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To: ICC-ES Evaluation Committee

From: Chris Allen, P.E.

Date: January 27, 2021

Subject: Proposed Revisions to the Acceptance Criteria for Metal Roof Coverings, Subject AC166-0221-R1 (CA/YM)

MEMO

The technical revision to the acceptance criteria was proposed in the staff letter dated November 30, 2020. In response we received one comment from the proponent GAF in favor of the proposed revisions.

The comment was posted on the ICC-ES web site at https://icc-es.org/wp-content/uploads/2020/11/AC166-0221-R1-GAF.pdf.

In addition to the technical revisions, with this memo the ICC-ES staff is proposing an editorial revision to update the acceptance criteria to the 2021 *International Building Code*® (IBC) and the *International Residential Code*® (IRC). The editorial revisions are identified by the double strikethroughs and double underlines in the acceptance criteria draft enclosed with this memo. The single strikethroughs and single underlines in the acceptance criteria draft enclosed with this memo identify technical revisions identified in the draft enclosed with the staff letter dated November 30, 2020.

Should the Evaluation Committee approve the proposed revisions to AC166, the ICC-ES staff will recommend an immediate effective date. Current applicants for new reports and holders of existing reports will be required to address the applicable requirements of the revised acceptance criteria approved by the committee.

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PROPOSED REVISIONS TO ACCEPTANCE CRITERIA FOR METAL ROOF COVERINGS

AC166

Proposed February 2020

Previously approved October 2012, February 2011, June 2010, June 2009, May 2008, October 2007, February 2007, July 2006, October 2005, November 2001, March 2000

(Previously editorially revised January 2018, June 2015)

PREFACE

Evaluation reports issued by ICC Evaluation Service, LLC (ICC-ES), are based upon performance features of the International family of codes. (Some reports may also reference older code families such as the BOCA National Codes, the Standard Codes, and the Uniform Codes.) Section 104.11 of the *International Building Code*® reads as follows:

> **The provisions of this code are not intended to prevent the installation of any materials or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been approved. An alternative material, design or method of construction shall be approved where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety.**

ICC-ES may consider alternate criteria for report approval, provided the report applicant submits data demonstrating that the alternate criteria are at least equivalent to the criteria set forth in this document, and otherwise demonstrate compliance with the performance features of the codes. ICC-ES retains the right to refuse to issue or renew any evaluation report, if the applicable product, material, or method of construction is such that either unusual care with its installation or use must be exercised for satisfactory performance, or if malfunctioning is apt to cause injury or unreasonable damage.

Acceptance criteria are developed for use solely by ICC-ES for purposes of issuing ICC-ES evaluation reports

PROPOSED REVISIONS TO ACCEPTANCE CRITERIA FOR METAL ROOF COVERINGS (AC166)

1.0 INTRODUCTION

1.1 Purpose: The purpose of this criteria is to establish requirements for ~~recognition~~evaluation of metal roof coverings in ICC Evaluation Service, LLC (ICC-ES), evaluation reports under the 2021, 2018, 2015, 2012 and 2009 *International Building Code*® (IBC) and the 2021, 2018, 2015, 2012 and 2009 *International Residential Code*® (IRC).

The reason for development of this criteria is to clarify requirements for metal roof coverings set forth in the codes.

1.2 Scope: This criteria applies to metal roof shingles and panels complying with the applicable code and installed over solid or closely fitted decking, ~~and~~ shingles installed over spaced sheathing and panels installed over spaced supports, and metal roof shingles with factory-applied adhesive. For compliance with the 2006 *International Building Code*® (IBC) and 2006 *International Residential Code*® (IRC), refer to a previous version of this criteria, dated October 2012 (available from ICC-ES upon request). For compliance with the 1997 *Uniform Building Code*™ (UBC), refer to a previous version of this criteria, dated February 2011 (available from ICC-ES upon request).

1.3 Definitions:

1.3.1 Closely Fitted Decking: Roof sheathing, dimensional lumber, or filled-in spaced sheathing with joints spaced approximately $^1/_8$ inch (3 mm).

1.3.2 Metal Roof Panel: Interlocking metal sheet having a minimum installed weather exposure of 3 square feet (0.279 m^2).

1.3.3 Metal Roof Shingle: Interlocking sections of metal sheet having an installed weather exposure of less than 3 square feet (0.279 m^2).

1.3.4 Nonstructural Standing Seam Metal Roof Panel: A standing seam metal roof panel used mainly as roof covering and requiring the support of an independent roof deck or solid sheathing.

1.3.5 Standing Seam Metal Roof Panel: A metal roof panel with a generally flat profile except for the raised edge or "standing seam" designed to interlock with the adjoining panel on each side.

1.3.6 Metal Roof Shingle with Factory-applied Adhesive: Non-interlocking metal roof shingles with factory-applied adhesive, having an installed weather exposure of less than 3 square feet (0.279 m^2), that are mechanically attached over roof underlayment to closely fitted decking.

1.4 Codes and Referenced Standards: See Table 1 for edition of standards.

1.4.1 2021, 2018, 2015, 2012 and 2009 *International Building Code*® (IBC), International Code Council.

1.4.2 2021, 2018, 2015, 2012 and 2009 *International Residential Code*® (IRC), International Code Council.

1.4.3 Factory Mutual:

1.4.3.1 FM 4470, Approval Standard for Class I Roof Coverings, Factory Mutual.

1.4.3.2 FM 4474, Approval Standard for Evaluating the Simulated Wind Uplift Resistance of Roof Assemblies Using Static Positive and/or Negative Differential Pressures.

1.4.4 ASTM International:

1.4.4.1 ASTM A463, Specification for Steel Sheet, Aluminum-Coated, by the Hot Dip Process.

1.4.4.2 ASTM A653, Specification for Steel Sheet, Zinc-Coated Galvanized or Zinc-Iron Alloy-coated Galvannealed by the Hot-Dip process.

1.4.4.3 ASTM A755, Specification for Steel Sheet, Metallic-Coated by the Hot-Dip Process and Prepainted by the Coil-Coating Process for Exterior Exposed Building Products.

1.4.4.4 ASTM A792, Specification for Steel Sheet, 55% Aluminum-Zinc Alloy-Coated by the Hot-Dip Process.

1.4.4.5 ASTM A875, Standard Specification for Steel Sheet Zinc-5 percent, Aluminum Alloy-coated by the Hot-dip process.

1.4.4.6 ASTM D6381, Standard Test Method for Measurement of Asphalt Shingle Mechanical Uplift Resistance.

~~1.4.4.6~~1.4.4.7 ASTM E72, Standard Test Methods of Conducting Strength Tests of Panels for Building Construction.

~~1.4.4.7~~1.4.4.8 ASTM E455, Standard Test Method for Static Load Testing of Framed Floor or Roof Diaphragm Constructions for Buildings.

~~1.4.4.8~~1.4.4.9 ASTM E108, Test Methods for Fire Tests of Roof Coverings.

~~1.4.4.9~~1.4.4.10 ASTM E1592, Standard Test Method for Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure Difference.

~~1.4.4.10~~1.4.4.11 ASTM G152, Practice for Operating Open-Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials.

~~1.4.4.11~~1.4.4.12 ASTM G155, Practice for Operating Xenon Arc Light Apparatus for Exposure of Nonmetallic Materials.

~~1.4.4.12~~1.4.4.13 ASTM G154, Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials.

1.4.5 Underwriters Laboratories Inc. :

1.4.5.1 UL 580, Tests for Uplift Resistance of Roof Assemblies.

1.4.5.2 UL 790, Standard Test Methods for Fire Tests of Roof Coverings.

1.4.5.3 UL 1897, Uplift Tests for Roof Covering Systems.

1.4.6 ICC-ES Acceptance Criteria for Steel Deck Roof and Floor Systems (AC43).

2.0 BASIC INFORMATION

2.1 General: The following information shall be submitted:

2.1.1 Product Description: Complete information concerning materials, dimensions, coatings, manufacturing process and installation instructions shall be submitted.

2.1.2 Installation Instructions: Dimensioned scale drawings and details noting all thicknesses; size and location of fasteners; and installation details, including flashing and roof slope limitations, shall be submitted.

2.1.3 Packaging and Identification: Method of packaging and identifying components shall be specified. Product identification shall be in accordance with the product identification provisions of the ICC-ES Rules of Procedure for Evaluation Reports. Identification shall include the ICC-ES evaluation report number and notice of any product installation limitations.

2.1.4 Field Preparation: Method of field cutting, trimming or forming, and treatment of cut edges, shall be submitted.

2.2 Testing Laboratories: Testing laboratories shall comply with Section 2.0 of the ICC-ES Acceptance Criteria for Test Reports (AC85) and Section 4.2 of the ICC-ES Rules of Procedure for Evaluation Reports.

2.3 Test Reports: Test reports shall comply with AC85.

2.4 Product Sampling: Test specimens shall be sampled in accordance with the product sampling requirements of AC85. Section 3.1 of AC85 applies to tests conducted in accordance with Section 3.1.7 of this criteria. Section 3.2 of AC85 applies to all other tests.

2.5 Qualification Test Plan: A qualification test plan shall be submitted to and approved by ICC-ES staff prior to any testing being conducted.

3.0 TEST AND PERFORMANCE REQUIREMENTS

3.1 General: Metal roof coverings shall comply with IBC Section 1507.4 or 1507.5 and IRC Section R905.4 or R905.10, with clarification as noted below:

3.1.1 Materials: For steel products, minimum thickness requirements shall be based on the galvanized thickness. For materials other than those listed in IBC Tables 1507.4.3(1) and 1507.4.3(2) or IRC Tables R905.10.3(1) and R905.10.3(2), the material shall be shown to be equivalent to those listed.

3.1.2 Weathering Tests: For ~~recognition~~evaluation under the IBC, reports of weatherometer tests in accordance with IBC Section 1504.6 are required for products installed at slopes less than 2:12 (16.67%). Physical integrity shall be confirmed based on visual and physical examination of exposed test specimens.

3.1.3 Underlayment: Under the 2021 and 2018 IBC and IRC, underlayment for metal roof panels shall comply with IBC Sections 1507.1.1 and 1507.4.5 or IRC Sections R905.1.1 and R905.10.5, as applicable. Under the 2021 and 2018 IBC and IRC, underlayment for metal roof shingles and metal roof shingles with factory-applied adhesive shall comply with IBC Sections 1507.1.1 and 1507.5.3 or IRC Sections R905.1.1 and R905.4.3, as applicable. Under the 2015 and 2012 IBC and IRC, underlayment shall comply with IBC Section 1507.5.3 or IRC Section R905.4.3 for metal shingles and metal roof shingles with factory-applied adhesive and IBC Section 1507.4.5 or IRC R905.10.5 for metal panels. Under the 2009 IBC and IRC, underlayment shall comply with IBC Section 1507.5.3 or IRC Section R905.4.3 for metal shingles and metal roof shingles with factory-applied adhesive and IRC Section R905.10.5 for metal panels.

Exception: Underlayment is not required for metal panels or metal shingles supported by solid or closely fitted decking, provided reports of tests showing compliance with Section 4.2 of this criteria are submitted.

3.1.4 Wind Resistance:

General: 2021 and 2018 IBC: ~~Recognition~~Evaluation may be granted for use in areas subject to a maximum basic design wind speed of 130 mph (209 km/h) on structures a maximum of 40 feet (12.2 m) in height in Exposure B areas, provided the proponent can verify, in writing, that he has investigated and determined that his product will perform satisfactorily when installed under these conditions. ~~Recognition~~Evaluation for use in areas beyond these limits shall be justified by tests conducted in accordance with Sections 3.1.4.1 or 3.1.4.3 or design in accordance with Section 3.1.4.2. For use in any area, metal roof shingles with factory-applied adhesive shall be evaluated by testing in accordance with Section 3.1.4.1.

2021 and 2018 IRC, 2015 IBC, 2015 IRC and 2012 IBC: ~~Recognition~~Evaluation may be granted for use in areas subject to a maximum ultimate design wind speed of 130 mph (209 km/h) on structures a maximum of 40 feet (12.2 m) in height in Exposure B areas, provided the proponent can verify, in writing, that he has investigated and determined that his product will perform satisfactorily when installed under these conditions. ~~Recognition~~Evaluation for use in areas beyond these limits shall be justified by tests conducted in accordance with Sections 3.1.4.1 or 3.1.4.3 or design in accordance with Section 3.1.4.2. For use in any area, metal roof shingles with factory-applied adhesive shall be evaluated by testing in accordance with Section 3.1.4.1.

2012 IRC, 2009 IBC and 2009 IRC: ~~Recognition~~Evaluation may be granted for use in areas subject to a maximum basic wind speed of 100 mph (161 km/h) on structures a maximum of 40 feet (12.2 m) in height in Exposure B areas, provided the proponent can verify, in writing, that he has investigated and determined that his product will perform satisfactorily when installed under these conditions. ~~Recognition~~Evaluation for use in areas beyond these limits shall be justified by tests conducted in accordance with Sections 3.1.4.1 or 3.1.4.3 or design in accordance with Section 3.1.4.2. For use in any area, metal roof shingles with factory-applied adhesive shall be evaluated by testing in accordance with Section 3.1.4.1.

3.1.4.1 Metal roof shingles, ~~and~~ metal roof panels and metal roof shingles with factory-applied adhesive to be installed on solid or closely fitted decking shall be tested in accordance with UL 1897. (Note: For nonstructural standing seam metal roof panel, refer to Section 3.1.4.3). Connections to framing or to sheathing shall be based on minimum conditions (since test specimens establish a basis of acceptance). Allowable loading will be based on a minimum factor of safety of 2.0, applied to the peak load. Positive loads will be based on the adequacy of the structural framing and sheathing.

Metal shingles to be installed on spaced sheathing and metal panels to be installed on spaced supports shall be tested in accordance with FM 4474, UL 580, ASTM E1592 or UL 1897. Connections to framing or to sheathing shall be based on minimum conditions (since test

specimens establish a basis of acceptance). Allowable loading will be based on a minimum factor of safety of 2.0, applied to the peak load. Testing shall be for both positive and negative loads.

Metal roof shingles with factory-applied adhesive to be installed on solid or closely fitted decking shall be evaluated by testing in accordance with UL 1897. Connections to framing or to sheathing shall be based on minimum conditions (since test specimens establish a basis of acceptance). Allowable loading will be based on a minimum factor of safety of 2.0, applied to the peak load. Positive loads will be based on the adequacy of the structural framing and sheathing.

Testing for gravity loads (Section 3.1.5) may be substituted for positive wind load testing. When using gravity load testing, the allowable positive wind load will be based on a minimum factor of safety of 2.0, applied to the average peak load.

3.1.4.2 The roof coverings shall be designed for wind loads in accordance with Chapter 16 of the IBC.

3.1.4.3 Nonstructural standing seam metal roof panels to be installed on solid wood sheathing shall be tested for wind resistance in accordance with Section 4.3. Allowable wind uplift resistance shall be based on a safety factor of 2 applied to the highest uplift pressure that is sustained for a minimum of one minute, meeting the conditions of acceptance in Section 4.3.4.

3.1.5 Gravity Loads: For shingles applied to spaced sheathing and panels applied to spaced supports, the maximum allowable gravity load on the shingles shall be determined by standard engineering methods in accordance with the applicable materials design standard or by testing in accordance with Section 4.1. The maximum allowable load, when based on testing, shall be the lesser of the average ultimate load determined in accordance with Section 4.1 divided by 2.5 or the least load causing a shingle or panel deflection of l/60.

As an alternative, the ICC-ES Acceptance Criteria for Steel Deck Roof and Floor Systems (AC43) may be used to determine the maximum allowable gravity loads on the roof covering system.

3.1.6 Impact Resistance: For ~~recognition~~evaluation under the IBC, metal panels installed at roof slopes below 2:12 (16.67%) shall comply with the "Resistance to Foot Traffic Test" in Section 4.6 of FM 4470.

3.1.7 Fire Classification:

Roofing assemblies shall be tested in accordance with either ASTM E108 or UL 790. Classification shall be established based on testing, or as described in IRC Section R902.1 or in the exceptions to Section 1505.2 of the ~~2018, 2015, 2012 and 2009~~ IBC, unless use is limited to non-classified roofing.

3.1.8 Roof Diaphragm (Optional): For applications under the IRC only, ~~recognition~~certification may be established for use of the metal roof covering on spaced sheathing or spaced supports as an alternative to the roof diaphragm provided by the prescriptive roof deck construction specified in the IRC. The results of metal roof shear testing in accordance with Section 4.4 and Appendix A shall comply with the applicable strengths specified in Table 2.

3.1.9 Adhesive Durability for Metal Roof Shingles with Factory-applied Adhesive:

3.1.9.1 General: Forty (40) specimens shall be constructed in accordance with ASTM D6381 Procedure A. Thirty (30) of the forty (40) specimens shall be subjected to twelve consecutive cycles of temperature cycling exposure with each cycle consisting of fourteen hours at an ambient temperature of 180°F (82°C), followed by one hour at an ambient temperature of 70°F (21.1°C), followed by one hour of water exposure at room temperature, followed by six hours at an ambient temperature of minus 40°F (-40°F), followed by two hours at an ambient temperature of 70°F (21.1°C). Between cycles, such as on weekends and holidays, the specimens may be maintained at an ambient temperature of 70°F (21.1°C). A +5°F (+2.8°C) tolerance is allowed on the specified temperatures. Spray nozzles for the water exposure shall be located approximately seven feet (2143 mm) above the test specimens and shall deliver 6 inches (152 mm) of water per hour at a water temperature of 40˚F to 60˚F (4.4˚C to 15.6˚C). The test specimens shall be installed at the minimum slope for which recognition is sought, as specified in the manufacturer's installation instructions, but in no case at a slope of less than 2:12 (17 percent slope). At the conclusion of every fourth full cycle, ten (10) specimens exposed to temperature cycling shall be tested in accordance with ASTM D6381 Procedure A and the individual uplift resistance and average uplift resistance recorded. The remaining ten (10) control specimens that were not subjected to temperature cycling shall be conditioned at 180°F (82°C) for 14 hours. After being allowed to cool to room temperature, these ten (10) control specimens shall be tested in accordance with ASTM D6381 Procedure A and the individual uplift resistance and average uplift resistance recorded.

~~3.1.7~~3.1.9.2 Conditions of Acceptance: Each group of ten (10) specimens exposed to temperature cycling shall have an average uplift resistance of not less than 90 percent of the average uplift resistance of the ten (10) control specimens that were not exposed to temperature cycling.

4.0 TEST METHODS

4.1 Gravity Loads: Testing for gravity loads shall be in accordance with the bag method of ASTM E72, Section 11, for three test specimens. Testing need only be performed in one direction on the assembly, consistent with the direction of the gravity loads on the in-place roof covering. The test specimen shall be of sufficient size to test connections or overlaps between shingles as applicable, or a minimum of 4 feet by 8 feet (1219 by 2438 mm), whichever is larger.

4.2 Wind-driven Rain Test:

4.2.1 General: The test frame shall be approximately 10 feet by 10 feet (3048 mm by 3048 mm) and hinged at the lower end to permit roof pitch variations. It shall be rigidly supported during the test. The test specimen shall be sized to fill the area within the test frame as completely as possible. Components shall be conditioned to have an initial moisture content representative of field conditions.

Components shall be trimmed as necessary to fit within the test frame and to provide pitched, vertical and horizontal joints, if this is the practice. Components shall be laid in accordance with installation instructions that shall be a part

of the laboratory report. Batten lifts removed while cutting peripheral tile shall be simulated with suitable packing.

Gaps along the frame and unused nail holes shall be sealed with a suitable compound. The frame shall not be erected against the side of a higher building or other solid surface where normal airflow over the specimen can be affected.

The airflow over the test frame shall be directed and smoothed by suitably shaped baffles. The airstream velocity measured on a vertical plane midway between the upper and lower edge of the test specimen on a 24-inch (610 mm) grid shall be within the required axial velocity. The test report shall include the wind velocity profile developed on the 24-inch (610 mm) grid basis. The axial velocity over the test section shall be monitored with a calibrated vane-type velocimeter mounted approximately 6 feet (1829 mm) down-stream of the wind source at the mid-height of the panel.

The velocimeter readings shall be taken with a stopwatch using a minimum 1-minute duration. The wind velocity is maintained between 35 and 40 miles per hour (56 and 64 km/h), and water is introduced into the wind stream.

4.2.2 Apparatus:

4.2.2.1 Wind Source: Airflow over the test rig shall be calibrated as previously indicated.

4.2.2.2 Water Supply: A sprinkle-pipe system, mounted on a movable frame capable of simulating a uniform 6-inch-per-hour (152 mm/hr) rainfall as monitored with flow gages calibrated in cubic feet per second, is an example of an acceptable system.

Uniform distribution of simulated rainfall requires calibration of water flow gages, monitoring the water supply to ensure sufficient distribution over the test specimen surface at each specified pitch, proper orientation and air-speed. The simulated rain striking the test specimen shall be uniformly distributed within a 20 percent variation over the test deck.

Distribution and calibration of water flow may also be determined by the following method: A shallow tray is attached to the test rig in place of the test specimen. The tray bottom is covered with a layer of thick absorbent paper (high-wet-strength, extra-thick, white filter paper) that has been weighed and lined to form 12-inch (305 mm) squares. At the required wind velocity, water is fed into the airstream at a suitable rate, indicated by the flow-rate meters, for a time sufficient to wet but not saturate the paper. The air and water flows are then stopped, and the paper is removed and cut into squares. Each square is weighed. Using the initial average dry weight and sample weight after exposure, the amount of water striking the test area, and the distribution, can be determined. The test is repeated with different flow meter settings at the same air velocity, to determine if distribution is affected by water flow. A chart shall then be prepared, for review and future reference, that describes the simulated-rain distribution for each flow meter setting, pitch and orientation. When the simulated-rain distribution is determined, calibration may be made by collecting water falling into a sealed box gasketed and clamped to the underside of the test rig when the test specimen frame is left open. The volume of water collected in the box over a suitable time interval serves as a check for the required flow. This method allows water to be collected over a longer period or allows water to be measured continuously as it is drained from the test rig box.

4.2.3 Procedure: The underside of the test specimen shall be photographed immediately prior to starting tests.

The airflow shall be between 35 and 40 miles per hour (56 and 64 km/h), with velocity and pressure differentials across the test surface measured and recorded. The pressure distribution across the surface shall be measured at not less than 10 points.

The water supply rate shall be adjusted for a simulated rainfall of 6 inches (152 mm) per hour.

The roof slope should be the flattest proposed for installation.

For tile and panel roofing materials, a slope of 3:12 is used. The test shall commence at the specified airspeed with three cycles of simulated rainfall of 15 minutes each, with the wind generator stopped for 5 minutes after each cycle to allow observation and recording of the specimen condition. The condition of joints (as viewed from the under-side) shall be reported after each rainfall insofar as water infiltration is concerned. Damage, if any, to specimens and fasteners shall also be reported. Upon completion of the test, components shall be dismantled and condition of lapped areas and undersurfaces noted and photographed.

4.2.4 Conditions of Acceptance: There can be no leaks. The test report shall indicate the extent of tile or panel fluttering during the test periods and whether it was due to oversized nail holes or loosening fasteners.

4.3 Wind Uplift Resistance of Nonstructural Standing Seam Metal Roof Panels: Nonstructural standing seam metal roof panels to be installed on solid wood sheathing shall be tested in accordance with UL 580, modified to add the following considerations:

4.3.1 Sample: One roof assembly or test specimen shall be constructed and tested for each fastening condition.

4.3.2 Apparatus: Sheathing shall be a minimum of $^{15}/_{32}$-inch-thick plywood. Supporting members shall be provided, such as joists, braces and perimeter framing, that is representative of the construction for which classification is desired. Test roof assemblies shall be installed such that the measured pressure differential shall occur between the top of the sheathing and the top of the metal roof panel.

Over the sheathing and under the metal roof panels, underlayment shall be omitted, and a loose-fitting, pleated, 4-mil plastic film shall be provided to assist in obtaining uniform pressure on the metal roof panels. The standing seam panels shall be secured through the plastic film into the plywood sheathing with anchor clips, in accordance with the manufacturer's installation instructions.

4.3.3 Procedure: The test assembly shall be subjected to positive and negative pressures at the values and time duration given for the Class 30, 60, and 90 classifications. Subsequent to the completion of Phase 5 of the Class 90 test sequence, the test specimen may be subjected to supplemental static uplift pressures at the option of the manufacturer. If additional testing is desired:

- The negative pressure in the vacuum chamber shall be maintained at 56.5 psf (2.71 kPa).

- The static uplift pressure shall be supplied from below. The initial positive static uplift pressure shall be 63.5 psf (3.04 kPa). Subsequent pressure intervals shall increase in increments of 15 psf (0.72 kPa), with each pressure level held for one minute, until failure or until the desired uplift pressure is attained. The allowable uplift pressure shall be based on the safety factor as noted in Section 3.1.4.3.

4.3.4 Conditions of Acceptance: There shall be no buckling of metal panels that results in permanent loss of stiffness as determined by separate load tests comparing buckled and unbuckled panels. There shall be no separation of components or permanent distortion on any of the metal panels. There shall be no sidejoint disengagement. There shall be no failure of one or more fasteners of any type.

4.4 Metal Roof Shear Test: Either 12-foot-by-12-foot (3658 mm by 3658 mm) or 24-foot-by-24-foot (7315 mm by 7315 mm) metal roof covering specimens shall be tested in accordance with Appendix A. The number of test specimens in a test set shall be in accordance with Section 8.1 of ASTM E455. A set of specimens shall be tested with the load applied parallel to the framing, and a second set of specimens shall be tested with the load applied perpendicular to the framing. The performance of the metal roof covering shall be determined as equivalent to the performance of the prescriptive wood structural diaphragm in the IRC when the average strength values and average secant stiffness values noted in Table 2 are achieved for the specimen size tested.

5.0 QUALITY CONTROL

5.1 Quality documentation complying with the ICC-ES Acceptance Criteria for Quality Documentation (AC10) shall be submitted.

5.2 A qualifying inspection shall be conducted at each manufacturing facility when required by the ICC-ES Acceptance Criteria for Inspections and Inspection Agencies (AC304).

5.3 The product shall be manufactured under an approved quality control program with inspection by ICC-ES or by a properly accredited inspection agency that has a contractual relationship with ICC-ES.

5.4 The documentation shall contain sufficient detail to verify that each type of metal complies with that specified in the evaluation report. Mill certificates shall verify that all metal, mechanical, chemical and corrosion resistance properties comply with standards specified in the evaluation report. Quality control tests, and conditions of acceptance for coatings applied to metal, shall be specified in the documentation. Additionally, the dimensions shall be checked periodically to ensure that when installed in a specific manner, a uniform and tight installation is achieved. Complete records of all mill certificates, independent laboratory tests and in-house tests shall be retained on file for a minimum of two years.

6.0 EVALUATION REPORT ~~RECOGNITION~~ REQUIREMENTS

6.1 Reports on shingles applied to spaced sheathing with allowable gravity loads of less than 48 psf (2.3 kPa), shall include a condition of use stating that the shingles must not be used in applications subject to the 300-pound (1.3 kN) concentrated load specified in 2021 and 2018 IBC Sections 1607.4 and 1607.13 and Item 26 of Table 1607.1; 2015 and 2012 IBC Sections 1607.4 and 1607.12 and Item 26 of Table 1607.1; and 2009 IBC Sections 1607.4 and 1607.11 and Item 29 of Table 1607.1.

6.2 Reports on metal roof coverings ~~recognized~~evaluated as an alternative to the roof diaphragm provided by the unblocked prescriptive wood structural panel roof deck construction nailed at 6 inches on center on the perimeter and 12 inches on center in the field, specified in the IRC, shall have the roof diaphragm ~~recognited~~evaluated limited to reroofing applications. ■

TABLE 1—REFERENCED STANDARDS

STANDARD	EDITION OF STANDARD				
	2009 IBC and IRC	2012 IBC and IRC	2015 IBC and IRC	2018 IBC and IRC	2021 IBC and IRC
FM 4470	1992	1992	2012	2016	2016
ASTM A463	2005	2006	2010	2015	2015
ASTM A653	2007	2008	2011	2015	2017
ASTM A755	2007	2003 (2008)	2011	2005~~15~~	2016e1
ASTM A792	2006a	2008	2010	2010 (2015)	2010 (2015)
ASTM A875	2006	2006	2013	2013	2013
ASTM D6381	2015 (2020)	2015 (2020)	2015 (2020)	2015 (2020)	2015 (2020)
ASTM E72	2002	2002	2014a	2014a	2014a
ASTM E108	2007a	2007a	2011	2016	2017
ASTM E455	2004	2004	2004	2004	2004
ASTM E1592	2001	2005	2005 (2012)	2005 (2012)	2005 (2017)
ASTM G152	2006	2006	2006	2013	2013
ASTM G154	2005	2006	2006	2012a	2016a
ASTM G155	2005a	2005a	2005a	2013	2013
UL 580	2006	2006 with revisions through July 2009	2006 with revisions through July 2009	2006 with revisions through October 2013	2016
UL 790	2004	2004 with revisions through October 2008	2004 with revisions through October 2008	2004 with revisions through July 2014	2004 with revisions through October 2018
UL 1897	2004	2004 with revisions through May 2008	2012	2012 with revisions through September 2015	2015

TABLE 2—MINIMUM METAL ROOF COVERING DIAPHRAGM TEST RESULTS

SPECIMEN SIZE (ft)	LOADING	AVERAGE STRENGTH (lbf/ft)	AVERAGE SECANT STIFFNESS (lb/in)
24 x 24	Parallel to framing	488	3940
	Perpendicular to framing	489	3745
12 x 12	Parallel to framing	762	6260
	Perpendicular to framing	854	4796

For **SI:** 1 inch = 25.4 mm, 1 lb = 4.4482 N.

Appendix A

Comparison Diaphragm Testing of Metal Roof Covering to Prescriptive Wood Structural Panels in the *International Residential Code*® (IRC).

A1.0 Introduction

A1.1 Purpose: The purpose of this appendix is to provide for testing metal roof covering installed over either spaced sheathing or spaced supports, to determine equivalency to wood structural panel diaphragms, as prescribed in the IRC, when constructed with solid or closely fitted decks.

A1.2 Scope: The average strength and average secant stiffness for the metal roof covering are compared to the wood structural panel diaphragms constructed in accordance with the IRC and tested to determine their average strength and average secant stiffness.

A1.3 Referenced Standards

A1.3.1 ASTM D4444-08, *Standard Test Method for Laboratory Standardization and Calibration of Hand-Held Moisture Meters.*

A1.3.2 ASTM E455-04, *Standard Test Method for Static Load Testing of Framed Floor or Roof Diaphragm Constructions for Buildings.*

A2.0 Definitions:

Average peak load: The average peak load is the maximum load from average load-displacement curve. (See ASTM E455, Section 8.1.)

Average strength: The average peak load divided by the depth of the specimen.

Secant stiffness: The slope of the line from the origin (after slack of the system is removed) to the peak load.

A3.0 Specimen Construction

A3.1 Diaphragm Framing Materials

LUMBER DIMENSION	SPECIES AND GRADE	END USE IN DIAPHRAGM
2 x 10	Douglas fir No. 2 & better	Rafter, chord, blocking for loading positions when load oriented perpendicular to framing direction
2 x 6	Douglas fir No. 2 & better	Sill plate and sistered load beam support
2 x 4	Douglas fir–larch standard & better	Blocking between rafters and continuous blocking along strut

A3.2 Fasteners and End Use

FASTENER DESCRIPTION	DIAMETER (IN)	LENGTH (IN)	END USE IN DIAPHRAGM
8d common	0.131	2.5	Toe-nail blocking
10d common	0.148	3	Stitch sill plate together
16d common	0.162	3.5	Blocking to sill plate connection and 2 x 2 to rafters
20d common	0.192	4	Chord to rafter connection
Simpson Strong-Tie SDS25412	0.25	4.5 (2.75 thread length)	2 x 6 sistered to rafter (Load beam)

For **SI:** 1 inch = 25.4 mm.

A3.3 Framing Moisture Content: The moisture content shall be measured at four locations around the perimeter of each specimen using a pin-type moisture meter complying with ASTM D4444. The average moisture content for each specimen prior to testing shall be less than or equal to 19%.

A4.0 Specimen Instrumentation:

A4.1 24 ft x 24 ft Specimen: Two load cells and seven string potentiometers shall be utilized to monitor the applied load and diaphragm displacement, respectively, for the 24-foot (7315 mm) square specimen (See Figure A4.1). Measurement Devices 1 and 2 shall be utilized to monitor the deflections induced by Actuator 1, while devices 4 and 5 shall be utilized to monitor the deflections induced by Actuator 2. The string potentiometer at the location labeled 3 shall be used to monitor center span diaphragm displacement. String potentiometers at locations labeled S1 and S2 shall be utilized to monitor any movement between the specimen and the restraint steel in order to ensure that the connection between the specimen and the restraint steel is providing effective resistance to the applied loads.

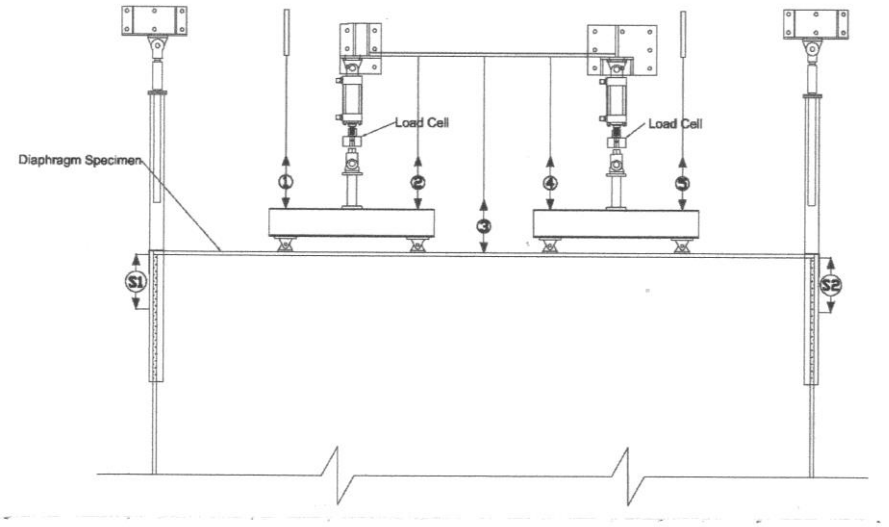


FIGURE A4.1

A4.2 12 ft x 12 ft Specimen: One load cell and five string potentiometers shall be utilized to monitor the applied load and diaphragm displacement, respectively, for the 12-foot (3658 mm) square specimen (See Figure A4.2). Measurement Devices 1 and 2 shall be utilized to monitor the deflections induced by Actuator 1. The string potentiometer at the location labeled 3 shall be used to monitor center span diaphragm displacement. String potentiometers at locations labeled S1 and S2 shall be utilized to monitor any movement between the specimen and the restraint steel in order to ensure that the connection between the specimen and the restraint steel is providing effective resistance to the applied loads.

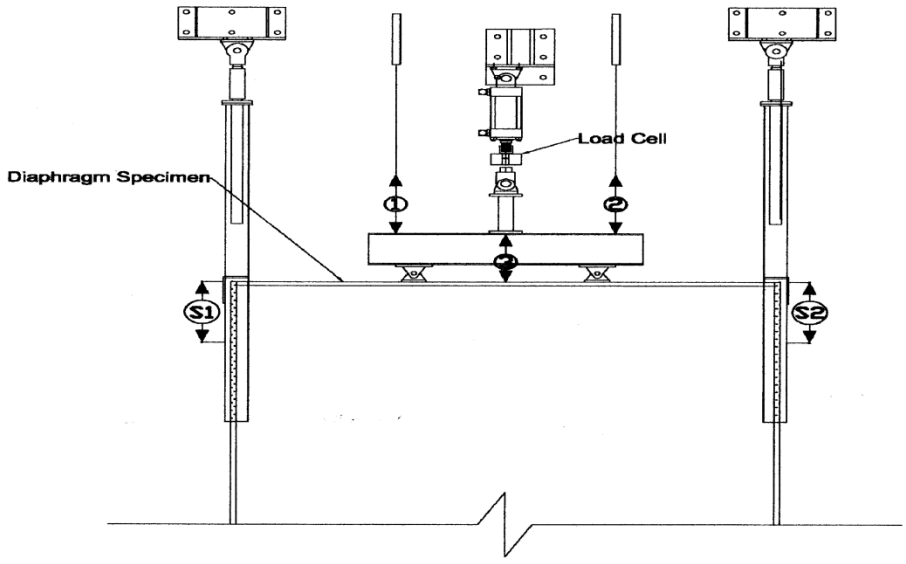
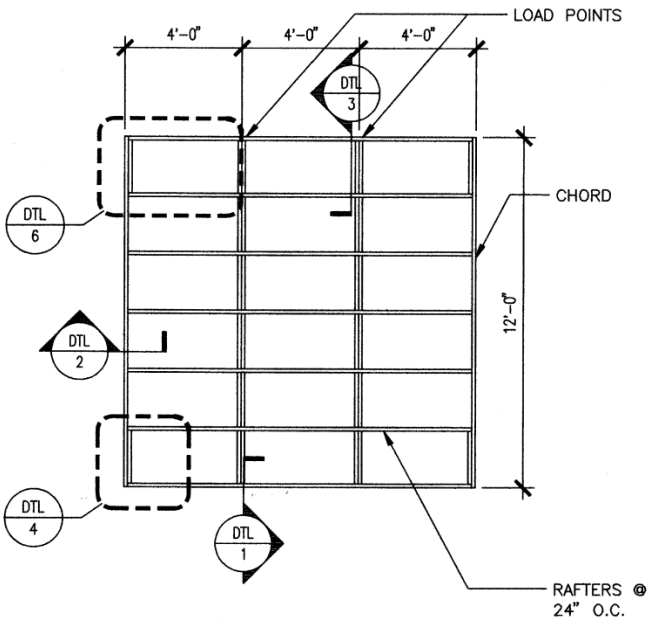


Figure A4
Location of Data Acquisition Instrumentation for Each Tested 12 ft Square Diaphragm

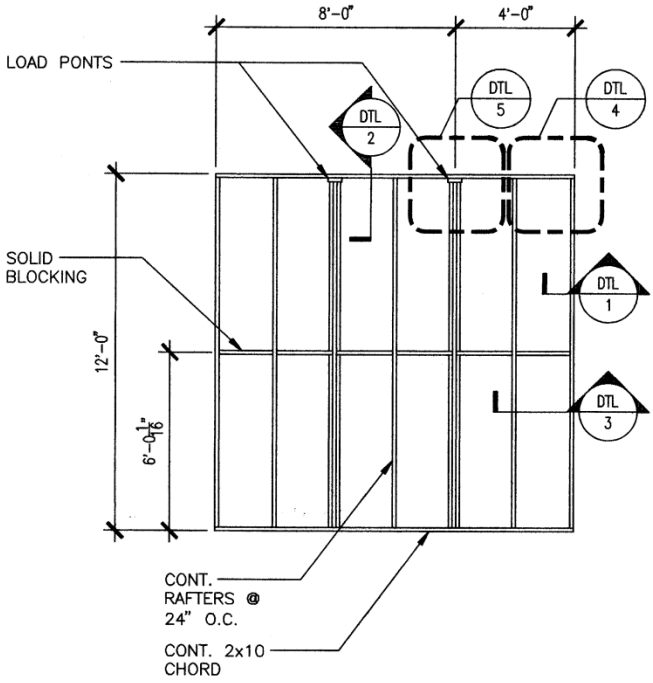
A5.0 Testing Protocol: Horizontal diaphragm testing shall be conducted in accordance with ASTM E455 utilizing the Simple Beam Diaphragm methodology from Section 6.1.3.2 for load applied parallel to the framing and for load applied perpendicular to the framing. Rollers may be used to prevent any displacement of the specimen out of plane while not restricting any in-plane displacements. For the tested specimens, it is deemed unnecessary to conduct testing to determine the stiffness of the frame without the installation of the sheathing, as described in ASTM E455 Section 9.1. Once the specimen is constructed, the load mechanism and the necessary data acquisition instrumentation shall be installed, and verified, displacement shall be applied to the specimens at a constant rate of 0.2 inch per minute for the 12-foot-by-12-foot specimens and 0.4 inch per minute for the 24-foot-by-24-foot specimens. The maximum loads shall be attained in not less than 10 minutes, as stipulated in Section 9.2 of ASTM E455. Loads shall be applied and monitored beyond the point of maximum load until the load has reduced to 80% of the peak load. All load and deflection data shall be continuously recorded at approximately 1-second intervals throughout testing. The specimen shall be held in the deformed state until observations regarding the modes of failure and damage incurred during loading has been documented.

A6.0 Test Specimen Metal Roof Covering Attachment: The attachment of the metal roof covering to the specimen frame shall be in accordance with the metal roof covering manufacturer's installation instructions. These installation instructions shall include applicable details for the installation of spaced sheathing or spaced supports and the metal roof covering to be recognized in the roof diaphragm section of the evaluation report. The spaced sheathing or space supports shall be installed to represent the weakest installation to be recognized in the roof diaphragm section of the evaluation report.

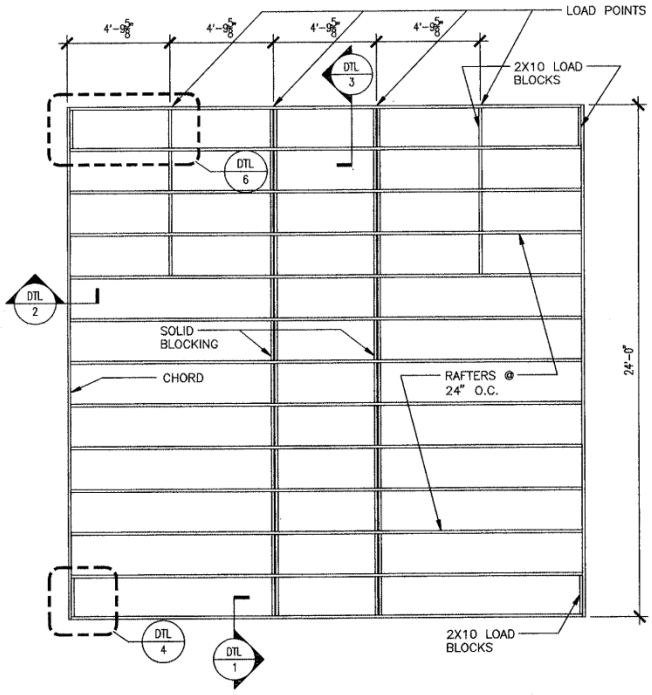
A7.0 Specimen Frame Construction Figures: The following figures shall be used to construct the framing for the metal roof covering specimens.



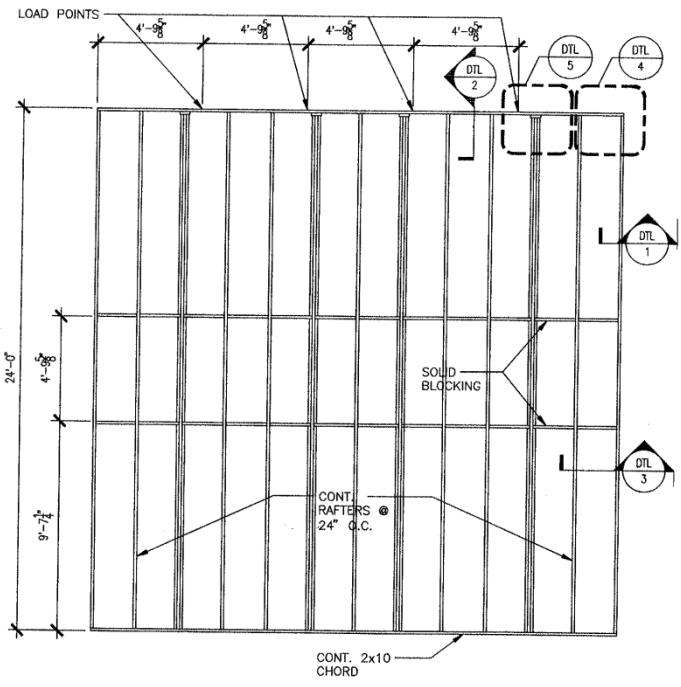
12x12 Metal Roof Covering Diaphragm
Diaphragm Loaded Perpendicular to Framing



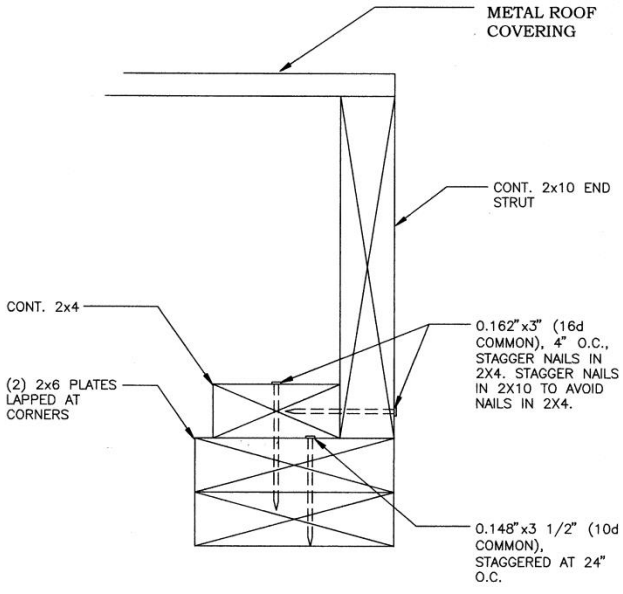
12x12 Metal Roof Covering Diaphragm
Diaphragm Loaded Parallel to Framing



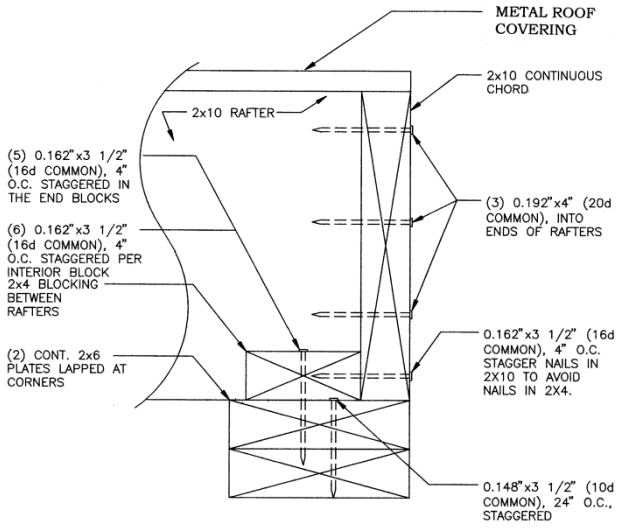
24' x 24' Metal Roof Covering Diaphragm
Diaphragm Loaded Perpendicular to Framing



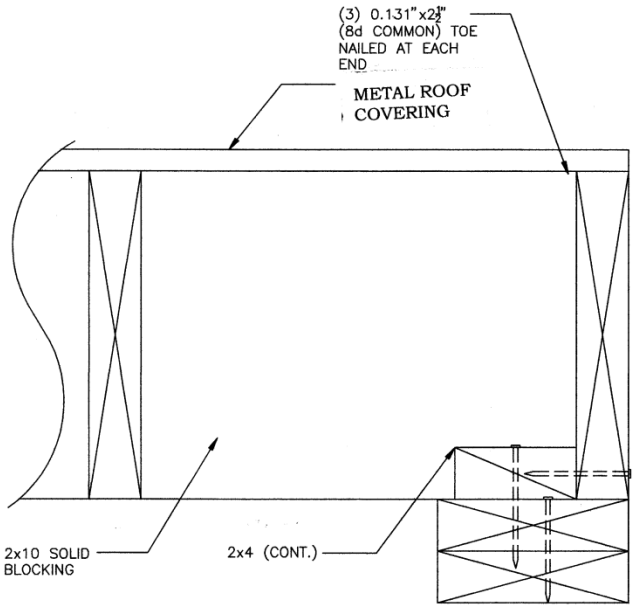
24' x 24' Metal Roof Covering Diaphragm
Diaphragm Loaded Parallel to Framing



Detail 1
12x12 Metal Roof Covering Diaphragm
End Rafter Section

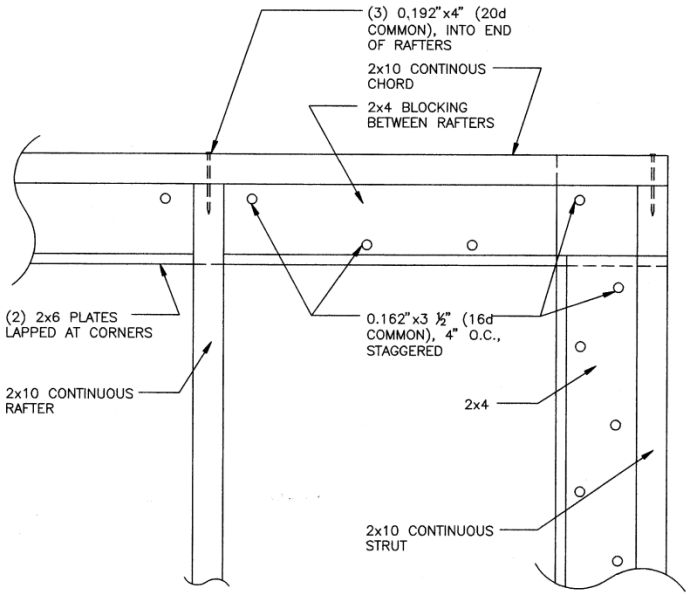


Detail 2
12x12 Metal Roof Covering Diaphragm
Chord Section

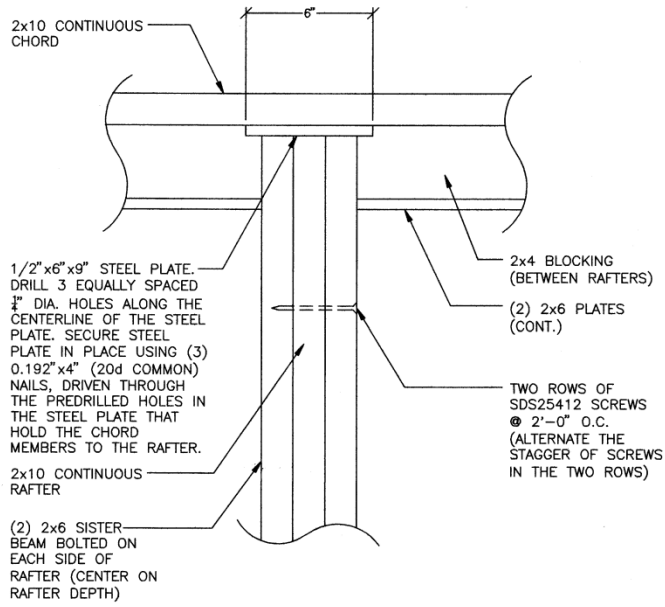


SOLID BLOCKING IS CONSTRUCTED BY CUTTING 2x10'S TO FIT BETWEEN THE RAFTERS. NAIL THE 2x10'S TOGETHER USING (3) 0.131"x2 ½" (8d COMMON) NAILS IN A "V" PATTERN. ATTACH THE DOUBLE 2x10 TO THE RAFTERS USING (3) 0.131"x2 ½" (8d COMMON) NAILS TOE–NAILED AT EACH END ON EACH ON EACH SIDE (SEE SHEET 10 OF 10).

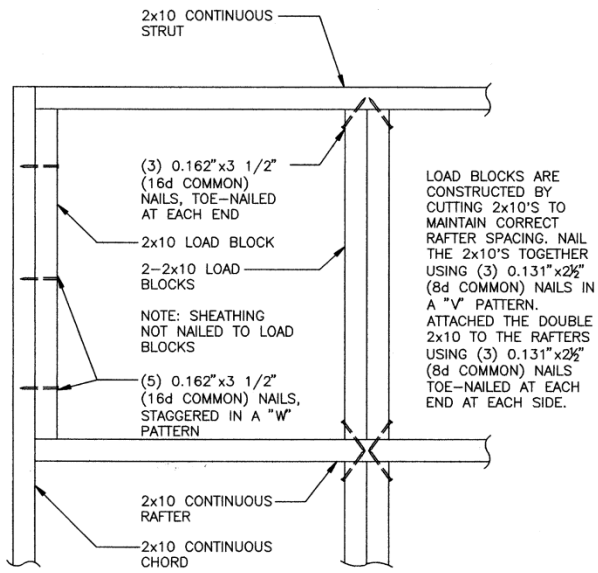
Detail 3
12x12 Metal Roof Covering Diaphragm
Solid Bridging



Detail 4
12x12 Metal Roof Covering Diaphragm
Corner Detail



Detail 5
12x12 Metal Roof Covering Diaphragm
Steel Plate and 2x6 Scabs



Detail 6
12x12 Metal Roof Covering Diaphragm
Load Block Detail