Technical Evaluation Report
TER 1904-03
Tstud™ – Canada – Limit States
Design

Roosevelt Energy, Inc.

Product:
Tstud™ Structural Insulated
Wall Stud

Issue Date:
July 8, 2019
Revision Date:
March 2, 2020
Subject to Renewal:
October 1, 2020
COMPANY INFORMATION: Roosevelt Energy, Inc.
14048 Terrace Road NE
Ham Lake, MN 55304

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 - Building 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 NBC—10, 15: National Building Code of Canada
2.1.2 NECB—17: National Energy Code of Canada for Buildings
2.1.3 O Reg. 33/12 – Ontario Building Code (OBC)

1 Building codes require data from valid certification, evaluation, and qualification reports be obtained from accredited third-party organizations. An accredited certifying organization (a type of accredited third-party organization) is a certification body that performs "certification of a product, process, or system." An accredited third-party organization is accomplished via accreditation using ISO/IEC 17065 evaluation procedures meeting code requirements of independence, accredited testing, and professional 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, such as Canada, 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 about DrJ's accreditation, refer to this letter from the Standards Council of Canada (SCC).
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 2015 version of the NBC. This alternative solution is also approved for use with the 2010 NBC and the standards referenced therein (e.g., CAN/CSA, CAN/ULC). Where this TER is not approved, the AHJ shall respond in writing stating the reasons this TER was not approved. For any variations in provincial, territorial, and local codes, see Section 8.

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

4 References in this TER to the National Building Code of Canada (NBC) apply to the Ontario Building Code (OBC), unless noted otherwise.

SUBJECT TO RENEWAL: OCTOBER 1, 2020

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2.2 Standards and Referenced Documents
2.2.1 ASTM D198: Standard Test Methods of Static Tests of Lumber in Structural Sizes
2.2.2 ASTM D2559: Standard Specification for Adhesives for Bonded Structural Wood Products for Use Under Exterior Exposure Conditions
2.2.3 ASTM D2915: Sampling and Data Analysis for Structural Wood and Wood Based Products
2.2.4 ASTM E72: Standard Test Methods of Conducting Strength Tests of Panels for Building Construction
2.2.5 CSA O86: Engineering Design in Wood

3 PERFORMANCE EVALUATION
3.1 Tstud™ was evaluated to determine its applicability for use as an alternative material where nominal 2"x4" (38x89 mm) and 2"x6" (38x140 mm) solid sawn lumber is specified in accordance with the NBC 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 the following:
3.3.1 Use as an alternative solution to that described in NBC Division B Part 4, in particular, compliance with requirements for the design and construction of wood-based products as described in NBC Subsection 4.1.3 for limit states design (LSD).
3.3.2 Compliance with NBC Section 4.1, CSA O86 per NBC Subsection 4.3.1, and NBC Section 9.23 for wood frame construction applications.
3.3.3 Use as an alternative material and method of construction in compliance with NBC Article 1.2.1.1.
3.3.3.1 When used in an application that exceeds the limits of NBC Section 4.1 or NBC Section 9.23, an engineered design shall be submitted in accordance with NBC Volume 1 commentary on Conformity Assessment and this TER.
3.4 Evaluation of Tstud™ for performance under seismic loading is outside the scope of this TER.
3.5 Any code-compliance issues not specifically addressed in this section are outside the scope of this TER.
3.6 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 and Figure 2.

![Figure 1. TSTUD™ PRODUCT STAMP](image-url)
4.2 Tstud™ is made from a minimum of 2" x 3" (38 x 64 mm) No. 2 Spruce Pine Fir (SPF) lumber, wooden dowels, and approximately 64 mm (2½") of polyisocyanurate (polyiso) insulation.

4.2.1 Overall size of Tstud™ is 64 mm x 140 mm (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 64 mm (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 exceeding 165 mm (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: 38 mm (1½")

4.3.1.3 Width: 64 mm (2½")

4.3.1.4 Length: up to 4.9 m (16')

4.3.2 Dowels:

4.3.2.1 Grade: No. 2 SPF or 1650f – 1.5E SPF

4.3.2.2 Diameter: 17.5 mm (11/16")

4.3.3 Polyiso:

4.3.3.1 The polyiso is manufactured with a minimum density of 345.6 N/m³ (2.2 lb/ft³).

5 Applications

5.1 Prescriptive Provisions

5.1.1 Tstud™ is an alternative to solid sawn 2" x 4" lumber in all cases and 2" x 6" lumber in most cases for wall structural members.

5.1.1.1 For use as a 2" x 6", 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 NBC Section 4.1 and CSA O86 per NBC Subsection 4.3.1.

5.1.2 Polyiso insulation is in accordance with NBC Division B Article 3.1.5.15 and OBC Article 3.1.5.12.
5.1.3 Cutting, notching, and boring

5.1.3.1 Notches in structural members (2" x 3" or dowels) are not permitted.

5.1.3.2 Holes may only be bored in polyiso insulation of Tstud™. Holes shall be spaced a minimum of 610 mm (24") o.c., shall not exceed 64 mm (2½") in diameter, and are not permitted within 610 mm (24") from either end of the stud.

5.1.3.3 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, mm (in)</th>
<th>Installation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling Joists to Plate</td>
<td>(3) - 4&quot; × 0.131&quot; (3.3 mm)</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>(toe nail)</td>
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</tr>
<tr>
<td>Rim Joist to Sill or Top Plate</td>
<td>2½&quot; × 0.113&quot; (2.9 mm)</td>
<td>102 (4) o.c.</td>
<td>Fasten by toe-nailing</td>
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<tr>
<td></td>
<td>2½&quot; × 0.131&quot; (3.3 mm)</td>
<td>152 (6) o.c.</td>
<td></td>
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<tr>
<td>Rafter or Roof Truss to Plate</td>
<td>(3) - 3½&quot; × 0.135&quot; (3.4 mm)</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>(toe nail)</td>
<td>(4) – 4&quot; × 0.131&quot; (3.3 mm)</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>Built-up Studs</td>
<td>4&quot; × 0.131&quot; (3.3 mm)</td>
<td>406 (16) o.c.</td>
<td>Fasten two (2) face nails, one (1) into each wood member</td>
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<tr>
<td>(face nail)</td>
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<tr>
<td>Abutting Studs at Intersecting Wall</td>
<td>4&quot; × 0.131&quot; (3.3 mm)</td>
<td>305 (12) o.c.</td>
<td>Fasten one (1) face nail into exterior-facing wood member</td>
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<tr>
<td>Corners</td>
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<tr>
<td>Double 2″x6″ Top Plates</td>
<td>4&quot; × 0.131&quot; (3.3 mm)</td>
<td>305 (12) o.c.</td>
<td>Fasten two (2) face nails, one (1) into each wood member</td>
</tr>
<tr>
<td>(face nail)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Double Top Plates, Minimum 24″ Offset of</td>
<td>(12) – 4&quot; × 0.131&quot; (3.3 mm)</td>
<td>–</td>
<td>Fasten twelve (12) face nails on each side of end joint (minimum 610 mm (24&quot;) lap splice length each side of joint)</td>
</tr>
<tr>
<td>End Joints, Face Nail in Lapped Area</td>
<td>(4) – 4&quot; × 0.131&quot; (3.3 mm)</td>
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<td></td>
</tr>
<tr>
<td>Stud to Plate</td>
<td>(3) – 4&quot; × 0.131&quot; (3.3 mm)</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>(toe nail)</td>
<td>(2) – 4½&quot; × 0.162&quot; (4.1 mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plate to Stud</td>
<td>(2) – 4&quot; × 0.131&quot; (3.3 mm)</td>
<td>–</td>
<td>Fasten two (2) 4&quot; x 0.131&quot; nails into one wood member and one (1) 4&quot; x 0.131&quot; nail into other wood member</td>
</tr>
<tr>
<td>(end nail)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top Plates, Laps at Corners &amp; Intersections</td>
<td>(2) – 4&quot; × 0.131&quot; (3.3 mm)</td>
<td>–</td>
<td>Fasten two (2) 4&quot; x 0.131&quot; face nails, one into each wood member</td>
</tr>
</tbody>
</table>

SI: 1 mm = 0.0394 in
1. Care shall be taken to avoid splitting.
5.1.4 Tstud™ may be used as a single top plate in accordance with NBC Division B Article 9.23.11.3 and the following:

5.1.4.1 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" (3.3 mm) nails: one (1) into one wood member and two (2) into the other wood member.

5.1.5 Tstud™ may be used as a flat header.

5.1.5.1 Fasten multi-ply Tstud™ header members using 4" x 0.131" (3.3 mm) nails. Drive one nail into each Tstud™ wood member at 406 mm (16") o.c. i.e. In other words, 406 mm (16") o.c. along each side of the Tstud™.

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

5.1.6.1 Install cripple studs between the bottom plate and rough sill using three (3) 4" x 0.131" (3.3 mm) nails: one (1) into one wood member and two (2) into the other wood member.

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

5.1.8 Trusses and rafters having a maximum factored reaction of 23.2 kN (5,215 lbs) may be placed anywhere on walls with single Tstud™ top plates.

5.1.9 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 23.2 kN (5,215 lbs) per ply (e.g., 46.4 kN per 2-ply, built-up stud). In this case, the built-up stud shall be located directly under the applied load.

5.1.9.1 Walls with nominal 2x6 lumber top plates shall be in accordance with NBC Division B Article 9.23.11.3.

5.2 Engineering Design

5.2.1 The design provisions for wood construction noted in NBC Division B Subsection 4.1.3 apply to Tstud™ for limit states design (LSD), unless otherwise noted in this TER.

5.2.2 Material Properties:

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

<table>
<thead>
<tr>
<th>Specified Design Values</th>
<th>Lumber Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1650f – 1.5E SPF</td>
</tr>
<tr>
<td>Specified Bending, $f_b$</td>
<td>2 215 N-m (1,635 lb-ft)</td>
</tr>
<tr>
<td>Specified Compression Parallel to Grain, $f_c$</td>
<td>18.1 MPa (2 620 psi)</td>
</tr>
<tr>
<td>Specified Tension Parallel to Grain, $f_t$</td>
<td>11.4 MPa (1 650 psi)</td>
</tr>
<tr>
<td>Specified Compression Perpendicular to Grain, $f_{cp}$</td>
<td>5.3 MPa (765 psi)</td>
</tr>
<tr>
<td>Specified Shear Force, $V_c$</td>
<td>2.63 kN (590 lb)</td>
</tr>
<tr>
<td>Bending Stiffness, $E_I$</td>
<td>87 600 N-m² (30,500,000 lb-in²)</td>
</tr>
<tr>
<td>Bending Stiffness for Beam and Column Stability, $E_{I05}$</td>
<td>76 200 N-m² (26,500,000 lb-in²)</td>
</tr>
</tbody>
</table>

SI: 1 mm = 0.0394 in, 1 N = 0.225 lb, 1 kN/m = 68.5 lb/ft, 1 kN/m² = 20.9 psf, 1 MPa = 145 psi

5.2.2.2 Reference design values for Tstud™ shall be multiplied by the adjustment factors defined in CSA O86 Section 15.3.2 and Section 6.4.

5.2.3 Design for Axial Loads:

5.2.3.1 The maximum factored compressive load for Tstud™ is defined in Table 3.
5.2.3.2 The maximum factored compressive load is based on the minimum of perpendicular-to-grain crushing of SPF top and bottom plates, and compression parallel to grain of the Tstud™.

5.2.3.3 The factored compressive resistance parallel to grain for Tstud™ can be calculated using the provisions of CSA O86 Subsection 15.3.3.4.

5.2.3.4 The factored compressive resistance parallel to grain, $P_r$, shall be computed using the formula:

$$ P_r = \varphi F_c A K_c K_{zc} $$

Where: $A$ = net cross-sectional area of Tstud™

$$ = 38 \text{ mm} \times (2 \times 63.5 \text{ mm} - 17.5 \text{ mm}) = 4161 \text{ mm}^2 $$

5.2.3.5 For computing stability, the Euler buckling load in the plane of the applied moment, $P_E$, shall be computed using the formula:

$$ P_E = \frac{\pi E_0 K_{SE} K_I I}{L_E^2} $$

### Table 3. Tstud™ Maximum Factored Compressive Load

<table>
<thead>
<tr>
<th>Tstud™ Length (m)</th>
<th>1650fb – 15.5E SPF Lumber (kN)</th>
<th>No. 2 SPF Lumber (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 3.05 (10)</td>
<td>23.2 (5215)$^1$</td>
<td>23.2 (5215)$^1$</td>
</tr>
<tr>
<td>3.66 (12)</td>
<td>23.2 (5215)$^1$</td>
<td>22.6 (5080)</td>
</tr>
<tr>
<td>4.27 (14)</td>
<td>23.0 (5170)</td>
<td>18.2 (4090)</td>
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<tr>
<td>4.88 (16)</td>
<td>17.6 (3955)</td>
<td>14.5 (3260)</td>
</tr>
</tbody>
</table>

St: $1" = 25.4 \text{ mm}, 1 \text{ lb} = 4.448 \text{ N}$

1. Compression perpendicular to grain of top and bottom plates controls.
2. Compression perpendicular to grain of 5.3 MPa (per CSA O86 Table 6.3.1A) is assumed (Table 2). Adjustment for plates having a higher or lower value for compression perpendicular to grain 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™ defined 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 resistance to combined bending and axial loads can be computed using the following equation:

$$ \left(\frac{P_f}{P_r}\right)^2 + \frac{M_f}{M_r} \left[1 - \frac{1}{\frac{P_f}{P_E}}\right] \leq 1 $$

Where: $P_f$ = factored compressive axial load applied to Tstud™ (N)

$P_r$ = factored compressive resistance parallel to grain of Tstud™ (N)

$M_f$ = factored bending moment applied to Tstud™ (N-m)

$M_r$ = factored bending moment resistance of Tstud™ (N-m)

$P_E$ = Euler buckling load (N)

5.2.5.3 The axial loads in Tstud™ member shall be checked in accordance with CSA O86 Subsection 15.3.3.4 and 15.3.3.6.

5.2.5.4 The equation is Section 5.2.5.2 includes a check to ensure the factored bending moment in Table 2 is not exceeded for Tstud™.

5.2.5.5 Specified wind pressure resistances for Tstud™ subject to axial loads are provided in Table 4 and Table 5.
<table>
<thead>
<tr>
<th>Stud Spacing mm (in)</th>
<th>Wall Height m (ft)</th>
<th>Specified Wind Pressure, p (kPa)</th>
<th>0.30</th>
<th>0.58</th>
<th>0.86</th>
<th>1.13</th>
<th>1.41</th>
<th>1.69</th>
<th>1.97</th>
<th>2.24</th>
<th>2.52</th>
<th>2.80</th>
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<tr>
<td>305 (12)</td>
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<td>2.44 (8)</td>
<td>23.15 (L/5697)</td>
<td>23.15 (L/2958)</td>
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<td>2.74 (9)</td>
<td>23.15 (L/3945)</td>
<td>23.15 (L/2049)</td>
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<td>3.05 (10)</td>
<td>23.15 (L/2844)</td>
<td>23.15 (L/1477)</td>
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<td>3.66 (12)</td>
<td>21.35 (L/1619)</td>
<td>19.5 (L/841)</td>
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<td>16.1 (L/1007)</td>
<td>13.6 (L/523)</td>
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<tr>
<td>4.88 (16)</td>
<td>11.4 (L/669)</td>
<td>8.05 (L/347)</td>
<td>4.75 (L/235)</td>
<td>1.4 (L/177)</td>
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<td>23.15 (L/4272)</td>
<td>23.15 (L/2218)</td>
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<td>23.15 (L/2959)</td>
<td>23.15 (L/1536)</td>
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<td>18.2 (L/630)</td>
<td>15.75 (L/426)</td>
<td>13.3 (L/321)</td>
<td>10.85 (L/258)</td>
<td>8.35 (L/216)</td>
<td>5.9 (L/185)</td>
<td>3.45 (L/162)</td>
<td>0.95 (L/144)</td>
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<td>4.27 (14)</td>
<td>15.2 (L/756)</td>
<td>11.8 (L/392)</td>
<td>8.45 (L/265)</td>
<td>5.05 (L/200)</td>
<td>1.7 (L/161)</td>
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<td>4.88 (16)</td>
<td>10.2 (L/502)</td>
<td>5.75 (L/261)</td>
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<td>2.44 (8)</td>
<td>23.15 (L/2848)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.74 (9)</td>
<td>23.15 (L/1973)</td>
<td>23.15 (L/1024)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.05 (10)</td>
<td>23.15 (L/1422)</td>
<td>22.8 (L/738)</td>
<td>20.25 (L/499)</td>
<td>17.7 (L/376)</td>
<td>15.2 (L/302)</td>
<td>12.65 (L/253)</td>
<td>10.1 (L/17)</td>
<td>7.55 (L/190)</td>
<td>5.05 (L/169)</td>
<td>2.5 (L/152)</td>
<td>9.8 (L/211)</td>
<td></td>
</tr>
<tr>
<td>3.66 (12)</td>
<td>19.35 (L/909)</td>
<td>15.65 (L/420)</td>
<td>11.95 (L/284)</td>
<td>8.25 (L/214)</td>
<td>4.55 (L/172)</td>
<td>0.85 (L/144)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>4.27 (14)</td>
<td>13.4 (L/504)</td>
<td>8.3 (L/262)</td>
<td>3.25 (L/177)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>4.88 (16)</td>
<td>7.8 (L/334)</td>
<td>1.15 (L/174)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td></td>
</tr>
</tbody>
</table>

St: 25.4 mm = 1 in, 1 N = 0.225 lb, 1 MPa = 145 psi
1. Specified wind pressures for ultimate limit states (ULS) and serviceability limit states (SLS) are determined in accordance with NBC Division B Article 4.1.7.3.
<table>
<thead>
<tr>
<th>Stud Spacing mm (in)</th>
<th>Wall Height m (ft)</th>
<th></th>
<th>Specified Wind Pressure, p (kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0.30</td>
<td>0.58</td>
</tr>
<tr>
<td>3.05 (12)</td>
<td>2.44 (8)</td>
<td>23.15</td>
<td>23.15</td>
</tr>
<tr>
<td></td>
<td>2.74 (9)</td>
<td>23.15</td>
<td>23.15</td>
</tr>
<tr>
<td></td>
<td>3.05 (10)</td>
<td>23.15</td>
<td>23.15</td>
</tr>
<tr>
<td></td>
<td>3.66 (12)</td>
<td>23.15</td>
<td>23.15</td>
</tr>
<tr>
<td></td>
<td>4.27 (14)</td>
<td>21.25</td>
<td>18.7</td>
</tr>
<tr>
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<td>4.88 (16)</td>
<td>14.75</td>
<td>11.45</td>
</tr>
<tr>
<td>406 (16)</td>
<td>2.44 (8)</td>
<td>23.15</td>
<td>23.15</td>
</tr>
<tr>
<td></td>
<td>2.74 (9)</td>
<td>23.15</td>
<td>23.15</td>
</tr>
<tr>
<td></td>
<td>3.05 (10)</td>
<td>23.15</td>
<td>23.15</td>
</tr>
<tr>
<td></td>
<td>3.66 (12)</td>
<td>23.15</td>
<td>23.15</td>
</tr>
<tr>
<td></td>
<td>4.27 (14)</td>
<td>20.3</td>
<td>16.95</td>
</tr>
<tr>
<td></td>
<td>4.88 (16)</td>
<td>13.55</td>
<td>9.1</td>
</tr>
<tr>
<td>610 (24)</td>
<td>2.44 (8)</td>
<td>23.15</td>
<td>23.15</td>
</tr>
<tr>
<td></td>
<td>2.74 (9)</td>
<td>23.15</td>
<td>23.15</td>
</tr>
<tr>
<td></td>
<td>3.05 (10)</td>
<td>23.15</td>
<td>23.15</td>
</tr>
<tr>
<td></td>
<td>3.66 (12)</td>
<td>23.15</td>
<td>23.15</td>
</tr>
<tr>
<td></td>
<td>4.27 (14)</td>
<td>18.5</td>
<td>13.4</td>
</tr>
<tr>
<td></td>
<td>4.88 (16)</td>
<td>11.15</td>
<td>4.5</td>
</tr>
</tbody>
</table>

Sl: 25.4 mm = 1 in, 1 N = 0.225 lb, 1 MPa = 145 psi
1. Specified wind pressures for ultimate limit states (ULS) and serviceability limit states (SLS) are determined in accordance with NBC Division B Article 4.1.7.3.
5.2.5.6 Tstud™ used as headers in a wall have the following factored load capacities (Table 6).

**TABLE 6. FACTORED LOADS FOR TSTUD™ AS HEADERS**

<table>
<thead>
<tr>
<th>Number of Members</th>
<th>0.61 (2)</th>
<th>0.91 (3)</th>
<th>1.22 (4)</th>
<th>1.52 (5)</th>
<th>1.83 (6)</th>
<th>2.13 (7)</th>
<th>2.44 (8)</th>
<th>2.74 (9)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(L/1026)</td>
<td>(L/457)</td>
<td>(L/257)</td>
<td>(L/240)</td>
<td>(L/240)</td>
<td>(L/240)</td>
<td>(L/240)</td>
<td>(L/240)</td>
</tr>
<tr>
<td>1</td>
<td>5.2</td>
<td>3.5</td>
<td>2.6</td>
<td>1.4</td>
<td>0.8</td>
<td>0.5</td>
<td>0.3</td>
<td>0.2</td>
</tr>
<tr>
<td>2</td>
<td>10.3</td>
<td>6.9</td>
<td>5.2</td>
<td>2.8</td>
<td>1.6</td>
<td>1.0</td>
<td>0.7</td>
<td>0.5</td>
</tr>
<tr>
<td>3</td>
<td>15.5</td>
<td>10.4</td>
<td>7.8</td>
<td>4.3</td>
<td>2.5</td>
<td>1.5</td>
<td>1.0</td>
<td>0.7</td>
</tr>
<tr>
<td>4</td>
<td>20.7</td>
<td>13.8</td>
<td>10.4</td>
<td>5.7</td>
<td>3.3</td>
<td>2.1</td>
<td>1.4</td>
<td>1.0</td>
</tr>
<tr>
<td>5</td>
<td>25.9</td>
<td>17.3</td>
<td>12.9</td>
<td>7.1</td>
<td>4.1</td>
<td>2.6</td>
<td>1.7</td>
<td>1.2</td>
</tr>
<tr>
<td>6</td>
<td>31.0</td>
<td>20.7</td>
<td>15.5</td>
<td>8.5</td>
<td>4.9</td>
<td>3.1</td>
<td>2.1</td>
<td>1.5</td>
</tr>
<tr>
<td>7</td>
<td>36.2</td>
<td>24.2</td>
<td>18.1</td>
<td>9.9</td>
<td>5.7</td>
<td>3.6</td>
<td>2.4</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Values limited to serviceability limit state (deflection).

SI: 25.4 mm = 1 in, 1 kN/m = 737.6 lb/ft
1. Table values are based on Tstud™ of No. 2 SPF lumber.
2. Tables 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, where L is equal to the header span.

5.2.6 For applications outside of the scope of the applicable code, consult the manufacturer’s installation instructions or a structural engineer registered in the province of the project.

5.2.7 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 Installation shall comply with the manufacturer’s installation instructions and this TER. 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 2" x 4" (38 mm x 89 mm) solid sawn lumber, and in most cases, but not all, nominal 2" x 6" (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 2" x 6", design shall be permitted in accordance with accepted engineering procedures, experience, and technical judgment. In these cases, referenced design values as defined in Table 2 shall be used in accordance with CSA O86 Section 15.3 and Clause 5.

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

6.2.2.1 For the NBC Section 4.3.1 and Section 9.23, 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 NBC, CSA O86, and the standards referenced 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 CSA O86.
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 Structural Building Components Research Institute (SBCRI) under contract with Qualtim, Inc.

7.2 Bending Tests of Tstud™, by SBCRI under contract with Qualtim, Inc.

7.3 Bending Tests of Tstud™ Top Plates, by SBCRI under contract with Qualtim, Inc.

7.4 Some information contained herein is the result of testing and/or data analysis by other sources which conforms to 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., NBC, NECC, CAN/CSA). 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 grade/properties provided by raw material supplier to be accurate and conforming to the mechanical properties defined in the relevant material standard.

8 **FINDINGS**

8.1 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 2" x 4" (38 mm x 89 mm) solid sawn lumber in all cases and 2" x 6" (38 mm x 140 mm) solid sawn lumber in most cases for wall structural members.

8.1.1.1 For use as a 2" x 6", design shall be permitted in accordance with accepted engineering procedures, experience, and technical judgment. In these cases, referenced design values as defined in Table 2 shall be used in accordance with NBC Section 4.1 and Section 9.23.

8.2 **NBC Article 1.2.1.1. states:**

1.2.1.1. Compliance with this Code

1) Compliance with this Code shall be achieved by

a) complying with the applicable acceptable solutions in Division B (see Note A-1.2.1.1.(1)(a)), or

b) using alternative solutions that will achieve at least the minimum level of performance required by Division B in the areas defined by the objectives and functional statements attributed to the applicable acceptable solutions (see Note A-1.2.1.1.(1)(b)).

2) For the proposes of compliance with this Code as required in Clause 1.2.1.1.(1)(b), the objectives and functional statements attributed to the acceptable solutions in Division B shall be the objectives and functional statements referred to in Subsection 1.1.2. of Division B.

8.3 **NBC Division C Section 2.3 includes additional guidance for alternative solutions.**

8.4 This product has been evaluated in the context of the codes listed in Section 2 and is compliant with all known provincial, territorial, and local building codes. Where there are known variations in provincial, territorial, or local codes applicable to this evaluation, they are listed here.

8.4.1 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 4.88 m (16 ft).

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 authority having jurisdiction 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 Authority Having Jurisdiction (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 designer (e.g., owner).

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 with quality control inspections established by the governing legislation of the adopting province or territory, as described in NBC Volume 1 commentary on Conformity Assessment.

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 AHJ 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 AHJ'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.

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 factored axial load for an 2.44 m (8 ft) Tstud of No. 2 SPF lumber spaced 610 mm (24" o.c.) and subject to a specified wind pressure of 2.80 kPa (ULS) and 2.1 kPa (SLS).

\[ \begin{align*}
  s &= 610 \text{ mm} \quad \text{“stud spacing”} \\
  p_{u0} &= 2.80 \text{ kPa} \quad \text{“specified wind pressure, ultimate limit state”} \\
  p_{u0} &= 2.1 \text{ kPa} \quad \text{“specified wind pressure, servicability limit state”} \\
  w &= 1.4 \cdot p_{u0} \cdot s = 2391 \frac{N}{m} \quad \text{“factored wind load”}
\end{align*} \]

**Material Properties of Tstud:**

The material properties of the No. 2 SPF Tstud are given in Table 2 of the TER.

\[ \begin{align*}
  f_c &= 11.5 \text{ MPa} \\
  f_t &= 5.5 \text{ MPa} \\
  f_{cp} &= 5.3 \text{ MPa} \\
  f_y S &= 2215 \text{ N} \cdot \text{m} \\
  V_c &= 2630 \text{ N} \\
  E I &= 86900 \text{ N} \cdot \text{m}^2 \\
  E I_{min} &= 75600 \text{ N} \cdot \text{m}^2 \\
  E &= 9646 \text{ MPa} \\
  E_{05} &= 0.87 \cdot E = 8392 \text{ MPa} \\
  I &= 9005799 \text{ mm}^4
\end{align*} \]

**Section Properties of Tstud:**

\[ \begin{align*}
  d_1 &= 1.5 \text{ in} = 38 \text{ mm} \quad \text{“wide face dimension”} \\
  d_2 &= 2.5 \text{ in} = 64 \text{ mm} \quad \text{“narrow face dimension”} \\
  A &= d_1 \cdot (2 \cdot d_2 - 17.5 \text{ mm}) = 4172 \text{ mm}^2 \quad \text{“net section area”} \\
  h &= 8 \text{ ft} = 2438.40 \text{ mm} \quad \text{“height of Tstud”} \\
  d &= 5.5 \text{ in} = 140 \text{ mm} \quad \text{“effective depth of stud”}
\end{align*} \]

**Bending Moment Resistance:**

\[ \begin{align*}
  \phi &= 0.90 \\
  K_{IP} &= 1.15 \quad \text{“short term”} \\
  K_{IP} &= 1.04 \quad \text{“system factor for SCL in a load–sharing system”} \\
  K_{S0} &= 1.0 \quad \text{“bending at extreme fiber, dry service condition”} \\
  K_T &= 1.0 \quad \text{“untreated”} \\
  F_y S &= f_y S \cdot (K_D \cdot K_H \cdot K_{S0} \cdot K_T) = 2649 \text{ N} \cdot \text{m} \\
  K_{Zb} &= 1.4 \quad \text{“size factor in bending”} \\
  K_L &= 1.0 \quad \text{“lateral stability factor assuming lateral support”} \\
  M_0 &= \phi \cdot F_y S \cdot K_{Zb} \cdot K_L = 3338 \text{ N} \cdot \text{m} \quad \text{“bending moment resistance”}
\end{align*} \]
Compressive Resistance Parallel to Grain:

\[ \phi = 0.80 \]
\[ K_e := 1.00 \quad \text{“effective length factor”} \]
\[ K_D := 1.00 \quad \text{“standard term”} \]
\[ K_s := 1.00 \quad \text{“compression parallel to grain, dry service condition”} \]
\[ K_T := 1.0 \quad \text{“untreated”} \]
\[ F_c := f_c \cdot (K_D \cdot K_s \cdot K_T) = 11.5 \text{ MPa} \]
\[ K_{Zc} := 1 \quad \text{“compression parallel to grain”} \]
\[ L_e := K_e \cdot h = 2438 \text{ mm} \quad \text{“effective length”} \]
\[ C_C := \frac{L_e}{d} = 17 \quad \text{“slenderness ratio”} \]
\[ K_{SE} := 1 \quad \text{“MOE, dry service condition”} \]
\[ K_C := \left(1 + \frac{F_c \cdot K_{Zc} \cdot C_C^3}{35 \cdot E_{05} \cdot K_{SE} \cdot K_T}\right)^{-1} = 0.83 \quad \text{“slenderness factor”} \]
\[ P_v := \phi \cdot F_c \cdot A \cdot K_C \cdot K_{Zc} = 31768 \text{ N} \quad \text{“factored compressive resistance parallel to grain”} \]

Compressive Resistance Perpendicular to Grain:

\[ \phi = 0.80 \]
\[ K_D := 1.00 \quad \text{“standard term”} \]
\[ K_S := 1.0 \quad \text{“dry service conditions”} \]
\[ K_T := 1.0 \quad \text{“untreated”} \]
\[ F_{cp} := f_{cp} \cdot (K_D \cdot K_S \cdot K_T) \]
\[ A_h := 2 \cdot d_1 \cdot d_2 = 4839 \text{ mm}^2 \quad \text{“bearing area”} \]
\[ K_B := 1.13 \quad \text{“length of bearing factor”} \]
\[ K_{Zcp} := 1 \quad \text{“size of bearing factor”} \]
\[ Q_t := \phi \cdot F_{cp} \cdot A_h \cdot K_B \cdot K_{Zcp} = 23183 \text{ N} \quad \text{“factored compressive resistance perpendicular to grain”} \]
Check Resistance to Combined Bending and Axial Load:

\[ P_f := 16.35 \text{ kN} = 16350 \text{ N} \]  
“factored axial load per Table 4, selected to result in a CSI of 1.0”

\[ P_r := \min (P_r, Q_r) = 23183 \text{ N} \]  
“check for failure in compression perpendicular to grain”

\[ P_E := \left( \frac{\pi^2 E_{05} K_{SE} K_T I}{L_v^2} \right) = 125452 \text{ N} \]  
“Euler buckling load”

\[ M_f := \left( w \cdot h^2 \right) \frac{8}{3} = 1777 \text{ N} \cdot \text{m} \]  
“factored bending moment from wind”

\[
\left( \frac{P_f}{P_r} \right)^2 + \frac{M_f}{M_r} \left( 1 - \frac{P_f}{P_E} \right) \leq 1 \quad \text{OK}
\]

Check Deflection Limit:

\[ \Delta := \frac{5 \cdot (p_d \cdot s) \cdot h^4}{384 \cdot EI} = 6.786 \text{ mm} \]  
“deflection”

\[ \frac{h}{\Delta} = 359 > 240 \quad \text{OK} \]

Summary of Design Calculations for Tstud:

The Tstud has a calculated axial load capacity of 23.2 kN for 2.44 m (8 ft) Tstud of No. 2 SPF lumber spaced 610 mm (24" o.c.) and subject to a wind pressure of 2.80 kPa. The axial load is limited by the compression strength of the Tstud member under combined axial and wind loading.