



**CERTIFICATION**



Approved. Sealed. Code Compliant.

## **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:

August 24, 2020

Subject to Renewal:

October 1, 2021



COMPANY  
INFORMATION:

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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

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1 PRODUCT EVALUATED<sup>1</sup>

1.1 Tstud™ Structural Insulated Wall Stud

2 APPLICABLE CODES AND STANDARDS<sup>2,3</sup>

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)<sup>4</sup>*

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<sup>1</sup> 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 [ANAB-Accredited Product Certification Body – Accreditation #1131](#).

Through ANAB 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 ANAB 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](http://drjcertification.org).

<sup>2</sup> 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 7.5.

<sup>3</sup> All terms defined in the applicable building codes are italicized.

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

## 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 Dr.J'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



FIGURE 2. TSTUD™ WITHOUT POLYISO (LEFT) AND FINAL PRODUCT (RIGHT)

- 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/m<sup>3</sup> (2.2 lb/ft<sup>3</sup>).



## 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 1. ACCEPTABLE USES OF TSTUD™

Application	Number & Type of Fastener	Fastener Spacing, mm (in)	Installation
Ceiling Joists to Plate (toe nail)	(3) - 4" × 0.131" (3.3 mm)	–	Fasten two (2) toe nails into interior wood member and one (1) toe nail into exterior wood member
Rim Joist to Sill or Top Plate	2½" × 0.113" (2.9 mm)	102 (4) o.c.	Fasten by toe-nailing
	2½" × 0.131" (3.3 mm)	152 (6) o.c.	
Rafter or Roof Truss to Plate (toe nail)	(3) - 3½" × 0.135" (3.4 mm)	–	Fasten two (2) toe nails into interior wood member and two (2) toe nails into exterior wood member
	(4) – 4" × 0.131" (3.3 mm)		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.
Built-up Studs (face nail)	4" × 0.131" (3.3 mm)	406 (16) o.c.	Fasten two (2) face nails, one (1) into each wood member
Abutting Studs at Intersecting Wall Corners (face nail)	4" × 0.131" (3.3 mm)	305 (12) o.c.	Fasten one (1) face nail into exterior-facing wood member
Double 2"x6" Top Plates (face nail)	4" × 0.131" (3.3 mm)	305 (12) o.c.	Fasten two (2) face nails, one (1) into each wood member
Double Top Plates, Minimum 24" Offset of End Joints, Face Nail in Lapped Area	(12) – 4" × 0.131" (3.3 mm)	–	Fasten twelve (12) face nails on each side of end joint (minimum 610 mm (24") lap splice length each side of joint)
Stud to Plate (toe nail)	(4) – 4" × 0.131" (3.3 mm)	–	Fasten two (2) toe nails into sole plate on each side of the stud (each wood member)
Plate to Stud (end nail)	(3) – 4" × 0.131" (3.3 mm)	–	Fasten two (2) 4" x 0.131" nails into one wood member and one (1) 4" x 0.131" nail into other wood member
	(2) – 4½" × 0.162" (4.1 mm)		Fasten two (2) 4½" x 0.162" nails, one (1) into each wood member
Top Plates, Laps at Corners & Intersections (face nail)	(2) – 4" × 0.131" (3.3 mm)	–	Fasten two (2) 4" x 0.131" face nails, one into each wood member
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 LSD, unless otherwise noted in this TER.
- 5.2.2 Material Properties:
  - 5.2.2.1 Specified design values for Tstud™ are defined in Table 2.

TABLE 2. TSTUD™ SPECIFIED DESIGN VALUES FOR LSD

Specified Design Values	Lumber Grade	
	1650f – 1.5E SPF	No. 2 SPF
Specified Bending, $f_bS$	2 215 N-m (1,635 lb-ft)	2 215 N-m (1,635 lb-ft)
Specified Compression Parallel to Grain, $f_c$	18.1 MPa (2 620 psi)	11.5 MPa (1 665 psi)
Specified Tension Parallel to Grain, $f_t$	11.4 MPa (1 650 psi)	5.5 MPa (795 psi)
Specified Compression Perpendicular to Grain, $f_{cp}$	5.3 MPa (765 psi)	5.3 MPa (765 psi)
Specified Shear Force, $V_c$	2.63 kN (590 lb)	2.63 kN (590 lb)
Bending Stiffness, $EI$	87 600 N-m <sup>2</sup> (30,500,000 lb-in <sup>2</sup> )	86 900 N-m <sup>2</sup> (30,200,000 lb-in <sup>2</sup> )
Bending Stiffness for Beam and Column Stability, $EI_{05}$	76 200 N-m <sup>2</sup> (26,500,000 lb-in <sup>2</sup> )	75 600 N-m <sup>2</sup> (26,300,000 lb-in <sup>2</sup> )
SI: 1 mm = 0.0394 in, 1 N = 0.225 lb, 1 kN/m = 68.5 lb/ft, 1 kN/m <sup>2</sup> = 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:

$$P_r = \phi F_c A K_c K_{Zc}$$

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

$$= 38 \text{ mm} \times (2 \times 63.5 \text{ mm} - 17.5 \text{ mm}) = 4\,161 \text{ mm}^2$$

- 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:

$$P_E = \frac{\pi E_{05} K_{SE} K_T I}{L_E^2}$$

TABLE 3. TSTUD™ MAXIMUM FACTORED COMPRESSIVE LOAD

Tstud™ Length m (ft)	No. 2 SPF Lumber kN (lb)	1650fb – 1.5E SPF Lumber kN (lb)
≤ 3.05 (10)	23.2 (5,215) <sup>(1)</sup>	23.2 (5,215) <sup>(1)</sup>
3.66 (12)	23.2 (5,215) <sup>(1)</sup>	23.2 (5,215) <sup>(1)</sup>
4.27 (14)	18.9 (4,250)	23.2 (5,215) <sup>(1)</sup>
4.88 (16)	15.0 (3,370)	18.4 (4,140)

SI: 1" = 25.4 mm, 1 lb = 4.448 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:

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

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 in 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 4. LSD FACTORED AXIAL LOAD FOR WALLS SUBJECT TO WIND PRESSURES – NO. 2 LUMBER

Stud Spacing mm (in)	Wall Height m (ft)	Factored Axial Load (kN) & (Deflection Ratio)									
		Specified Wind Pressure, p (kPa)									
		0.30	0.58	0.86	1.13	1.41	1.69	1.97	2.24	2.52	2.80
300 (12)	2.44 (8)	23.15 (L/7595)	23.15 (L/3944)	23.15 (L/2663)	23.15 (L/2011)	23.15 (L/1615)	23.15 (L/1349)	23.15 (L/1159)	23.15 (L/1015)	23.15 (L/903)	23.15 (L/814)
	2.74 (9)	23.15 (L/5260)	23.15 (L/2731)	23.15 (L/1845)	23.15 (L/1392)	23.15 (L/1118)	23.15 (L/934)	23.15 (L/802)	22.1 (L/703)	21.1 (L/626)	20.05 (L/564)
	3.05 (10)	23.15 (L/3792)	23.15 (L/1969)	23.15 (L/1330)	22.9 (L/1004)	21.65 (L/806)	20.35 (L/674)	19.1 (L/578)	17.8 (L/507)	16.55 (L/451)	15.3 (L/406)
	3.66 (12)	21.35 (L/2158)	19.5 (L/1121)	17.65 (L/757)	15.8 (L/571)	13.95 (L/459)	12.1 (L/383)	10.25 (L/329)	8.4 (L/289)	6.55 (L/257)	4.7 (L/231)
	4.27 (14)	16.1 (L/1343)	13.6 (L/697)	11.05 (L/471)	8.5 (L/356)	6 (L/286)	3.45 (L/239)	0.9 (L/205)	--	--	--
	4.88 (16)	11.4 (L/892)	8.05 (L/463)	4.75 (L/313)	1.4 (L/236)	--	--	--	--	--	--
400 (16)	2.44 (8)	23.15 (L/5697)	23.15 (L/2958)	23.15 (L/1997)	23.15 (L/1508)	23.15 (L/1211)	23.15 (L/1012)	23.15 (L/869)	23.15 (L/761)	22.75 (L/678)	21.7 (L/610)
	2.74 (9)	23.15 (L/3945)	23.15 (L/2049)	23.15 (L/1383)	23.15 (L/1044)	23.15 (L/839)	22.1 (L/701)	20.7 (L/602)	19.35 (L/527)	18 (L/469)	16.65 (L/423)
	3.05 (10)	23.15 (L/2844)	23.15 (L/1477)	22.85 (L/997)	21.15 (L/753)	19.5 (L/605)	17.8 (L/505)	16.1 (L/434)	14.4 (L/380)	12.7 (L/338)	11 (L/305)
	3.66 (12)	20.7 (L/1619)	18.2 (L/841)	15.75 (L/568)	13.3 (L/429)	10.85 (L/344)	8.35 (L/288)	5.9 (L/247)	3.45 (L/216)	0.95 (L/193)	--
	4.27 (14)	15.2 (L/1007)	11.8 (L/523)	8.45 (L/353)	5.05 (L/267)	1.7 (L/214)	--	--	--	--	--
	4.88 (16)	10.2 (L/669)	5.75 (L/347)	1.3 (L/235)	--	--	--	--	--	--	--
600 (24)	2.44 (8)	23.15 (L/3798)	23.15 (L/1972)	23.15 (L/1332)	23.15 (L/1005)	23.15 (L/807)	22.75 (L/675)	21.15 (L/579)	19.55 (L/508)	17.95 (L/452)	16.35 (L/407)
	2.74 (9)	23.15 (L/2630)	23.15 (L/1366)	23.15 (L/922)	22.05 (L/696)	20 (L/559)	17.95 (L/467)	15.9 (L/401)	13.85 (L/352)	11.85 (L/313)	9.8 (L/282)
	3.05 (10)	23.15 (L/1896)	22.8 (L/985)	20.25 (L/665)	17.7 (L/502)	15.2 (L/403)	12.65 (L/337)	10.1 (L/289)	7.55 (L/253)	5.05 (L/226)	2.5 (L/203)
	3.66 (12)	19.35 (L/1079)	15.65 (L/560)	11.95 (L/378)	8.25 (L/286)	4.55 (L/229)	0.85 (L/192)	--	--	--	--
	4.27 (14)	13.4 (L/672)	8.3 (L/349)	3.25 (L/236)	--	--	--	--	--	--	--
	4.88 (16)	7.8 (L/446)	1.15 (L/232)	--	--	--	--	--	--	--	--

SI: 25.4 mm = 1 in, 1 N = 0.225 lb, 1 MPa = 145 psi

- The specified wind pressures provided above are for ultimate limit states (ULS), which uses an importance factor of 1, and are used to determine the allowable axial load in accordance with NBC Division B Article 4.1.7.3. The deflection ratio is based on serviceability limit states (SLS) per NBC Article 4.1.3.5, which uses an importance factor of 0.75 when determining specified wind pressure.

TABLE 5. LSD FACTORED AXIAL LOAD FOR WALLS SUBJECT TO WIND PRESSURES – 1650F – 1.5E LUMBER

Stud Spacing mm (in)	Wall Height m (ft)	Factored Axial Load (kN) & (Deflection Ratio)									
		Specified Wind Pressure, p (kPa)									
		0.30	0.58	0.86	1.13	1.41	1.69	1.97	2.24	2.52	2.80
300 (12)	2.44 (8)	23.15 (L/7655)	23.15 (L/3975)	23.15 (L/2680)	23.15 (L/2025)	23.15 (L/1625)	23.15 (L/1360)	23.15 (L/1165)	23.15 (L/1020)	23.15 (L/910)	23.15 (L/820)
	2.74 (9)	23.15 (L/5300)	23.15 (L/2750)	23.15 (L/1855)	23.15 (L/1400)	23.15 (L/1125)	23.15 (L/940)	23.15 (L/805)	23.15 (L/705)	23.15 (L/630)	23.15 (L/565)
	3.05 (10)	23.15 (L/3820)	23.15 (L/1980)	23.15 (L/1340)	23.15 (L/1010)	23.15 (L/810)	23.15 (L/675)	23.15 (L/580)	23.15 (L/510)	23.15 (L/450)	23.15 (L/405)
	3.66 (12)	23.15 (L/2175)	23.15 (L/1125)	23.15 (L/760)	23.15 (L/575)	21.65 (L/460)	19.8 (L/385)	17.95 (L/330)	16.1 (L/290)	14.25 (L/255)	12.4 (L/230)
	4.27 (14)	21.25 (L/1350)	18.7 (L/700)	16.15 (L/470)	13.65 (L/355)	11.1 (L/285)	8.55 (L/240)	6 (L/205)	3.5 (L/180)	0.95 (L/160)	--
	4.88 (16)	14.75 (L/895)	11.45 (L/465)	8.1 (L/315)	4.75 (L/235)	1.45 (L/190)	--	--	--	--	--
400 (16)	2.44 (8)	23.15 (L/5740)	23.15 (L/2980)	23.15 (L/2010)	23.15 (L/1520)	23.15 (L/1220)	23.15 (L/1020)	23.15 (L/875)	23.15 (L/765)	23.15 (L/680)	23.15 (L/615)
	2.74 (9)	23.15 (L/3975)	23.15 (L/2065)	23.15 (L/1390)	23.15 (L/1050)	23.15 (L/845)	23.15 (L/705)	23.15 (L/605)	23.15 (L/530)	23.15 (L/470)	23.15 (L/425)
	3.05 (10)	23.15 (L/2865)	23.15 (L/1485)	23.15 (L/1005)	23.15 (L/755)	23.15 (L/605)	23.15 (L/505)	23.15 (L/435)	23.15 (L/380)	23.15 (L/340)	22.2 (L/305)
	3.66 (12)	23.15 (L/1630)	23.15 (L/845)	23.15 (L/570)	21 (L/430)	18.55 (L/345)	16.05 (L/285)	13.6 (L/245)	11.15 (L/215)	8.65 (L/190)	6.2 (L/170)
	4.27 (14)	20.3 (L/1015)	16.95 (L/525)	13.55 (L/355)	10.2 (L/265)	6.8 (L/215)	3.4 (L/180)	0.05 (L/150)	--	--	--
	4.88 (16)	13.55 (L/670)	9.1 (L/350)	4.7 (L/235)	0.25 (L/175)	--	--	--	--	--	--
600 (24)	2.44 (8)	23.15 (L/3825)	23.15 (L/1985)	23.15 (L/1340)	23.15 (L/1010)	23.15 (L/810)	23.15 (L/680)	23.15 (L/580)	23.15 (L/510)	23.15 (L/455)	23.15 (L/410)
	2.74 (9)	23.15 (L/2650)	23.15 (L/1375)	23.15 (L/925)	23.15 (L/700)	23.15 (L/560)	23.15 (L/470)	23.15 (L/400)	23.15 (L/350)	23.15 (L/315)	22.95 (L/280)
	3.05 (10)	23.15 (L/1910)	23.15 (L/990)	23.15 (L/670)	23.15 (L/505)	23.15 (L/405)	23.15 (L/335)	21.3 (L/290)	18.75 (L/255)	16.25 (L/225)	13.7 (L/200)
	3.66 (12)	23.15 (L/1085)	23.15 (L/560)	19.65 (L/380)	15.95 (L/285)	12.25 (L/230)	8.6 (L/190)	4.9 (L/165)	1.2 (L/145)	--	--
	4.27 (14)	18.5 (L/675)	13.4 (L/350)	8.35 (L/235)	3.3 (L/175)	--	--	--	--	--	--
	4.88 (16)	11.15 (L/445)	4.5 (L/230)	--	--	--	--	--	--	--	--

SI: 25.4 mm = 1 in, 1 N = 0.225 lb, 1 MPa = 145 psi

- The specified wind pressures provided above are for ultimate limit states (ULS), which uses an importance factor of 1, and are used to determine the allowable axial load in accordance with NBC Division B Article 4.1.7.3. The deflection ratio is based on serviceability limit states (SLS) per NBC Article 4.1.3.5, which uses an importance factor of 0.75 when determining specified wind pressure.

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

Number of Members	Factored Header Load (kN/m) & (Deflection Ratio)							
	Header Span, m (ft)							
	0.61 (2)	0.91 (3)	1.22 (4)	1.52 (5)	1.83 (6)	2.13 (7)	2.44 (8)	2.74 (9)
1	5.2 (L/1367)	3.5 (L/609)	2.6 (L/342)	1.4 (L/320)	0.8 (L/320)	0.5 (L/320)	0.3 (L/320)	0.2 (L/320)
2	10.3 (L/1367)	6.9 (L/609)	5.2 (L/342)	2.8 (L/320)	1.6 (L/320)	1 (L/320)	0.7 (L/320)	0.5 (L/320)
3	15.5 (L/1367)	10.4 (L/609)	7.8 (L/342)	4.3 (L/320)	2.5 (L/320)	1.5 (L/320)	1 (L/320)	0.7 (L/320)
4	20.7 (L/1367)	13.8 (L/609)	10.4 (L/342)	5.7 (L/320)	3.3 (L/320)	2.1 (L/320)	1.4 (L/320)	1 (L/320)
5	25.9 (L/1367)	17.3 (L/609)	12.9 (L/342)	7.1 (L/320)	4.1 (L/320)	2.6 (L/320)	1.7 (L/320)	1.2 (L/320)
6	31 (L/1367)	20.7 (L/609)	15.5 (L/342)	8.5 (L/320)	4.9 (L/320)	3.1 (L/320)	2.1 (L/320)	1.5 (L/320)
7	36.2 (L/1367)	24.2 (L/609)	18.1 (L/342)	9.9 (L/320)	5.7 (L/320)	3.6 (L/320)	2.4 (L/320)	1.7 (L/320)
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. 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, 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 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 purposes 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 TER, 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 Tstud™ is used as a top plate, a separate means of fireblocking shall be provided in accordance with NBC Subsection 3.1.11.
- 9.3 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.
- 9.4 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.
- 9.5 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*).
- 9.6 At a minimum, this product shall be installed per Section 6 of this TER.
- 9.7 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.
- 9.8 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.
- 9.9 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.
- 10.2 Additional technical information can be found at [www.tstud.com](http://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](http://drjcertification.org).
- 11.2 For information on the current status of this TER, contact [DrJ Certification](http://DrJ Certification).

## APPENDIX A: TSTUD™ EXAMPLE CALCULATION

Determine the factored axial load for a 2.4 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).

$s := 610 \text{ mm}$	Stud spacing
$p_{uls} := 2.80 \text{ kPa}$	Specified wind pressure, ultimate limit state
$I_W := 0.75$	Importance factor for wind load, Normal, SLS
$p_{sls} := I_W \cdot p_{uls} = 2.1 \text{ kPa}$	Specified wind pressure, serviceability limit state
$w := 1.4 \cdot p_{uls} \cdot s = 2391 \frac{\text{N}}{\text{m}}$	Factored wind load

### Material Properties of Tstud™:

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

$f_b S := 2215 \text{ N} \cdot \text{m}$	Specified bending
$f_c := 11.5 \text{ MPa}$	Specified compression parallel to grain
$f_t := 5.5 \text{ MPa}$	Specified tension parallel to grain
$f_{cp} := 5.3 \text{ MPa}$	Specified compression perpendicular to grain
$V_c := 2630 \text{ N}$	Specified shear force
$EI := 86900 \text{ N} \cdot \text{m}^2$	Bending stiffness
$EI_{05} := 75600 \text{ N} \cdot \text{m}^2$	Bending stiffness for beam and column stability
$I := 9005799 \text{ mm}^4$	Moment of inertia
$E_{05} := \frac{EI_{05}}{I} = 8395 \text{ MPa}$	Modulus of elasticity for design of compression members

### Section Properties of Tstud™:

$d := 5.5 \text{ in} = 140 \text{ mm}$	Effective depth of stud
$d_1 := 1.5 \text{ in} = 38 \text{ mm}$	Wide face dimension
$d_2 := 2.5 \text{ in} = 64 \text{ mm}$	Narrow face dimension
$d_{dowel} := \frac{11}{16} \text{ in} = 17 \text{ mm}$	Dowel diameter
$A := (d_1 \cdot d_2) + ((d_2 - d_{dowel}) \cdot d_1) = 4173 \text{ mm}^2$	Net section area of Tstud™
$h := 2340 \text{ mm} = 8 \text{ ft}$	Height of Tstud™

### Bending Moment Resistance:

$\phi := 0.90$	
$K_D := 1.15$	Load duration factor for short term
$K_H := 1.04$	System factor for load-sharing system

$K_{Sb} := 1.0$	Service condition factor for dry, bending at extreme fiber
$K_T := 1.0$	Treatment factor for untreated lumber products
$F_b S := f_b S \cdot (K_D \cdot K_H \cdot K_{Sb} \cdot K_T) = 2649 \text{ N} \cdot \text{m}$	
$K_{Zb} := 1.4$	Size factor in bending
$K_L := 1$	Lateral stability factor assuming lateral support
$M_r := \phi \cdot F_b S \cdot K_{Zb} \cdot K_L = 3338 \text{ N} \cdot \text{m}$	Bending moment resistance, CSA O86 Section 15.3.3.1

#### Compressive Resistance Parallel to Grain:

$\phi := 0.80$	
$K_e := 1.00$	Effective length factor
$K_D := 1.00$	Load duration factor for standard term
$K_{sc} := 1.00$	Service condition factor for dry, compression parallel to grain
$K_T := 1.0$	Treatment factor for untreated lumber products
$F_c := f_c \cdot (K_D \cdot K_{sc} \cdot K_T) = 11.5 \text{ MPa}$	
$K_{Zc} := 1.0$	Size factor for compression parallel to grain
$L_e := K_e \cdot h = 2340 \text{ mm}$	Effective length
$C_C := \frac{L_e}{d} = 17$	Slenderness ratio
$K_{SE} := 1.0$	Service condition factor for dry, MOE
$K_C := \left( 1.0 + \frac{F_c \cdot K_{Zc} \cdot C_C^3}{35 \cdot E_{05} \cdot K_{SE} \cdot K_T} \right)^{-1} = 0.84$	Slenderness factor
$P_r := \phi \cdot F_c \cdot A \cdot K_C \cdot K_{Zc} = 32430 \text{ N}$	Factored compressive resistance parallel to grain, CSA O86 Section 15.3.3.4

#### Compressive Resistance Perpendicular to Grain:

$\phi := 0.80$	
$K_D := 1.00$	Load duration factor for standard term
$K_S := 1.0$	Service condition factor for dry service
$K_T := 1.0$	Treatment factor for untreated lumber products
$F_{cp} := f_{cp} \cdot (K_D \cdot K_S \cdot K_T)$	
$A_b := 2 \cdot d_1 \cdot d_2 = 4839 \text{ mm}^2$	Bearing area
$K_B := 1.13$	Length of bearing factor
$K_{Zcp} := 1$	Size factor for bearing
$Q_r := \phi \cdot F_{cp} \cdot A_b \cdot K_B \cdot K_{Zcp} = 23183 \text{ N}$	Compressive resistance perpendicular to grain, CSA O86 Section 15.3.3.6



Resistance to Combined Bending and Axial Load:

$$P_f := 16.35 \text{ kN} = 16350 \text{ N}$$

Factored axial load on the Tstud™ is 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

$$P_E := \frac{(\pi^2 \cdot E_{05} \cdot K_{SE} \cdot K_T \cdot I)}{L_e^2} = 136267 \text{ N}$$

Euler buckling load in the plane of the applied moment

$$M_f := \frac{(w \cdot h^2)}{8} = 1637 \text{ N} \cdot \text{m}$$

Factored bending moment

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

Resistance to combined bending and axial load, CSA O86 Section 15.3.3.9

Deflection Limit:

$$\Delta := \frac{5 \cdot (p_{sls} \cdot s) \cdot h^4}{384 \cdot EI} = 5.755 \text{ mm}$$

Deflection

$$\frac{h}{\Delta} = 407 > 240 \quad \text{OK}$$

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.