.2.1.2 – If the test is used to evaluate design shear resistance of the wall assembly without the involvement of anchorage details, the framing shall be constructed that the framing materials (size and specific gravity), stud spacing, and nail size and spacing shall conservatively represent the range of applications that use the same design shear resistance value.~~

14.2.42 *Application of Sheathing*—The method of applying the sheathing shall be ~~exactly~~ as specified by the manufacturer and include at least one centered vertical sheathing joint. ~~The spacing of fasteners shall be as recommended.~~ Sheathing fasteners shall be installed using the minimum edge distance recommended by the manufacturer along all four sheathing edges. The number of fasteners installed along each edge shall be equal to the length of the sheathing edge, divided by the specified fastener spacing, plus one. Spacing between the sheathing corner fastener and the next adjacent fastener is permitted to be less than the recommended spacing to accommodate the required edge distance. Sheathing ~~F~~fasteners shall be driven through the sheathing into only the outside stud of each corner post shown in Fig. 6. ~~The importance of the attachment of sheathing to the framing cannot be overemphasized. Slight differences in edge clearances, angle of fastener, and amounts of penetration of heads of fasteners into the sheathing have appreciable effects on the results of test.~~ Unless otherwise specified, fasteners shall be driven perpendicular to the surface of the sheathing. ~~with the center of each fastener the specified distance from the edge of the sheathing.~~ Sheathing ~~F~~fasteners shall be driven so that the head of the fastener contacts the surface of the sheathing but not so deep as to crush the surface, unless specified differently by the manufacturers.

Note X: Differences in edge distance, angle of fastener, and amount of fastener head penetration into the sheathing may impact the results of the tests and should be consistently installed in accordance with the manufacturer's installation instructions.

14.3 *Apparatus*—The apparatus shall be assembled as shown in Fig. 7. In-plane lateral load shall be applied and measured by any suitable means capable of the precision specified by practice E4~~of a testing machine, or a dynamometer attached to cables that load the specimen, or in linkage with a hydraulic jack used to apply load.~~ The essential parts of the testing apparatus, exclusive of the loading ~~frame~~apparatus, are as described in 14.3.1–14.3.5. The test report shall include a detailed diagram of the test setup.

14.3.1 *Base and Loading Fixtures~~rame~~*—The test panel shall be attached to ~~a~~ timber or steel base and loading fixtures~~plate~~. The base fixture ~~that~~ is in turn attached rigidly to the base of the ~~loading~~ test frame. ~~in such a manner that w~~When the panel is racked, the sheathing shall freely rotate without ~~will not~~ bearing on the base fixture, loading fixture, or any other portion of the test frame. Th~~ise~~ base and loading fixtures ~~member~~ may be of any convenient cross section, but ~~it~~ shall be at least as long as the panel and not greater in width than the thickness of the frame, 89 mm (31/2 in.). Means shall be provided to bolt or otherwise attach the ~~sole~~ top and bottom plates of the test panel firmly to ~~this member~~ the base and loading fixtures. For illustrative purposes, two bolts are shown in Fig. 7. More may be used if required. The attachment between the test panel and the loading fixtures shall be reported.

Note x: In special applications, when the sheathing bears upon a wood plate or floor surface in application (such as in structural insulated panel walls), representative details may be provided between the wall panel and the test frame fixtures.

14.3.2 *Top-plate Restraining Hold-Down*— A top-plate restraining hold-down shall be provided as shown in Fig. 7 to rigidly overcome the tendency of one end of the panel to rise as the racking load is applied. Plates and rollers shall be provided between the ~~test specimen~~loading fixture and the hold-down so that the top of the specimen can deflect horizontally with respect to the bottom without ~~unnecessary~~ interference from the hold-down. Because the amount of tension in the rods of the hold-down may have an effect on the results of the test, nuts on the hold-down rods shall be tightened prior to load application so that the total force in each rod does not exceed 90 N (20 lbf) at the beginning of test as determined by previous calibration. A load measuring device shall be attached to measure the vertical amount of load imparted to the hold-downs during the test.

14.3.3 *Loading Apparatus*—Load shall be applied to the specimen in shear through ~~an 89 by 89 mm (3.5 by 3.5 in.) timber firmly bolted to the upper plates of the panel~~ a horizontal compressive force applied to the loading fixture. ~~Loading shall be a compressive force against the end of the timber attached to the upper plate. When a testing~~

~~machine is used, pulleys and cables may be used to transmit the vertical movement of the tension head of the machine to the horizontal movement in the specimen.~~

14.3.4 *Lateral Guides*—Lateral guides shall be provided so that the specimen will deflect in a plane. The rollers should be bearing-supported to reduce friction to a minimum. The lateral guides shall be firmly attached to the loading frame. Plates for the rollers shall be provided. ~~may be up to 300 mm (12 in.) in length as required.~~

14.3.5 ~~*Deflection*~~ *Displacement Measuring Devices*—linear displacement measuring devices, ~~indicating dials, or scales and wires,~~ shall be provided to measure the displacement of the different parts of the panel during test. ~~The readings shall be recorded to the nearest 0.25 mm (0.01 in.).~~ The deflection measurement devices shall be Class "B" or higher when evaluated in accordance with Practice E2309. The locations and sign conventions of the ~~deflection~~ displacement measuring devices shall be as shown ~~in the lower left, lower right, and upper right corners of the side view of the test assembly~~ in Fig. 7. The devices are used to measure: the lateral displacement of the centerline of the top plate (Δ_1) and the bottom plate (Δ_2), and the vertical displacement at the center of the tension stud (Δ_3) and the compression stud (Δ_4). ~~The device at the lower left, which is attached to the stud, measures any rotation of the panel, the device at the lower right measures any slippage of the panel, and the device at the upper right measures the total of the other two plus the deformation of the panel. Therefore, the horizontal deflection of the panel at any load is the reading of the device at the upper right less the sum of the readings of the other two.~~

Note X: Δ_1 provides a gross horizontal displacement measurement for the racking test specimen that includes lateral movement from specimen shear deformation, rigid body rotation, and rigid body translation Δ_2, Δ_3 , and Δ_4 provide displacement measurements used to analytically determine the assembly deformation that excludes movement from rigid body rotation and translation.

14.4 *Procedure*: The racking load shall be applied using a series of stages that are a function of the targeted ~~allowable seismic design load~~ ultimate load. The targeted ~~allowable seismic design~~ load shall be determined based upon experience, calculation, or standardized product requirements. The panel shall be loaded at a uniform rate using a minimum of three stages, with the final stage loading the panel to failure. Loads and displacements are measured and recorded through all stages at a frequency of not less than once every 20 seconds.

14.4.1 *Loading Rate*—Load shall be applied ~~Apply the load~~ continuously throughout test at a uniform rate of racking load or fixture displacement ~~motion of the loading device used~~. The ~~recommended~~ speed of testing shall be such that the peak load in the first stage shall be achieved ~~the loading to 3.5 kN (790 lbf) total load shall be completed~~ in not less than 2 minutes~~. from the start of the test. The loading to 7.0 to 10.5 kN (1570 to 2360 lbf) total load and to failure shall employ the same rate of travel of the loading~~ The same load or displacement rate shall be used for subsequent stages. Report ~~device as for the loading to 3.5 kN. Give~~ the speed of testing used ~~in the report of test~~. The unloading portion of each stage shall take place in 30 seconds or less.

14.4.2 *Loading Procedure*—Load the specimen ~~in~~ using a minimum of the three mandatory stages outlined below. Additional preliminary stages shall be permitted.

14.4.2.1 *First Stage*- Load the specimen to a load level not less than 1/3 the targeted ~~allowable seismic design racking strength~~ ultimate load. Unload the specimen. Allow the specimen to relax for 5 ± 1 minutes.

14.4.2.2 *Second Stage* - Load the specimen to not less than ~~twice~~ 2/3 the targeted ~~allowable seismic design racking strength~~ ultimate load. Unload the specimen. Allow the specimen to relax for 5 ± 1 minutes.

14.4.2.3 *Third Stage* – Load the specimen beyond the maximum (peak) load to failure or to the point where the measured post-peak racking resistance represents 80% of the maximum load, whichever occurs first. If this condition cannot be achieved by the test apparatus, the report shall indicate that the test was prematurely terminated at the maximum capability of the test equipment.

~~to 3.5, 7.0, and 10.5 kN (790, 1570, and 2360 lbf) total load at a uniform rate.~~

~~14.4.2.1 To provide data to meet performance requirements, other values of total load may be included in the test procedure. Use the same rate of loading as for the loadings specified and indicate additional loadings evaluated and the results obtained in the report.~~

~~14.4.2.2 After the load of 3.5 kN (790 lbf) is placed on the specimen, remove all of the load and any residual deflection (set) in the panel noted. Then load the specimen to 7.0 kN (1570 lbf) and again remove the load and note any additional set; after this increase the loading to 10.5 kN (2360 lbf), remove the load again, and note the set. Apply load continuously for each of the increment loads specified above and obtain load-deflection data. Obtainthese data for at least each 900 N (200 lbf) of loading. Obtain deflections during the loading cycle and, if desired, during the unloading cycle as well.~~

~~14.4.2.3 After the specimen is loaded as specified to 3.5, 7.0, and 10.5 kN (790, 1570, and 2360 lbf) load it again to failure or until the total deflection of the panel becomes 100 mm (4 in.). Obtain readings of deflection for the same intervals of load as were used for the other loadings.~~

14.5 *Calculations and Report:*

14.5.1 *Deformation*—For each ~~dial, or other~~ measuring device, calculate the movement under each racking load as the difference between the readings when load is applied and the initial readings at the start of the test. Calculate set readings as the difference between the readings when the load is removed and the initial readings. Calculate and report the horizontal deformation of the test specimen as:

$$\Delta_h = \Delta_1 - \Delta_2 - (\Delta_3 - \Delta_4)$$

Where:

Δ_h is the horizontal deformation of the assembly that excludes movement from rigid body rotation and translation, mm (in.)

Δ_1 is the horizontal displacement of the top plate, mm (in.)

Δ_2 is the horizontal displacement of the bottom plate, mm (in.)

Δ_3 is the vertical displacement of the tension stud, mm (in.)

Δ_4 is the vertical displacement of the compression stud, mm (in.)

14.5.2 *Data Presentation*—Report the targeted load levels for each stage, peak loads and corresponding deformations ~~deflections~~ measured during each load stage. Report the ~~at 3.5, 7.0, and 10.5 kN (790, 1570, and 2360 lbf) and the~~ set after loading to these amounts. Present the load-deflection curves obtained ~~during loading to failure and to 3.5, 7.0, and 10.5 kN~~ in the form of a graph ~~as prescribed in Section 6~~. Include maximum (peak) load, ~~the interpolated load corresponding to a horizontal deformation of 5 mm (0.2 in.)~~, the post-peak deflection at 80% of the maximum (peak) load and any observations on the behavior of the panel during test and at failure. Express residual deflections (sets) as percentages of the deflections that produced the sets as well as in millimeters or inches. If the specimen fails, describe the visible failure. If the specimen has been subjected to any special conditioning prior to test, describe this treatment in detail. Describe in the report the sheathing used, the method of applying the sheathing, the type and spacing of fasteners, and the method and rate of loading employed. Describe in the report the loading fixture and base fixture. Report the vertical load in the hold-down at the load levels of each stage, at ultimate load, and at the post-peak deflection at 80% of the maximum (peak) load.

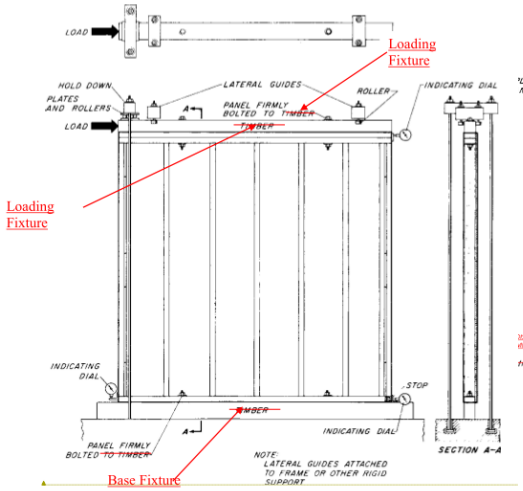


FIG. 7 Racking Load Assembly

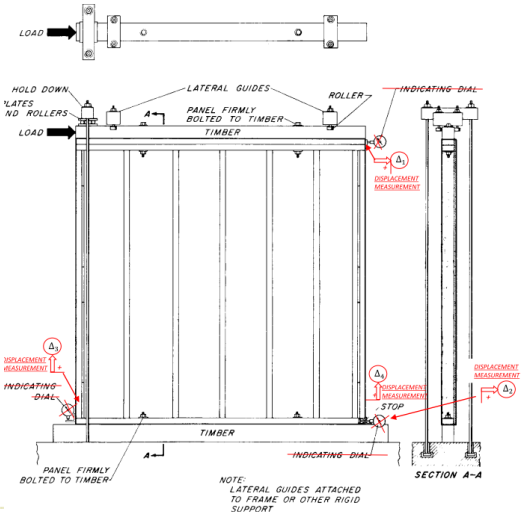


FIG. 7 Racking Load Assembly