EStud Structural Insulated Wall Stud **TER No. 1409-01**

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DIVISION: 06 00 00 – WOOD, PLASTICS, AND COMPOSITES
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Section: 07 21 00 – Building Insulation
Section: 07 21 13 – Foam Board Insulation

1. Product Evaluated:

1.1. EStud Structural Insulated Wall Stud

1.2. For the most recent version of this Technical Evaluation Report (TER), visit drjengineering.org. For more detailed state professional engineering and code compliance legal requirements and references, visit drjengineering.org/statelaw. DrJ is fully compliant with all state professional engineering and code compliance laws.

1.3. This TER can be used to obtain product approval in any country that is an IAF MLA Signatory (all countries found here) and covered by an IAF MLA Evaluation per the Purpose of the MLA (as an example, see letter to ANSI from the Standards Council of Canada). Manufacturers can go to jurisdictions in the U.S., Canada and other IAF MLA Signatory Countries and have their products readily approved by authorities having jurisdiction using DrJ's ANSI accreditation.

1.4. Building code regulations require that evaluation reports are provided by an approved agency meeting specific requirements, such as those found in *IBC* Section 1703. Any agency accredited in accordance with ANSI ISO/IEC 17065 meets this requirement within ANSI's scope of accreditation. For a list of accredited agencies, visit ANSI's website. For more information, see drjcertification.org.

1.5. Requiring an evaluation report from a specific private company (i.e. ICC-ES, IAPMO, CCMC, DrJ, etc.) can be viewed as discriminatory and is a violation of international, federal, state, provincial and local anti-trust and free trade regulations.

1.6. DrJ's code compliance work:

1.6.1. Conforms to code language adopted into law by individual states and any relevant consensus based standard such as an ANSI or ASTM standard.

1.6.2. Complies with accepted engineering practice, all professional engineering laws and by providing an engineer's seal DrJ takes professional responsibility for its specified scope of work.

2. Applicable Codes and Standards:[1]

2.1. *2012*, *2015* and *2018 International Building Code* (*IBC*)

2.2. *2012*, *2015* and *2018 International Residential Code* (*IRC*)

2.3. *ANSI/TPI 1 – National Design Standard for Metal Plate Connected Wood Truss Construction*

2.4. *ASCE/SEI 7 – Minimum Design Loads for Buildings and Other Structures*

2.5. *ASTM A653 – Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process*

2.6. *ASTM C578 – Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation*

2.7. *ASTM D198 – Standard Test Methods of Static Tests of Lumber in Structural Sizes*

2.8. *ASTM E72 – Standard Test Methods of Conducting Strength Tests of Panels for Building Construction*

2.9. *NDS – National Design Specification for Wood Construction*

3. Performance Evaluation:

3.1. EStud was evaluated to determine its applicability for use as an alternative material where nominal 2x4 solid sawn lumber is specified in accordance with the *IBC* and *IRC*.

3.2. EStud testing and analysis was conducted to determine its compression, flexural strengths and flexural stiffness.

3.3. This TER examines EStud for:

3.3.1. Use as an alternative material to that described in *IBC* Chapter 23, in particular, compliance with requirements for the design and construction of wood-based products as described in Section 2301.2 for allowable stress design and load and resistance factor design.

3.3.2. Compliance with *IBC* Section 2308 and Section 2304, and *IRC* Chapter 6 for conventional light-frame construction applications.

3.3.3. Use as an alternative material and method of construction in compliance with *IBC* Section 104.11 and *IRC* Section R104.11.

3.3.3.1. When used in an application that exceeds the limits of *IRC* Section R301 or *IBC* Section 2308, an engineered design shall be submitted in accordance with *IRC* Section R301.1.3 and this TER.

3.4. Any code compliance issues not specifically addressed in this section are outside the scope of this TER.

4. Product Description and Materials:

4.1. EStuds are made from a minimum of No. 2 Spruce Pine Fir (SPF) lumber and 2" (50.8 mm) extruded polystyrene (XPS) insulation.

4.1.1. Any lumber species can be used, as long as the design values of the lumber are equal to or greater than No. 2 SPF.

[1] Unless otherwise noted, all references in this code compliant technical evaluation report (TER) are from the 2018 version of the codes and the standards referenced therein, including, but not limited to, *ASCE 7*, *SDPWS* and *WFCM*. This product also complies with the 2000-2015 versions of the *IBC* and *IRC* and the standards referenced therein. As required by law, where this TER is not approved, the building official shall respond in writing, stating the reasons this TER was not approved. For variations in state and local codes, if any see Section 8.

4.1.2. The lumber is ripped length-wise into 1.75"-wide (44.5 mm) members, and the XPS insulation is placed between sections of cut lumber.

4.1.3. After ripping, the lumber is re-graded to a minimum of #2 grade of the given species.

4.1.4. Lumber re-grading shall be performed by an American Lumber Standards Committee (ALSC) approved grading agency.

4.2. The XPS insulation is manufactured in accordance with *ASTM C578* prior to EStud manufacture and is adhered to each section of the stud with a heat-resistant adhesive.

4.3. The adhesive used in the manufacturing process is a proprietary adhesive formulated specifically for bonding XPS insulation to wood surfaces.

4.4. Illinois Tool Works Building Components Group (ITWBCG), aka Alpine, 5" x 5", 20 gauge (36 mil) metal connector plates or equivalent are used to tie the stud assembly together with the lumber acting as tension and compression chords. See Figure 1.

4.4.1. Three (3) metal connector plates are installed on each wide face of the assembly (total 6 plates); one plate is placed at each end, and one is located in the center of the EStud length.

4.4.2. The plates at the ends are located 1" (25.4 mm) from the end of the EStud.

4.4.3. Plates shall be ITW wave plates or equivalent.

4.4.4. For top and bottom plate material, 2' x 5" metal connector plates are located 1 inch from each end and 12 inches on center along the plate material length.

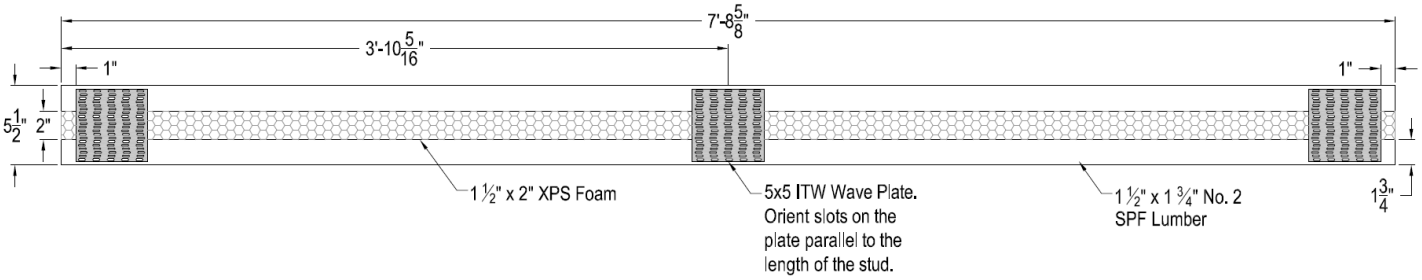

Figure 1: 8' EStud Construction Detail & Specifications

4.5. Materials

4.5.1. Lumber

4.5.1.1. Grade: No. 2 SPF

4.5.1.2. Thickness: $1^1/_2$" (38.1 mm)

4.5.1.3. Width: $1^3/_4$" (44.5 mm)

4.5.1.4. Lengths: 8', 9' and 10' (2.44 m, 2.74 m and 3.05 m) nominal

4.5.2. XPS Insulation

4.5.2.1. The XPS insulation is manufactured in accordance with *ASTM C578*.

4.5.3. Metal Connector Plates

4.5.3.1. Metal connector plates used in EStud are manufactured in accordance with *ANSI/TPI 1-2007 – National Design Standard for Metal Plate Connected Wood Truss Construction* Chapter 4.

4.5.3.2. Metal connector plates shall be made of 20 gauge (36 mil) *ASTM A653*, SS Grade 40 structural steel.

4.5.3.3. Metal connector plates shall have a minimum G60 galvanized coating (0.0005" thickness on each side).

Photo 1: Metal Connector Plate

Photo 2: EStud Cross Section

5. Applications:

5.1. Prescriptive Provisions

5.1.1. EStud is an alternative to solid sawn lumber for wall structural members.

5.1.1.1. EStud is an acceptable replacement to nominal 2x4 solid sawn lumber in accordance with *IRC* Section R602 and *IBC* Section 2308.

5.1.2. XPS insulation is in accordance with *IRC* Section R316, specifically Section R316.2, R316.3, and R316.4, and *IBC* Chapter 26, Section 2603.2, 2603.3, and 2603.4.

5.1.3. Metal connector plates used are per *ANSI/TPI 1-2007* Chapter 4, Section 4.3.3 and 4.3.4.

5.1.4. Cutting, notching and boring

5.1.4.1. Cross cutting EStuds is permitted. Where EStuds are cross cut such that a metal connector plate is not within 3" (76.2 mm) of the EStud end, one of the following shall be done:

5.1.4.1.1. The EStud chords must be nailed to another framing member.

5.1.4.1.2. A metal connector plate shall be field applied to connect the EStud chords, as shown in Figure 1.

5.1.4.2. Notches in structural members (chords or plates) are not permitted.

5.1.4.3. Holes may only be bored in the XPS insulation of EStud and shall not exceed 2" (50.8 mm) in diameter.

5.1.4.4. Holes shall not be bored in metal connector plates.

5.1.5. EStud used as structural members of a wall shall be fastened as specified in Table 1.

Application	Number & Type of Fastener	Fastener Spacing
Ceiling Joists to Plate (toe nail)	4 (2½" × 0.113")	2 toe nails into each chord
Rafter or Roof Truss to Plate (toe nail)	4 (3" × 0.128")	2 toe nails into each chord[1]
Built-up Studs (face nail)	(3" × 0.128")	1 nail into each chord at 16" o.c.
Abutting Studs at Intersecting Wall Corners (face nail)	(3¼" × 0.131")	1 nail into each chord at 12" o.c.
Double Studs (face nail)	(3" × 0.128")	1 nail into each chord at 16" o.c.
Double Top Plates (face nail)	(3" × 0.128")	1 nail into each chord at 12" o.c.
Double Top Plates, Minimum 24" Offset of End Joints, Face Nail in Lapped Area	18 (3" × 0.128")	9 nails into each chord
Stud to Plate (toe nail)	4 (2½" × 0.113")	2 toe nails into each chord
Top or Sole Plate to Stud (end nail)	2 (3½" × 0.162") or 4 (3" × 0.128")	1 nails into each chord or 2 nails into each chord
Top Plates, Laps at Corners & Intersections (face nail)	4 (3" × 0.128")	2 nails into each chord

For SI: 1" = 25.4 mm

1. Where a rafter is fastened to an adjacent parallel ceiling joist in accordance with this schedule, provide two (2) toe nails on one (1) side of the rafter and toe nails from the ceiling joist to top plate in accordance with this schedule. The toe nail on the opposite side of the rafter shall not be required.
2. For all connections, care must be taken to avoid splitting of EStud chords.

Table 1: Acceptable Uses of 2x4 EStud

5.1.6. EStud may be used as a top plate in accordance with *IRC* Section R602.3.2 and the following:

5.1.6.1. Top plate design shall include 2" x 5" metal plates spaced every 12 inches (305 mm) o.c., starting no more than 12 inches (305 mm) from each end of the board to allow the top plates to be cut to custom lengths in the field, while maintaining a metal plate within 12 inches (305 mm) of each end.

5.1.6.2. Fasteners for EStud connections shall be evenly distributed in each EStud chord. (e.g., top plate to stud connections shall have one fastener installed in each EStud chord).

5.1.6.3. Double top plates must be used on all walls.

5.1.7. Use as jack, trimmer and cripple studs is acceptable, provided at least two (2) metal connector plates are attached on each side of the stud, no less than 1" (25.4 mm) from the ends.

5.1.7.1. If cut in the field to accommodate sizing, EStud must be fastened to a double stud through its face with, at a minimum, 10d (3" x 0.128") nails 16" (610 mm) o.c. into each chord.

5.1.7.2. When used as a jack stud, EStud must be fastened to a king stud.

5.1.7.3. When used as a cripple stud, one (1) nail must be driven through the window sill plate into each end of the EStud structural members.

5.1.8. Structural sheathing shall be installed on one side of the wall and minimum ½" (12.7 mm) gypsum wallboard (GWB), or equivalent, on the other side of the wall fastened in accordance with the applicable building code. Sheathing attached to only one side of the wall is not permitted.

5.1.9. Trusses and rafters having a maximum reaction of 2,789 lbs. may be placed anywhere on walls with double EStud top plates.

5.1.9.1. For cases where a higher reaction needs to be supported, use of built-up studs fastened in accordance with Table 1 is permitted with a limit of 2,789 lbs. per ply (e.g., 5,578 lbs. per 2-ply built-up stud). In this case, the built-up stud shall be located directly under the applied load.

5.1.9.2. Walls with nominal 2x6 lumber top plates shall be in accordance with *IRC* Section R602.3.2.

5.2. Engineered Design

5.2.1. The design provisions for wood construction noted in *IBC* Section 2301.2 and *IRC* Section R301.1.3 apply to EStud for allowable stress design (ASD), unless otherwise noted in this TER.

5.2.2. Material Properties

5.2.2.1. Reference design values for EStud are specified in Table 2.

Reference Design Values	
F_b	875 psi
F_c	1,150 psi
F_t	450 psi
$F_{c\perp}$	425 psi
EI	8,400,000 lb.-in.^{2}
EI_{min}	3,100,000 lb.-in.^{2}
For SI: 1 psi = 0.00689 MPa	

Table 2: EStud Reference Design Values

5.2.2.2. Reference design values for EStud shall be multiplied by the applicable adjustment factors specified in *NDS* Section 4.3.

5.2.3. Design for Axial Loads

5.2.3.1. The maximum allowable compression load for EStud is specified in Table 3.

5.2.3.2. The maximum allowable compression load is based on perpendicular-to-grain crushing of SPF top and bottom plates.

5.2.3.3. The allowable axial compression for EStud can be calculated using the provisions of *NDS* Section 3.6 and 3.7.

5.2.3.4. For computing the column stability factor, the critical bucking design value, F_{cE}, shall be computed using the formula:

$$F_{cE} = \frac{\pi^2 E I_{min}}{A(\ell_e)^2}$$

Where: A = total cross-sectional area of EStud (wood only) = 2 x 1.5" x 1.75" = 5.25 in.^{2}
(for SI: 2 x 38.1 mm x 44.5 mm = 3391 mm^2)

Maximum Allowable Compression	
EStud Length	**Load (lbs.)**
≤ 10'	2789
For SI: 1 lb. = 4.448 newtons, 1" = 25.4 mm	

Table 3: EStud Maximum Allowable Compression

5.2.4. Design for Bending

5.2.4.1. EStud resists bending using tension and compression stresses in the chord members and bending in the chord member on the side of the EStud to which the loads are applied.

5.2.4.2. The axial stresses in each member can be computed using the following equation:

$$f_a = \frac{M}{0.5 \cdot A \cdot d_{eff}}$$

Where: M = bending moment applied to EStud (in lbs.-in.)

A = cross-sectional area of EStud chord = 1.5" x 1.75" = 2.625 in.^{2}
(for SI: 38.1 mm x 44.5 mm = 1695 mm^2)

d_{eff} = distance from center-to-center of EStud members = 3.75" (95.3 mm)

5.2.4.3. The bending stress in the member on the side of the EStud to which the loads are applied shall be calculated using *NDS* Section 3.3 as follows:

$$f_b = \frac{6M}{bd^2}$$

Where:

M = moment due to bending of the EStud member between metal connector plates = $\frac{\omega \ell^2}{12}$

ℓ = center-to-center spacing of metal connector plates

b = width of EStud members = 1.5" (38.1 mm)

d = depth of EStud members = 1.75" (44.5 mm)

5.2.4.4. The combined axial and bending stresses in EStud members shall be checked in accordance with *NDS* Section 3.9.

5.2.5. Design for Combined Bending and Axial Loads

5.2.5.1. Stresses due to axial loading of EStud shall be added to the axial stress due to bending and checked in accordance with *NDS* Section 3.9.

5.2.5.2. Allowable axial load values for EStud subject to ASD wind pressures are specified in Table 4.

5.2.5.3. Example design calculations for EStud subject to combined bending and axial loads can be found in Appendix A.

Allowable Axial Load (lbs.) (deflection)									
Stud Spacing (in.)	Wall Height (ft.)	ASD Wind Pressure (psf)							
		5	10	15	20	25	30	35	40
12	8	2789 (L/1948)	2555 (L/974)	2263 (L/649)	1985 (L/487)	1718 (L/390)	1457 (L/325)	1202 (L/278)	951 (L/244)
	9	2160 (L/1352)	1798 (L/676)	1464 (L/451)	1144 (L/338)	833 (L/270)	529 (L/225)	229 (L/193)	--
	10	1622 (L/976)	1214 (L/488)	832 (L/325)	463 (L/244)	102 (L/195)	--	--	--
16	8	2764 (L/1461)	2358 (L/731)	1985 (L/487)	1630 (L/365)	1287 (L/292)	951 (L/244)	621 (L/209)	295 (L/183)
	9	2035 (L/1014)	1574 (L/507)	1144 (L/338)	731 (L/253)	328 (L/203)	–	–	–
	10	1482 (L/732)	958 (L/366)	463 (L/244)	–	–	–	–	–
24	8	2484 (L/974)	1878 (L/487)	1321 (L/325)	787 (L/244)	268 (L/195)	–	–	–
	9	1732 (L/676)	1044 (L/338)	400 (L/225)	–	–	–	–	–
	10	1152 (L/488)	369 (L/244)	–	–	–	–	–	–
For SI: 1 psi = 0.00689 MPa, 1" = 25.4 mm									

Table 4: Allowable Axial Loads

5.3. For applications outside of the scope of the applicable code, consult the manufacturer's installation instructions or a registered design professional (RDP).

5.4. Where the application exceeds the limitations set forth herein, design shall be permitted in accordance with accepted engineering procedures, experience and good technical judgment.

6. Installation:

6.1. EStud shall be installed in accordance with the applicable code, the approved construction documents, this TER, the manufacturer's installation instructions, *NDS* and otherwise standard framing practices as applied to solid-sawn lumber.

6.1.1. In the event of conflict between the manufacturer's installation instructions and this TER, the more restrictive shall govern.

6.2. Installation Procedure

6.2.1. EStud is pre-assembled and designed to be used as a direct replacement of nominal 2x4 (38 mm x 89 mm) solid sawn lumber as wall studs and top plates.

6.2.2. Install EStud in the same manner as solid sawn lumber, except as noted herein.

6.2.2.1. For the *IRC* and *IBC* Section 2308, install in accordance with the provisions therein, except as noted in this TER.

6.2.2.2. For engineered design, walls shall be designed in accordance with the *IBC* and the referenced standards therein using the material properties and design limitations as noted in Section 5.

6.2.2.3. Design of connections using EStud shall be in accordance with *NDS*.

7. Test and Engineering Substantiating Data:

7.1. *Flexural Capacity of the EStud*; Richard DeVries, Ph.D., P.E.; Milwaukee School of Engineering.

7.2. *ESR-1118* – ICC-ES Evaluation Report for ITW Building Components Group Wave metal connector plates.

7.3. Cyclic Tests of WSP Shear Walls with EStud Framing, by SBC Research Institute under contract with Qualtim, Inc.

7.4. Compressive Load Testing of EStuds, by SBC Research Institute under contract with Qualtim, Inc.

7.5. Bending Tests of EStuds, by SBC Research Institute under contract with Qualtim, Inc.

7.6. Bending Tests of EStud Top Plates, by SBC Research Institute under contract with Qualtim, Inc.

7.7. The product(s) evaluated by this TER fall within the scope of one or more of the model, state or local building codes for building construction. The testing and/or substantiating data used in this TER is limited to buildings, structures, building elements, construction materials and civil engineering related specifically to buildings.

7.8. The provisions of model, state or local building codes for building construction do not intend to prevent the installation of any material or to prohibit any design or method of construction. Alternatives shall use consensus standards, performance-based design methods or other engineering mechanics based means of compliance. This TER assesses compliance with defined standards, accepted engineering analysis, performance-based design methods, etc. in the context of the pertinent building code requirements.

7.9. Some information contained herein is the result of testing and/or data analysis by other sources, which DrJ relies on to be accurate, as it undertakes its engineering analysis.

7.10. DrJ has reviewed and found the data provided by other professional sources are credible. The information in this TER conforms with DrJ's procedure for acceptance of data from approved sources.

7.11. DrJ's responsibility for data provided by approved sources conforms with *IBC* Section 1703 and any relevant professional engineering law.

7.12. Where appropriate, DrJ relies on the derivation of design values, which have been codified into law through codes and standards (e.g., *IRC*, *WFCM*, *IBC*, *SDPWS, NDS, ACI, AISI, PS-20, PS-2*, etc.). This includes review of code provisions and any related test data that aids in comparative analysis or provides support for equivalency to an intended end-use application. Where the accuracy of design values provided herein is reliant upon the published properties of commodity materials (e.g. lumber, steel, concrete, etc), DrJ relies upon

grade/properties provided by the raw material supplier to be accurate and conforming to the mechanical properties defined in the relevant material standard.

8. Findings:

8.1. EStud insulated wall studs installed as framing members in walls, as described in this TER, are compliant with the codes listed in Section 2 and are approved for use as an alternative to nominal 2x4 (38 mm x 89 mm) solid sawn lumber.

8.2. *IBC* Section 104.11 (*IRC* Section R104.11 and *IFC* Section 104.9 are similar) state:

> **104.11 Alternative materials, design and methods of construction and equipment.** The provisions of this code are not intended to prevent the installation of any material 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, not less than the equivalent of that prescribed in this code. … Where the alternative material, design or method of construction is not *approved*, the *building official* shall respond in writing, stating the reasons the alternative was not *approved*.

8.3. This product has been evaluated with the codes listed in Section 2, and is compliant with all known state and local building codes. Where there are known variations in state or local codes that are applicable to this evaluation, they are listed here:

8.3.1. No known variations

8.4. This TER uses professional engineering law, the building code, ANSI/ASTM consensus standards and generally accepted engineering practice as its criteria for all testing and engineering analysis. DrJ's professional engineering work falls under the jurisdiction of each state Board of Professional Engineers, when signed and sealed.

9. Conditions of Use:

9.1. Where required by the authority having jurisdiction (AHJ) in which the project is to be constructed, this TER and the installation instructions shall be submitted at the time of permit application.

9.2. Any generally accepted engineering calculations needed to show compliance with this TER shall be submitted to the code official for review and approval.

9.3. Design loads shall be determined in accordance with the building code adopted by the jurisdiction in which the project is to be constructed.

9.4. EStud shall be installed in accordance with the applicable code, the approved construction documents, this TER and the manufacturer's installation instructions. If there is a conflict between this TER and the manufacturer's instructions, the more restrictive shall govern.

9.5. The manufacturer's published installation instructions shall be available at the jobsite at all times during installation.

9.6. EStud complies with, or is a suitable alternative to, 2x4 sawn lumber as permitted by the codes listed in Section 2, subject to the following conditions:

9.6.1. Metal connector plates must not be removed.

9.6.1.1. If metal connector plates are missing upon arrival, are not applied correctly from the distributor, or fall off during installation, the stud shall be replaced.

9.6.2. EStud may not be used as a bottom plate where fixture to a sill plate and anchor bolts is required.

9.6.3. EStud may not be used as a stud pack where hold-downs are required for engineered design.

9.6.4. The maximum wall height for EStud is 10' (3.05 m).

9.6.5. Increases for duration of load shall be in accordance with the limitations of the applicable building code for sawn lumber.

9.6.6. Creep factors applicable to sawn lumber may be applied to this product, in accordance with the applicable building code.

9.7. Design

9.7.1. Building Designer Responsibility

9.7.1.1. Unless the AHJ allows otherwise, the Construction Documents shall be prepared by a Building Designer for the Building and shall be in accordance with *IRC* Section R106 and *IBC* Section 107.

9.7.1.2. The Construction Documents shall be accurate and reliable and shall provide the location, direction and magnitude of all applied loads and shall be in accordance with *IRC* Section R301 and *IBC* Section 1603.

9.7.2. Construction Documents

9.7.2.1. Construction Documents shall be submitted to the Building Official for approval and shall contain the plans, specifications and details needed for the Building Official to approve such documents.

9.8. Responsibilities

9.8.1. The information contained herein is a product, material, detail, design and/or application TER evaluated in accordance with the referenced building codes, testing and/or analysis through the use of accepted engineering practice, experience and technical judgment.

9.8.2. DrJ TERs provide an assessment of only those attributes specifically addressed in the Products Evaluated or Code Compliance Process Evaluated sections.

9.8.3. The engineering evaluation was performed on the dates provided in this TER, within DrJ's professional scope of work.

9.8.4. This product is manufactured under a third-party quality control program in accordance with *IRC* Section R104.4 and R109.2 and *IBC* Section 104.4 and 110.4.

9.8.5. The actual design, suitability and use of this TER, for any particular building, is the responsibility of the Owner or the Owner's authorized agent, and the TER shall be reviewed for code compliance by the Building Official.

9.8.6. The use of this TER is dependent on the manufacturer's in-plant QC, the ISO/IEC 17020 third-party quality assurance program and procedures, proper installation per the manufacturer's instructions, the Building Official's inspection and any other code requirements that may apply to demonstrate and verify compliance with the applicable building code.

10. Identification:

10.1. EStud, described in this TER, is identified by a label on the product or packaging material bearing the manufacturer's name, product name, TER number, and other information to confirm code compliance.

10.2. Additional technical information can be obtained by contacting lbwilkens@hotmail.com.

11. Review Schedule:

11.1. This TER is subject to periodic review and revision. For the most recent version of this TER, visit drjengineering.org.

11.2. For information on the current status of this TER, contact DrJ Engineering.

Appendix A:

EStud Example Calculations

Material Properties of EStud:

The EStud uses SPF lumber graded as No.2.

$F_c := 1150\ psi$ $F_b := 875\ psi$ $F_t := 450\ psi$

$C_{fc} := 1.15$ $C_{fb} := 1.5$ $C_{ft} := 1.5$

$F_{c\_perp} := 425\ psi$

$EI := 8400000\ lbf \cdot in^2$

$EI_{min} := 3100000\ lbf \cdot in^2$

Section Properties of EStud:

$d_1 := 1.75\ in$ Wide face dimension.

$d_2 := 1.5\ in$ Narrow face dimension.

$d_{eff} := 3.75\ in$ Moment arm between members.

$A := d_1 \cdot d_2 \cdot 2 = 5.25\ in^2$ Area of EStud.

$l_1 := 92.625\ in$ Height of EStud.

$l_3 := \frac{l_1 - 7\ in}{2} = 42.813\ in$ On center spacing of truss plates.

Calculate allowable stresses for the EStud:

$C_D := 1.6$

$C_r := 1.5$ Repetitive member factor for studs is 1.5 per SDPWS Section 3.1.1 for studs spaced 16" o.c. or less. For stud spacing greater than 16" o.c., the repetitive member factor is 1.15 per the NDS.

$C_b := \frac{d_2 + 0.375\ in}{d_2} = 1.25$

$F_t' := F_t \cdot C_D \cdot C_{ft} = 1080\ psi$

$F_b' := F_b \cdot C_D \cdot C_{fb} \cdot C_r = 3150\ psi$

$F_{c\_star} := F_c \cdot C_{fc} \cdot C_D = 2116\ psi$

$c := 0.8$ Constant for sawn lumber.

$K := 1.0$ Buckling effective length factor for pinned-pinned column.

$F_{cE} := \frac{\pi^2 \, EI_{min}}{A \, (K \cdot l_1)^2} = 679 \; psi$ The equation for the Euler buckling stress given in NDS Section 3.7.1 is rearranged to show the term EI.

$$C_p := \frac{1 + \left(\frac{F_{cE}}{F_{c.star}}\right)}{2 \cdot c} - \sqrt{\left(\frac{1 + \left(\frac{F_{cE}}{F_{c.star}}\right)}{2 \cdot c}\right)^2 - \frac{\left(\frac{F_{cE}}{F_{c.star}}\right)}{c}} = 0.296$$

$F_c' := F_{c.star} \cdot C_p = 627 \; psi$

Combined Axial and Wind Loads on EStud:

$p := 30 \; psf$ Wind pressures on wall. For combined axial and bending checks, MWFRS wind loads may be used. For checking bending stresses independent of axial stresses, C&C wind loads shall be used.

$Spacing_{studs} := 16 \; in$

$S := \frac{d_2 \cdot d_1^2}{6} = 0.766 \; in^3$

$w := 0.75 \; p \cdot Spacing_{studs} = 30 \; plf$ A 0.75 factor is applied to the wind load in accordance with load combination 6a in Section 2.4.1 of ASCE 7-10.

$M_{mem} := \frac{w \cdot l_3^2}{12} = 382 \; lbf \cdot in$ For bending of the individual members of the EStud, the equation for a beam fixed at each end is used.

$f_b := \frac{M_{mem}}{S} = 499 \; psi$

$M_{stud} := \frac{w \cdot l_1^2}{8} = 2681 \; lbf \cdot in$ For bending of the entire EStud, the equation for a beam pinned at each end is used.

$f_{a\_bend} := \frac{M_{stud}}{\left(\frac{A}{2}\right) \cdot d_{eff}} = 272 \; psi$ Calculate the axial stress in each member of the EStud due to bending as the moment divided by the distance between members and the area of the member.

$P := 951 \; lbf$ Axial load on the Estud is selected to result in a CSI of 1.0.

$P_{c\_perp} := F_{c\_perp} \cdot C_b \cdot A = 2789\ lbf$ > $P = 951\ lbf$

$f_{a\_comp} := \frac{P}{A} = 181\ psi$

For positive wind pressures:

$f_c := f_{a\_bend} + f_{a\_comp} = 454\ psi$ < $F_{cE} = 679\ psi$ and < $F_c' = 627\ psi$ **OK**

$\left(\frac{f_c}{F_c'}\right)^2 + \frac{f_b}{F_b' \cdot \left(1 - \frac{f_c}{F_{cE}}\right)} = 1.00$ **OK**

$f_{c\_in} := f_{a\_comp} - f_{a\_bend} = -91\ psi$ < $F_t' = 1080\ psi$ **OK**

For negative wind pressures:

$f_t := f_{a\_comp} - f_{a\_bend} = -91\ psi$ < $F_t' = 1080\ psi$ **OK**

$\frac{f_t}{F_t'} + \frac{f_b}{F_b'} = 0.07$ < 1.00 **OK**

$f_c := f_{a\_comp} + f_{a\_bend} = 454\ psi$ < $F_{cE} = 679\ psi$ and < $F_c' = 627\ psi$ **OK**

Check Deflection Limit for EStud:

$\Delta := \frac{5 \cdot \left(\frac{w}{0.75}\right) \cdot l_1^4}{384 \cdot EI} = 0.38\ in$

Note that the wind load may be taken as 0.7 times the C&C load for the purpose of determining the stud deflection per IRC Table R301.7 and IBC Table 1604.3.

$\frac{l_1}{\Delta} = 244$ > 240 **OK** (for gypsum board wall finish)

Summary of Design Calculations for EStud:

The EStud has an axial load capacity of 951 lbs for an 8' tall wall with a wind pressure of 30 psf.