Technical Evaluation Report
TER 1603-06
Tstud™

Roosevelt Energy, LLC

Product:
Tstud™ Structural Insulated Wall Stud

Issue Date:
July 21, 2017

Revision Date:
March 2, 2020

Subject to Renewal:
October 1, 2020
COMPANY INFORMATION:

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ADDITIONAL LISTEES:

DIVISION: 06 00 00 - WOOD, PLASTICS AND COMPOSITES
SECTION: 06 10 00 - Rough Carpentry

DIVISION: 07 00 00 - THERMAL AND MOISTURE PROTECTION
SECTION: 07 21 00 - Thermal Insulation
SECTION: 07 21 13 - Foam Board Insulation

1 PRODUCT EVALUATED

1.1 Tstud™ Structural Insulated Wall Stud

2 APPLICABLE CODES AND STANDARDS

2.1 Codes
2.1.1 IBC—12, 15, 18: International Building Code®
2.1.2 IRC—12, 15, 18: International Residential Code®

2.2 Standards and Referenced Documents
2.2.1 ANSI/AWC NDS: National Design Specification (NDS) for Wood Construction
2.2.2 ASCE/SEI 7: Minimum Design Loads and Associated Criteria for Buildings and Other Structures
2.2.3 ASTM D198: Standard Test Methods of Static Tests of Lumber in Structural Sizes
2.2.4 ASTM D2559: Standard Specification for Adhesives for Bonded Structural Wood Products for Use Under Exterior Exposure Conditions

1 Building codes require data from valid research reports be obtained from approved sources. An approved agency, which is an approved source, is defined as “an established and recognized agency that is regularly engaged in... furnishing product certification where such agency has been approved.” Being approved, defined as “acceptable to the building official,” is accomplished via accreditation using ISO/IEC 17065 evaluation procedures meeting code requirements of independence, adequate equipment, and experienced personnel. DrJ is an ISO/IEC 17065 ANSI-Accredited Product Certification Body – Accreditation #1131.

Through ANSI accreditation, DrJ certification can be used to obtain product approval in any country that is an IAF MLA Signatory and covered by an IAF MLA Evaluation per the Purpose of the MLA – “certified once, accepted everywhere.” Manufacturers can go to jurisdictions in any IAF MLA Signatory Country and have their products readily approved by authorities having jurisdiction using DrJ’s ANSI accreditation.

For more information on any of these topics or our mission, product evaluation policies, product approval process, and engineering law, see drjcertification.org.

2 Unless otherwise noted, all references in this TER are from the 2018 version of the codes and the standards referenced therein (e.g., ASCE 7, NDS, ASTM). This material, design, or method of construction also complies with the 2000-2015 versions of the referenced codes and the standards referenced therein. As required by code, where this TER is not approved, the building official shall respond in writing stating the reasons this TER was not approved. For any variations in state and local codes, see Section 8.

3 All terms defined in the applicable building codes are italicized.
3 PERFORMANCE EVALUATION

3.1 Tstud™ was evaluated to determine its applicability for use as an alternative material where nominal 2x4 and 2x6 solid sawn lumber is specified in accordance with the IBC and IRC including use as wall studs, top and bottom wall plates and headers.

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

3.3 This TER examines Tstud™ 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.

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.

3.5 Any engineering evaluation conducted for this TER was performed on the dates provided in this TER and within DrJ’s professional scope of work.

4 PRODUCT DESCRIPTION AND MATERIALS

4.1 The product evaluated in this TER is shown in Figure 1.

FIGURE 1. TSTUD™

4.2 Tstud™ is made from a minimum of 2x3 No. 2 Spruce Pine Fir (SPF) lumber, wooden dowels and approximately 2½” of polyisocyanurate (polyiso) insulation.

4.2.1 Overall size of Tstud™ is 2½” x 5½”.

4.2.2 Any lumber species can be used, as long as the design values of the lumber are equal to or greater than No. 2 SPF.
4.2.3 The lumber is placed in a form that leaves a gap of approximately 2½" between members. Wooden dowels are installed through one member into the other at opposing angles, forming a web-like pattern. Dowels are spaced evenly at a distance not to exceed 6½" on center and glued in place using an adhesive that conforms to the specifications of *ASTM D2559*.

4.2.4 Once the lumber has been fastened together, liquid polyiso is poured into the void between members and given time to harden.

4.3 Materials

4.3.1 Lumber:
- 4.3.1.1 Grade: No. 2 SPF or 1650f – 1.5E SPF
- 4.3.1.2 Thickness: 1½" (38.1 mm)
- 4.3.1.3 Width: 2½" (63.5 mm)
- 4.3.1.4 Length: up to 16' (4.9 m)

4.3.2 Dowels:
- 4.3.2.1 Grade: No. 2 SPF or 1650f – 1.5E SPF
- 4.3.2.2 Diameter: 11/16" (17.5 mm)

4.3.3 Polyiso:
- 4.3.3.1 The polyiso is manufactured with a minimum density of 2.2 pounds per cubic foot.

5 APPLICATIONS

5.1 Prescriptive Provisions

5.1.1 Tstud™ is an alternative to solid sawn 2x4 lumber in all cases and 2x6 lumber in most cases for wall structural members.

5.1.1.1 For use as a 2x6, design shall be permitted in accordance with accepted engineering procedures, experience and technical judgment. In these cases, referenced design values as specified in Table 2 shall be used in accordance with *IRC Section R602* and *IBC Section 2308*.

5.1.1.2 Polyiso 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.

5.1.1.3 Cutting, notching and boring:
- 5.1.1.3.1 Notches in structural members (2x3 or dowels) are not permitted.
- 5.1.1.3.2 Holes may only be bored in polyiso insulation of Tstud™. Holes shall be spaced a minimum of 24" o.c., shall not exceed 2½" (50.8 mm) in diameter and are not permitted within 24" from either end of the stud.

5.1.2 Tstud™ used as structural members of a wall shall be fastened as specified in Table 1.
<table>
<thead>
<tr>
<th>Application</th>
<th>Number &amp; Type of Fastener</th>
<th>Fastener Spacing</th>
<th>Installation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling Joists to Plate (toe nail)</td>
<td>3 (4&quot; x 0.131&quot;)</td>
<td>-</td>
<td>Fasten two (2) toe nails into interior wood member and one (1) toe nail into exterior wood member</td>
</tr>
<tr>
<td>Rim Joist to sill or top plate</td>
<td>(2½ x 0.113)</td>
<td>4&quot; o.c.</td>
<td>Fasten by toe-nailing</td>
</tr>
<tr>
<td>Rafter or Roof Truss to Plate (toe nail)</td>
<td>3 (3½ x 0.135&quot;)</td>
<td>-</td>
<td>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.</td>
</tr>
<tr>
<td>Rafter or Roof Truss to Plate (toe nail)</td>
<td>4 (4&quot; x 0.131&quot;)</td>
<td>-</td>
<td>Fasten two (2) toe nails into interior wood member and two (2) toe nails into exterior wood member</td>
</tr>
<tr>
<td>Built-up Studs (face nail)</td>
<td>(4&quot; x 0.131&quot;)</td>
<td>16&quot; o.c.</td>
<td>Fasten two (2) face nails, one (1) into each wood member</td>
</tr>
<tr>
<td>Abutting Studs at Intersection Wall Corner (face nail)</td>
<td>(4&quot; x 0.131&quot;)</td>
<td>12&quot; o.c.</td>
<td>Fasten one (1) face nail into exterior-facing wood member</td>
</tr>
<tr>
<td>Double 2x6 Top Plates (face nail)</td>
<td>(4&quot; x 0.131&quot;)</td>
<td>12&quot; o.c.</td>
<td>Fasten two (2) face nails, one (1) into each wood member</td>
</tr>
<tr>
<td>Double Top Plates, Minimum 24'' Offset of End Joints, Face Nail in Lapped Area</td>
<td>12 (4&quot; x 0.131&quot;)</td>
<td>-</td>
<td>Fasten twelve (12) face nails on each side of end joint (minimum 24” lap splice length each side of joint)</td>
</tr>
<tr>
<td>Stud to Plate (toe nail)</td>
<td>4 (4&quot; x 0.131&quot;)</td>
<td>-</td>
<td>Fasten two (2) toe nails into sole plate on each side of the stud (each wood member)</td>
</tr>
<tr>
<td>Plate to Stud (end nail)</td>
<td>3 (4&quot; x 0.131&quot;)</td>
<td>-</td>
<td>Fasten two (2) 4&quot; x 0.135” nails into one wood member and one (1) 4&quot; x 0.135” nail into other wood member</td>
</tr>
<tr>
<td>Top Plates, Laps at Corners &amp; Intersections (face nail)</td>
<td>2 (4½&quot; x 0.162&quot;)</td>
<td>-</td>
<td>Fasten two (2) 4½&quot; x 0.162” nails, one (1) into each wood member</td>
</tr>
<tr>
<td>Top Plates, Laps at Corners &amp; Intersections (face nail)</td>
<td>2 (4&quot; x 0.131&quot;)</td>
<td>-</td>
<td>Fasten two (2) 4&quot; x 0.135” face nails, one into each wood member</td>
</tr>
</tbody>
</table>

SI: 1 in = 25.4 mm
1. For all connections, care must be taken to avoid splitting.

5.1.3 Tstud™ may be used as a single top plate in accordance with IRC Section R602.3.2 and the following:

5.1.3.1 Fasteners for Tstud™ connections shall be distributed in each Tstud™ wood member (top plate to stud connections shall be fastened using three (3) 4" x 0.131" nails, one (1) into one wood member and two (2) into the other wood member).
5.1.4 Tstud™ may be used as a flat header.

5.1.4.1 Fasten multi-ply Tstud™ header members using 4" x 0.131" nails. Drive one nail into each Tstud™ wood member at 16" o.c (16" o.c. along each side of the Tstud™).

5.1.5 Use as jack, trimmer and cripple studs is permitted.

5.1.5.1 Install cripple studs between the bottom plate and rough sill using three (3) 4" x 0.131" nails, one into one wood member and 2 into the other wood member.

5.1.6 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.

5.1.7 Trusses and rafters having a maximum reaction of 3,665 lbs. may be placed anywhere on walls with single Tstud™ top plates and a maximum stud spacing of 24 inches on center.

5.1.7.1 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 3,665 lbs. per ply (e.g., 7,330 lbs. per 2-ply, built up stud). In this case, the built-up stud shall be located directly under the applied load.

5.1.7.2 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 2302.14 and IRC Section R301.1.3 apply to Tstud™ for allowable stress design (ASD), unless otherwise noted in this TER.

5.2.2 Material Properties:

5.2.2.1 Reference design values for Tstud™ are specified in Table 2.

<table>
<thead>
<tr>
<th>Lumber Grade</th>
<th>1650f – 1.5E SPF</th>
<th>No. 2 SPF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bending, FbS</td>
<td>889 lb-ft</td>
<td>889 lb-ft</td>
</tr>
<tr>
<td>Compression Parallel to Grain, Fc</td>
<td>1,700 psi</td>
<td>1,150 psi</td>
</tr>
<tr>
<td>Tension Parallel to Grain, Ft</td>
<td>1,020 psi</td>
<td>450 psi</td>
</tr>
<tr>
<td>Compression Perpendicular to Grain, Fc⊥</td>
<td>425 psi</td>
<td>425 psi</td>
</tr>
<tr>
<td>Shear Force, V</td>
<td>320 lbs</td>
<td>320 lbs</td>
</tr>
<tr>
<td>Bending Stiffness, EI</td>
<td>30,500,000 lb-in²</td>
<td>30,300,000 lb-in²</td>
</tr>
<tr>
<td>Bending Stiffness for Beam and Column Stability, Eimin</td>
<td>15,000,000 lb-in²</td>
<td>14,900,000 lb-in²</td>
</tr>
</tbody>
</table>

SI: 1 in = 25.4 mm, 1 lb = 4.45 N, 1 psi = 0.00689 MPa

5.2.2.2 Reference design values for Tstud™ shall be multiplied by the 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 Tstud™ 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 Tstud™ can be calculated using the provisions of NDS Section 3.6 and 3.7.

4 2015 IBC Section 2301.2
5.2.3.4 For computing the column stability factor, the critical bucking design value, $F_{cE}$, shall be computed using the formula in Equation 1.

**Equation 1. Critical Bucking Design Value**

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

Where $A =$ net cross-section area of Tstud™ = 1.5” x (2” x 2.5” – 0.6875”) = 6.47 in²

**Table 3. Tstud™ Maximum Allowable Compressive Load (lbs)¹**

<table>
<thead>
<tr>
<th>Tstud™ Length</th>
<th>No. 2 Lumber</th>
<th>1650Fb-1.5E Lumber</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 16'</td>
<td>3665</td>
<td>3665</td>
</tr>
<tr>
<td>16'</td>
<td>3625</td>
<td>3665</td>
</tr>
</tbody>
</table>

¹. Compression perpendicular to grain of 425 psi (adjusted per NDS Section 3.10.4) is assumed. Adjustments for plates having a higher or lower compression perpendicular to grain value is required.

5.2.4 Design for Bending

5.2.4.1 The maximum bending moment and shear forces shall not exceed the reference design values for the Tstud™ specified in Table 2.

5.2.5 Design for Combined Bending and Axial Compression Loads

5.2.5.1 The Tstud™ resists bending using tension and compression stresses in the wood members.

5.2.5.2 The axial compressive stress due to combined bending and axial load can be computed using Equation 2.

**Equation 2. Axial Compressive Stress**

$$f_a = \frac{P}{A} + \frac{M}{A_m \cdot d_{eff}}$$

Where: $P =$ axial load applied to Tstud™ (in lbs)

$M =$ bending moment applied to Tstud™ (in lbs-in)

$A_m =$ net cross-sectional area of member = 1.5” x (2.5” – 0.6875”) = 2.72 in²

$d_{eff} =$ distance from center-to-center of Tstud™ chord members = 4.00”

5.2.5.3 The axial stresses in Tstud™ member shall be checked in accordance with NDS Section 3.6 and 3.7.

5.2.5.4 The Tstud™ shall also be checked in bending only to insure the allowable bending moment in Table 2 is not exceeded.

5.2.5.5 Allowable wind pressures for Tstud™ subject to axial loads are specified in Table 4 and Table 5.

5.2.5.6 Tstud™ used as headers in a wall have the allowable loads as specified in Table 6.
### TABLE 4. ALLOWABLE (ASD) COMPONENT & CLADDING WIND PRESSURES (FOR NO. 2 LUMBER)

<table>
<thead>
<tr>
<th>Stud Spacing (in)</th>
<th>Wall Height (ft)</th>
<th>Wind Pressure (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>3665 (L/3401)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3665 (L/2366)</td>
</tr>
<tr>
<td>12</td>
<td>10</td>
<td>3665 (L/1698)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3665 (L/967)</td>
</tr>
<tr>
<td>16</td>
<td>14</td>
<td>3075 (L/602)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1440 (L/399)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9</td>
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<tr>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>24</td>
<td>8</td>
<td>3665 (L/1701)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14</td>
</tr>
</tbody>
</table>

*SI: 1 in = 25.4 mm, 1 psf = 0.0479 kN/m²*
### Table 5. Allowable (ASD) Component & Cladding Wind Pressures (for 1650F – 1.5E Lumber)

<table>
<thead>
<tr>
<th>Stud Spacing (in)</th>
<th>Wall Height (ft)</th>
<th>Wind Pressure (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>3665 (L/3424)</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>3665 (L/2371)</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>3665 (L/1710)</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>3665 (L/973)</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>3310 (L/606)</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td>1570 (L/402)</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>3665 (L/2568)</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>3665 (L/1778)</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>3665 (L/1282)</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>3665 (L/730)</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>2695 (L/454)</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>765 (L/302)</td>
</tr>
<tr>
<td>24</td>
<td></td>
<td>3665 (L/1712)</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>3665 (L/1186)</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>3665 (L/855)</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>3665 (L/486)</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>1470 (L/303)</td>
</tr>
</tbody>
</table>

SI: 1 in = 25.4 mm, 1 psf = 0.0479 kN/m²
<table>
<thead>
<tr>
<th>No. of Members</th>
<th>Span (ft)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>1</td>
<td>304 (L/360)</td>
<td>171 (L/267)</td>
</tr>
<tr>
<td>2</td>
<td>608 (L/360)</td>
<td>342 (L/267)</td>
</tr>
<tr>
<td>3</td>
<td>911 (L/360)</td>
<td>513 (L/267)</td>
</tr>
<tr>
<td>4</td>
<td>1215 (L/360)</td>
<td>684 (L/267)</td>
</tr>
<tr>
<td>5</td>
<td>1519 (L/360)</td>
<td>854 (L/267)</td>
</tr>
<tr>
<td>6</td>
<td>1823 (L/360)</td>
<td>1025 (L/267)</td>
</tr>
<tr>
<td>7</td>
<td>2127 (L/360)</td>
<td>1196 (L/267)</td>
</tr>
</tbody>
</table>

SI: 1 in = 25.4 mm

1. Table values are based on Tstud™ of No. 2 SPF lumber
2. Table values are based on a load duration factor of 1.0
3. Deflection checks of L/360 for live load and L/240 for total load are based on a live load to dead load ratio of 2:1.

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 technical judgment.

6 INSTALLATION

6.1 Tstud™ 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. In the event of a conflict between the manufacturer’s installation instructions and this TER, the more restrictive shall govern.

6.2 Installation Procedure

6.2.1 Tstud™ is pre-assembled and designed to be used as a direct replacement of nominal 2x4 (38 mm x 89 mm) solid sawn lumber, and in most cases, but not all, nominal 2x6 (38 mm x 140 mm) solid sawn lumber, as wall studs, top and bottom plates, and headers.

6.2.1.1 For use as a 2x6, design shall be permitted in accordance with accepted engineering procedures, experience and technical judgment. In these cases, referenced design values as specified in Table 2 shall be used in accordance with IRC Section R602 and IBC Section 2308.

6.2.2 Install Tstud™ 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 Tstud™ shall be in accordance with NDS.
6.2.3 ANCHORAGE
6.2.3.1 Stand walls and set into correct position. Ensure anchor bolts in foundation penetrate the center of the foam in the Tstud™ bottom plate.

6.2.3.2 Place metal plate over anchor bolts and fasten with a washer and nut. Once nut is tightened and the wall has been sufficiently anchored tight to the sill plate, drive four (4) 2½" #12 (0.216 dia.) screws (two [2] in each wood member) into the pre drilled holes in the metal plate.

7 TEST ENGINEERING SUBSTANTIATING DATA
7.1 Compressive Load Testing of Tstud™, by SBC Research Institute under contract with Qualtim, Inc.
7.2 Bending Tests of Tstud™, by SBC Research Institute under contract with Qualtim, Inc.
7.3 Bending Tests of Tstud™ Top Plates, by SBC Research Institute under contract with Qualtim, Inc.
7.4 Some information contained herein is the result of testing and/or data analysis by other sources which conform to IBC Section 1703 and relevant professional engineering law. DrJ relies on accurate data from these sources to perform engineering analysis. DrJ has reviewed and found the data provided by other professional sources to be credible.

7.5 Where appropriate, DrJ’s analysis is based on design values that have been codified into law through codes and standards (e.g., IBC, IRC, NDS®, and SDPWS). 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, and concrete), DrJ relies upon the grade mark, stamp, and/or design values provided by raw material suppliers to be accurate and conforming to the mechanical properties defined in the relevant material standard.

8 FINDINGS
8.1 When used and installed in accordance with this TER and the manufacturer’s installation instructions, the product(s) listed in Section 1.1 are approved for the following:

8.1.1 Tstud™ 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 in all cases and 2x6 (38 mm x 140 mm) solid sawn lumber in most cases for wall structural members.

8.1.2 For use as a 2x6, design shall be permitted in accordance with accepted engineering procedures, experience and technical judgment. In these cases, referenced design values as specified in Table 2 shall be used in accordance with IRC Section R602 and IBC Section 2308.

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

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 in the context of 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 applicable to this evaluation, they are listed here.

8.3.1 No known variations
9 CONDITIONS OF USE

9.1 Tstud™ complies with, or is a suitable alternative to, sawn lumber as permitted by the codes listed in Section 2, subject to the following conditions:

9.1.1 The maximum wall height for Tstud™ is 16' (3.05 m).
9.1.2 Increases for duration of load shall be in accordance with the limitations of the applicable building code for sawn lumber.
9.1.3 Creep factors applicable to sawn lumber may be applied to this product, in accordance with the applicable building code.

9.2 Where required by the building official, also known as 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.

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

9.4 Design loads shall be determined in accordance with the building code adopted by the jurisdiction in which the project is to be constructed and/or by the Building Designer (e.g., owner or registered design professional).

9.5 At a minimum, this product shall be installed per Section 6 of this TER.

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

9.7 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. Therefore, the TER shall be reviewed for code compliance by the building official for acceptance.

9.8 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 The product(s) listed in Section 1.1 are identified by a label on the board 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 found at www.tstud.com.

11 REVIEW SCHEDULE

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

11.2 For information on the current status of this TER, contact DrJ Certification.
APPENDIX A

**TStud Example Calculation:**

Determine the allowable axial load for an 10' Tstud of No. 2 SPF lumber spaced 24" o.c. and subject to wind speeds of 170 mph.

**Material Properties of Tstud:**

The material properties of the Tstud are given in Table 2 of the TER.

\[ F_c := 1150 \text{ psi} \quad F_t := 450 \text{ psi} \quad F_{c_{\text{perp}}} := 425 \text{ psi} \]

\[ C_{fc} := 1.15 \quad C_t := 1.5 \quad \text{Size factor for 2x3 lumber.} \]

\[ F_b S := 889 \text{ lbf \cdot ft} \quad V_n := 320 \text{ lbf} \]

\[ EI := 30300000 \text{ lbf \cdot in}^2 \]

\[ EI_{\text{min}} := 14900000 \text{ lbf \cdot in}^2 \]

**Section Properties of Tstud:**

\[ d_1 := 1.5 \text{ in} \quad \text{Wide face dimension.} \]

\[ d_2 := 2.5 \text{ in} \quad \text{Narrow face dimension.} \]

\[ d_{\text{eff}} := 4 \text{ in} \quad \text{Moment arm between members.} \]

\[ A := d_1 \cdot 2 \cdot d_2 - 0.6875 \text{ in} = 6.47 \text{ in}^2 \quad \text{Net section area of Tstud.} \]

\[ h := 116.125 \text{ in} \quad \text{Height of Tstud.} \]

**Compression Capacity of Tstud under Vertical Load only:**

\[ C_D := 1.0 \]

\[ F_{c_{\text{star}}} := F_c \cdot C_{fc} \cdot C_D = 1323 \text{ psi} \]

\[ c := 0.8 \quad \text{Constant for sawn lumber. See NDS Section 3.7.1} \]

\[ K := 1.0 \quad \text{Buckling effective length factor for pinned-pinned column.} \]

\[ F_{cb} := \frac{\pi^2 EI_{\text{min}}}{A \cdot (K \cdot h)^2} = 1686 \text{ psi} \quad \text{Critical buckling design value per TER Section 5.2.3.4.} \]
\[ C_p := \frac{1 + \left( \frac{F_{cE}}{F_{c,\text{star}}} \right)}{2 \cdot c} - \sqrt{\left( 1 + \left( \frac{F_{cE}}{F_{c,\text{star}}} \right) \right)^2 - \frac{\left( \frac{F_{cE}}{F_{c,\text{star}}} \right)}{c}} = 0.768 \]

\[ F'_{c} := F_{c,\text{star}} \cdot C_p = 1015 \text{ psi} \quad < \quad F_{cE} = 1686 \text{ psi} \]

\[ P_{\text{buckling}} := F_{c,\text{star}} \cdot C_p \cdot A = 6567 \text{ lbf} \]

\[ C_b := \frac{\frac{d_2}{d_2} + 0.375 \text{ in}}{d_2} = 1.15 \]

\[ P_{\text{comp, perp}} := F_{c,\text{perp}} \cdot C_b \cdot (2 \cdot d_1 \cdot d_2) = 3666 \text{ lbf} \]

**Bending Capacity of Tstud:**

\[ C_D := 1.6 \]

\[ A_{\text{eff}} := h \cdot \frac{h}{3} = 31 \text{ ft}^2 \quad \text{Effective wind area for a single Tstud.} \]

\[ p_{\text{pos}} := 29.7 \text{ psf} = 29.7 \text{ psf} \]

\[ p_{\text{neg}} := -39.0 \text{ psf} = -39 \text{ psf} \]

\[ S_{\text{spacing, studs}} := 24 \text{ in} \]

\[ w := (-p_{\text{neg}}) \cdot S_{\text{spacing, studs}} = 78.0 \text{ plf} \]

\[ M_{\text{req, a}} := \frac{w \cdot h^2}{8} = 10957 \text{ lbf} \cdot \text{in} \quad < \quad M_{\text{all}} := F_b S \cdot C_D = 17069 \text{ lbf} \cdot \text{in} \]

Check shear load:

\[ V_{\text{req, d}} := \frac{w \cdot h}{2} = 377 \text{ lbf} \quad < \quad V_{\text{all}} := V_n \cdot C_{D} = 512 \text{ lbf} \quad \text{OK} \]

**Combined Axial Load and Component & Cladding Wind Load on Tstud:**

\[ C_D := 1.6 \]

\[ F_{c,\text{star}} := F_c \cdot C_{f_c} \cdot C_D = 2116 \text{ psi} \]
\[ C_{p2} = \frac{1 + \left( \frac{F_{cE}}{F_{c,star}} \right)}{2 \cdot c} - \sqrt{\left( 1 + \left( \frac{F_{cE}}{F_{c,star}} \right) \right)^2 - \left( \frac{F_{cE}}{F_{c,star}} \right)} = 0.608 \]

\[ F'_c := F_{c,star} \cdot C_{p2} = 1287 \text{ psi} \]

Check combined bending and compression on the member:

\[ A_m := d_1 \cdot (d_2 - 0.625 \text{ in}) = 2.81 \text{ in}^2 \]

\[ M_{applied} := \frac{0.75 \cdot w \cdot h^2}{8} = 8217 \text{ lbf \cdot in} \]

\[ f_{a,bend} := \frac{M_{applied}}{A_m \cdot d_{eff}} = 730 \text{ psi} \]

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.

\[ P := 3570 \text{ lbf} \]

Axial Load on the Tstud is selected to result in a CSI of 1.0.

\[ f_{a,comp} := \frac{P}{A} = 551.9 \text{ psi} \]

\[ f_c := f_{a,bend} + f_{a,comp} = 1282 \text{ psi} < F_{cE} = 1686 \text{ psi} \quad \text{and} \quad < F'_c = 1287 \text{ psi} \quad \text{OK} \]

\[ CSI := \frac{f_c}{F'_c} = 0.997 \]

Check Deflection Limit for Tstud:

\[ \Delta := \frac{5 \cdot (0.7 \cdot w) \cdot h^4}{384 \cdot EI} = 0.356 \text{ in} \]

\[ \frac{h}{\Delta} = 327 > 240 \quad \text{OK} \]

Summary of Design Calculations for Tstud:

The Tstud has a calculated axial load capacity of 3570 lbs for an 10' tall wall with a 170 mph wind load. The axial load is limited by the compression strength of the Tstud member under combined axial and wind loading.