ACCEPTANCE CRITERIA FOR METAL WEBS FOR PARALLEL CHORD WOOD TRUSSES

AC387

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PREFACE

Evaluation reports issued by ICC Evaluation Service, Inc. (ICC-ES), are based upon performance features of the International family of codes and other widely adopted code families, including the Uniform Codes, the BOCA National Codes, and the SBCCI Standard 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.

Similar provisions are contained in the Uniform Codes, the National Codes, and the Standard Codes.

This acceptance criteria has been issued to provide all interested parties with guidelines for demonstrating compliance with performance features of the applicable code(s) referenced in the acceptance criteria. The criteria was developed and adopted following public hearings conducted by the ICC-ES Evaluation Committee, and is effective on the date shown above. All reports issued or reissued on or after the effective date must comply with this criteria, while reports issued prior to this date may be in compliance with this criteria or with the previous edition. If the criteria is an updated version from the previous edition, a solid vertical line (**I**) in the margin within the criteria indicates a technical change, addition, or deletion from the previous edition. A deletion indicator (**➜**) is provided in the margin where a paragraph has been deleted if the deletion involved a technical change. This criteria may be further revised as the need dictates.

ICC-ES may consider alternate criteria, provided the report applicant submits valid 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. Notwithstanding that a product, material, or type or method of construction meets the requirements of the criteria set forth in this document, or that it can be demonstrated that valid alternate criteria are equivalent to the criteria 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 an evaluation report, if the product, material, or type 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 unreasonable property damage or personal injury or sickness relative to the benefits to be achieved by the use of the product, material, or type or method of construction.

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

ACCEPTANCE CRITERIA FOR METAL WEBS FOR PARALLEL CHORD WOOD TRUSSES (AC387)

1.0 INTRODUCTION

1.1 Purpose: The purpose of this acceptance criteria is to establish requirements for evaluation of metal webs that are used in parallel chord wood trusses, to allow these products to be recognized in an ICC Evaluation Service, Inc. (ICC-ES), evaluation report under the 2006 *International Building Code*® (IBC) and the 2006 *International Residential Code*® (IRC). Bases of recognition are IBC Section 104.11 and IRC Section R104.11. Applicable code sections are IBC Sections 2303.4 (Trusses), 2303.4.2 (Metal-plate-connected trusses), 2306.1 (Allowable stress design), and 2308.10.10 (Conventional Light-Frame Construction—Wood trusses); and IRC Sections R502.11 (Floors—Wood Trusses), and R802.10 Roof-Ceiling Construction—(Wood trusses).

The reason for the development of this criteria is that the codes do not provide standards for evaluation of metal webs that are used in parallel chord wood trusses.

1.2 Scope: This criteria applies to metal webs with integral connector teeth that are used as structural components in parallel chord wood trusses. Figure 1 illustrates typical installations for metal webs. Chord member splices and wood-web connections are made with metal connector plates that are in accordance with ANSI/TPI 1. The connector plates and metal web members are pressed into the lumber using a hydraulic press or a gantry roller system.

1.3 Codes and Referenced Standards:

1.3.1 2006 *International Building Code*® (IBC), International Code Council.

1.3.2 2006 *International Residential Code*® (IRC), International Code Council.

1.3.3 ASTM D 2395-02, Standard Test Method for Specific Gravity of Wood and Wood Based Materials, ASTM International.

1.3.4 ASTM D 4442-92 (1997 ed.), Standard Test Method for Direct Moisture Content Measurement of Wood and Wood Based Materials, ASTM International.

1.3.5 ASTM D 4444-92 (2003), Standard Test Methods for Use and Calibration of Handheld Moisture Meters, ASTM International.

1.3.6 ASTM E 4-03, Standard Practices for Force Verification of Testing Machines, ASTM International.

1.3.7 ANSI/AF&PA NDS-05, National Design Specification (NDS) for Wood Construction, 2005 Edition, American Forest & Paper Association.

1.3.8 ANSI/TPI 1-2002, National Design Standard for Metal Plate Connected Wood Truss Construction, Truss Plate Institute.

1.3.9 ANSI/TPI 2-1995, Standard for Testing Metal Plate Connected Wood Trusses, Truss Plate Institute

1.4 Definition:

1.4.1 Metal Web: A web truss member formed from sheet steel that has integral teeth on each end for making connections to wood members. It is designed to transmit axial tension and/or compression forces between the wood members.

1.4.2 Proportional Limit: The highest load on the load/deflection plot at which the load/deflection does not deviate from a straight line drawn parallel to and positioned directly on the straight portion of the load/deflection plot. In lieu of a visually determined proportional limit load, it is acceptable to approximate the proportional limit as an offset yield load. Linear interpolation between data points is permitted to establish the load/deflection plot between measured data points.

2.0 BASIC INFORMATION

2.1 General: The following information shall be submitted:

2.1.1 Product Description: Complete information concerning material specifications, thickness, size and the manufacturing process. Product materials shall comply with an appropriate recognized national standard(s).

2.1.2 Installation Instructions: Installation details and limitations, and fastening methods.

2.1.3 Packaging and Identification: A description of the method of packaging and field identification of the metal webs. Identification provisions shall include the evaluation report number.

2.1.4 Field Preparation: Metal web use is limited to prefabricated trusses. Compliance with IBC Section 2303.4 or IRC Sections R502.1.4 and R802.10, as applicable, is required.

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. In addition, test reports shall include the dimensions and details of the test specimens, the configuration and dimensions of the test fixture, the number of tests conducted, the rate of load used, the type of failure, and the ultimate load obtained for each test.

2.4 Product Sampling: Sampling of the metal webs and wood for tests under this criteria shall comply with Sections 3.2 and 3.4 of AC85. Sampling of solid metal coupons, from the steel coil used to manufacture the metal webs, tested in accordance with this acceptance criteria, shall be in accordance with Sections 5.2.2.1 and 5.2.3 of ANSI/TPI-1. Specifications for the wood used in testing shall be documented by the testing laboratory in the final test report.

3.0 TESTS, TEST METHODS AND PERFORMANCE REQUIREMENTS

3.1 General: All metal web components shall be installed in the test specimens in a manner consistent with their intended use. Tests shall be conducted on test specimens at a constant movable crosshead speed to attain ultimate load in not less than one minute. The required tests noted below shall be conducted for each individual size of metal web product.

3.2 Materials: Lumber used for the test specimens shall be from species groups and of a lumber size that is consistent with the intended use of the product.

3.2.1 Moisture Content and Specific Gravity: Moisture content and specific gravity shall be measured and reported for each specimen tested. Measurements shall be taken from the wood pieces where withdrawal of the metal webs occurred. Measurements of moisture content shall be in accordance with ASTM D 4442 or D 4444. Measurements for specific gravity shall be in accordance with ASTM D 2395. The moisture content at the time of the test shall be 11 percent or greater.

3.3 Testing Apparatus: A testing machine shall be used that is capable of applying compressive loads at a constant rate of crosshead movement, and which is calibrated in accordance with ASTM E 4. The testing apparatus shall be capable of carrying the test joints to failure.

3.4 Types of Tests: Tests shall be done using either: (a) trusses matching typical applications of the metal web except that the truss length, number of panels, and other characteristics shall be limited as needed to produce the desired failure mode; or (b) with joints or portions of trusses so limited, when possible, to permit direct loading of a metal web. The test configurations chosen for testing to establish metal web strength values must be consistent with the usage of the metal webs in truss design. For example, if two parallel webs (a double web) are used to transfer axial forces, tests must be performed to determine the design capacity of the webs used in this configuration. Similarly, metal webs that are manufactured in a V-shape and that are permitted to be cut, or otherwise separated, to form two single webs which have fewer teeth on the separated end than on the opposite end, shall be tested as individual webs, in a doubled configuration with another web, or in whatever other manners they are permitted to be used. The proponent shall provide test setup details, including the locations where it is intended to make deflection measurements, to ICC-ES prior to testing. (See Figures 2 through 5 for examples of some setups.) The following tests shall be conducted to determine the capacity of the metal webs based on specified design assumptions:

3.4.1 Compression Test: Unless the metal web is limited in application so as not to be subject to compression loads, five tests shall be conducted that produce failure of a metal web due to axial compression in the webs. This will typically be buckling of the metal web cross section, but it may be withdrawal of the connector teeth at the chord. Load/deflection curves shall be created by recording the load and movement of the testing machine. These curves will be used to determine the load at the proportional limit.

3.4.2 Tension Test: Five tests shall be conducted that produce failure of a metal web due to axial tension in the webs. This will typically be a withdrawal of connector teeth at the chord, but may be a steel tension section or shear failure. Load/deflection curves shall be created by recording the load and movement of the testing machine. These curves will be used to determine the load at the proportional limit.

3.4.3 Reinforcement to Obtain Desired Failure Modes: Reinforcement of members other than metal webs and their connections shall be permitted without restriction in trusses tested to address the above capacities of metal webs, provided the determination of axial force in the metal webs of those trusses remains accurate. Reinforcement of metal webs to avoid steel-based failure modes, such as by clamping or otherwise attaching reinforcing members, shall be permitted provided sufficient additional specimens without reinforcement are also tested to identify and address steel-based failure modes as otherwise required by this criteria. No clamps shall occur over the tooth portions of the meal web when conducting compression testing.

3.4.4 Bearing Conditions: The effect of truss bearing conditions on the capacity of metal webs at or adjacent to bearings shall be considered.

3.4.5 Full-Scale and Diversified Confirmation Testing: Testing of full scale trusses fabricated with metal webs shall be conducted in accordance with TPI 2-1995. A representative sampling of trusses shall be tested to verify design values. The test plan must be submitted to ICC-ES staff for approval prior to the testing.

4.0 DESIGN PROPERTIES AND OTHER CONSIDERATIONS

4.1 Design Criteria: Design details for wood products noted and metal connector plates noted in the NDS and ANSI/TPI 1are applicable to these products utilizing metal webs.

4.2 Duration of Load: Code-prescribed adjustments for duration of load associated with sawn lumber are applicable to the wood trusses and their connections. Duration of load adjustments shall not apply to metal web values that are determined using this acceptance criteria.

4.3 Damage to Metal Webs: The allowable capacity of damaged metal webs is beyond the scope of this acceptance criteria. Refer to Section 6.3.5.

4.4 Metal Web Calculations of Allowable Basic Design Loads: The method used to calculate forces applied to metal webs from measured loads applied to the test truss (if tests are done using a truss or other assembly where direct measurement of the force applied to the metal web is not possible) must be consistent with the method used to structurally determine design forces applied to metal webs in standard truss design. For example, if the structural analysis used to determine the axial forces on a web in a truss is based on an assumption of a chord continuous through all web joints, then the structural analysis used to determine the maximum axial force on a web in a tested truss from the ultimate load measured as being applied to the tested truss shall also be based on an assumption of a chord continuous through all web joints. Metal webs that include connections to adjacent metal webs other than through the truss chord, such as for webs manufactured as single pieces forming a V-shape, shall account for transfer through this connection when determining lateral resistance stresses on the plate area and resulting design loads limited as needed. Metal webs that are manufactured in a V-shape which is permitted to be cut, or otherwise separated, to form two single webs which have fewer teeth on the separated end than on the opposite end, shall be assigned design values for that separated condition, which shall also be permitted to be applied to webs in the unseparated condition.

4.4.1 Allowable Tension: P_T = The lesser of (4.4.1.1), (4.4.1.2), or (4.4.1.3) where:

4.4.1.1 $(P_{tp}\ R_U\ R_T) / (1.6/\phi)$

4.4.1.2 $(P_{tp}\ R_G\ R_y\ (R_T)^{0.7})/3.0$

4.4.1.3 The average load at the proportional limit (for definition, refer to Section 1.4.2) from the load/deflection curve, divided by 1.6.

4.4.2 Allowable Compression: P_c = The lesser of (4.4.2.1), (4.4.2.2), or (4.4.2.3) where

4.4.2.1 $(P_{cp}\, R_{YS}\, R_T)/(1.6/\phi)$

4.4.2.2 P_T

4.4.2.3 The average load at the proportional limit (for defintion, refer to Section 1.4.2) from the load/deflection curve, divided by 1.6.

4.4.3 Reinforced Metal Web Tests: If separate sets of tests are performed to quantify lateral resistance failure modes using reinforced metal webs to preclude steel failures as permitted in Section 3.4.3, equation 4.4.1.2 in Section 4.4.1 shall be evaluated using the results of such reinforced web tests, while equations 4.4.1.1 and 4.4.1.3 shall be evaluated using the results of unreinforced web tests.

4.4.4 Nomenclature for Section 4.4:

F_{tc} = Average ultimate tensile strength of the solid metal control specimens, psi.

F_u = Specified minimum steel ultimate tensile strength, psi.

F_y = Specified minimum steel yield strength, psi.

F_{yc} = Average yield strength of the solid metal control specimens, psi.

P_c = Allowable compression force, pounds.

P_{cp} = Average ultimate value of the compression tests, pounds.

P_T = Allowable tension force, pounds.

P_{tp} = Average ultimate value of the tension tests, pounds.

R_G = Adjustment factor for specific gravity calculated according to Section 5.2.9.3 of ANSI/TPI-1, unit less.

R_T = Adjustment factor for thickness, unit less = t_{spec}/t_{test}.

R_U = Adjustment factor for ultimate strength, unit less = $F_u/F_{tc} \leq 1$.

R_y = Adjustment factor for yield strength calculated according to Section 5.2.2.1 of ANSI/TPI-1, unit less.

R_{YS} = Adjustment factor for yield on steel, unit less = $F_y/F_{yc} \leq 1$.

t_{test} = Average steel thickness of solid metal control specimens, inch.

t_{spec} = Specified minimum steel thickness, inch.

V_p = Coefficient of variation of test results, but not less than 6.5%, unit less.

ϕ = Resistance Factor

ϕ = $1.672\, e^c$

c = $-2.5[0.057 + (C_P V_p^2)]^{0.5}$

Cp = $(1 + 1/n)m/(m-2)$

n = number of tests

m = n-1

5.0 QUALITY CONTROL

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

5.2 Third-party follow-up inspections are not required under this acceptance criteria.

6.0 EVALUATION REPORT RECOGNITION

6.1 The design values of metal webs used in parallel chord wood trusses shall not exceed those determined by this criteria under load combinations in accordance with the applicable code. No adjustments for duration of load are permitted.

6.2 Allowable tension and compression loads shall be indicated in the evaluation report.

6.3 The evaluation report shall include the following Conditions of Use:

6.3.1 Materials and general design considerations must be in accordance with Chapter 6 of ANSI/TPI 1.

6.3.2 Truss member design procedures must be in accordance with Chapter 7 of ANSI/TPI 1.

6.3.3 Metal connector plate joint design must be in accordance with Chapter 8 of ANSI/TPI 1.

6.3.4 Truss designs that contain metal webs must be prepared and sealed by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed.

6.3.5 Trusses with damaged metal webs must not be used. Damaged metal webs includes dents, bends, cracks, cuts or holes in the metal other than specified characteristics described in the product specifications as intended features of the metal web.

6.3.6 Design of diaphragms is beyond the scope of this evaluation report.

6.3.7 Metal web use is limited to prefabricated trusses. Compliance with IBC Section 2303.4 or IRC Sections R502.1.4 and R802.10, as applicable, is required. ■

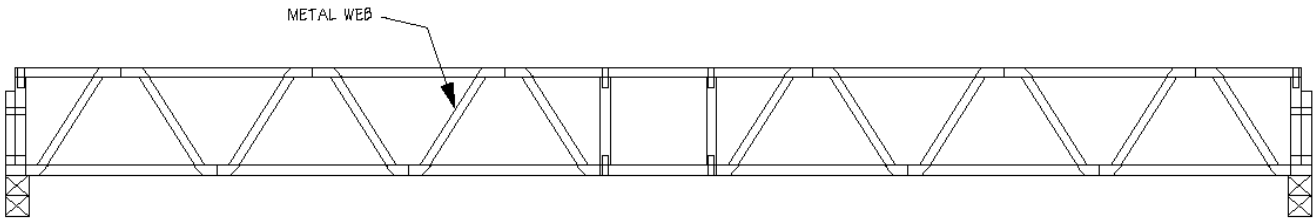

FIGURE 1—TYPICAL INSTALLATION

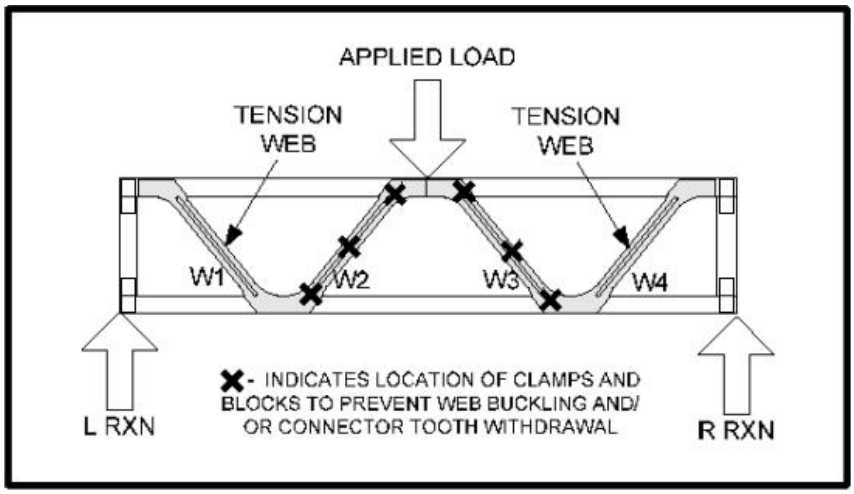

FIGURE 2—EXAMPLE OF TEST SETUP FOR TENSION CAPACITY OF METAL V-SHAPE WEB

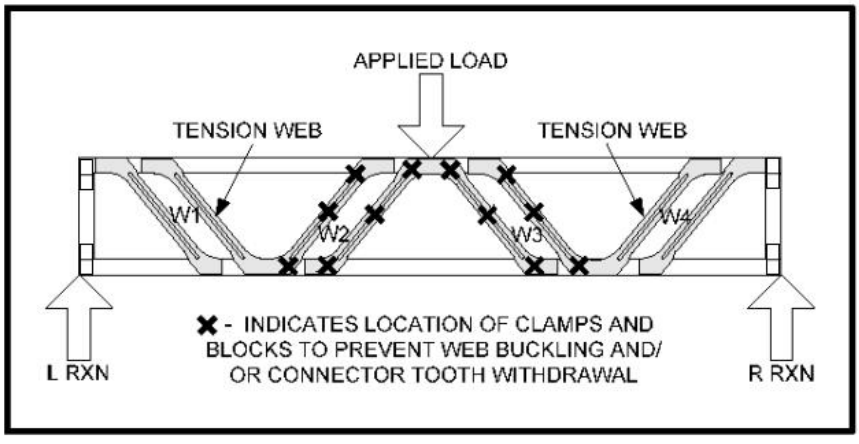

FIGURE 3—EXAMPLE OF TEST SETUP FOR TENSION CAPACITY OF METAL WEBS USED IN PAIRS (V-SHAPE + I-SHAPE)

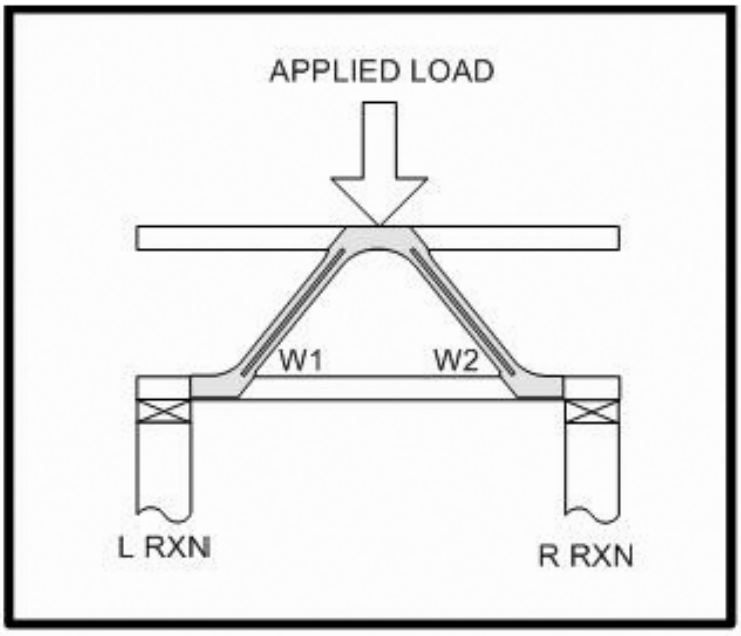

FIGURE 4—EXAMPLE OF TEST SETUP FOR COMPRESSION CAPACITY OF A METAL V-SHAPE WEB

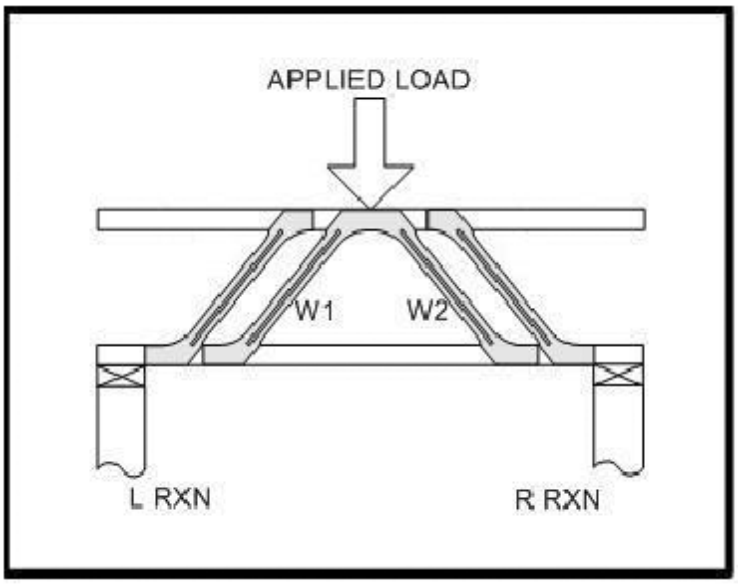

FIGURE 5—EXAMPLE OF TEST SETUP FOR COMPRESSION CAPACITY OF METAL WEBS USED IN PAIRS (V-SHAPE + I-SHAPE)