# How to use the Mass Timber Fastening Design Guide ?

October 7th, 2021

# JEAN-PHILIPPE LETARTE

EIT

Engineering & Technical Service Manager

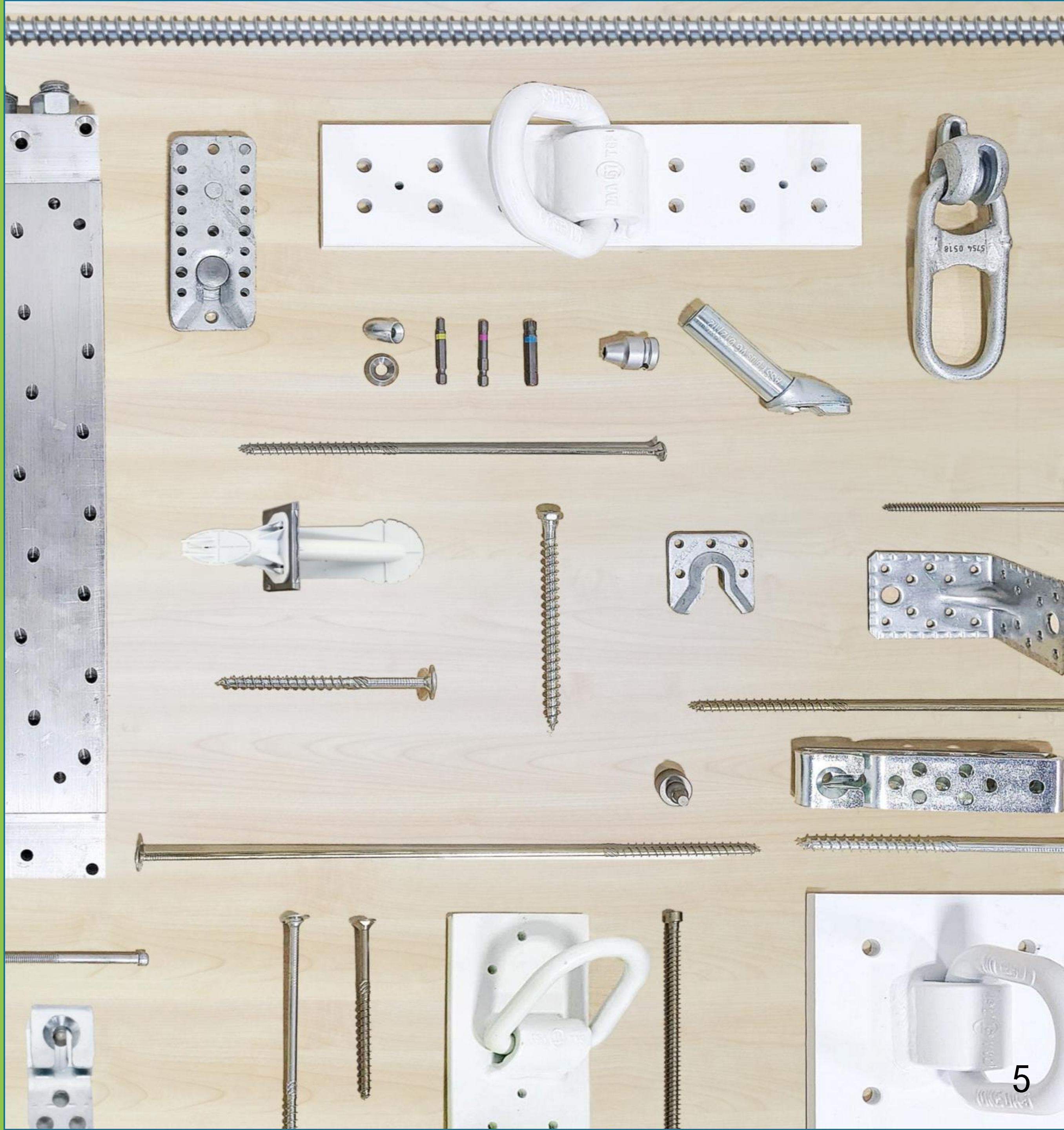

## Products

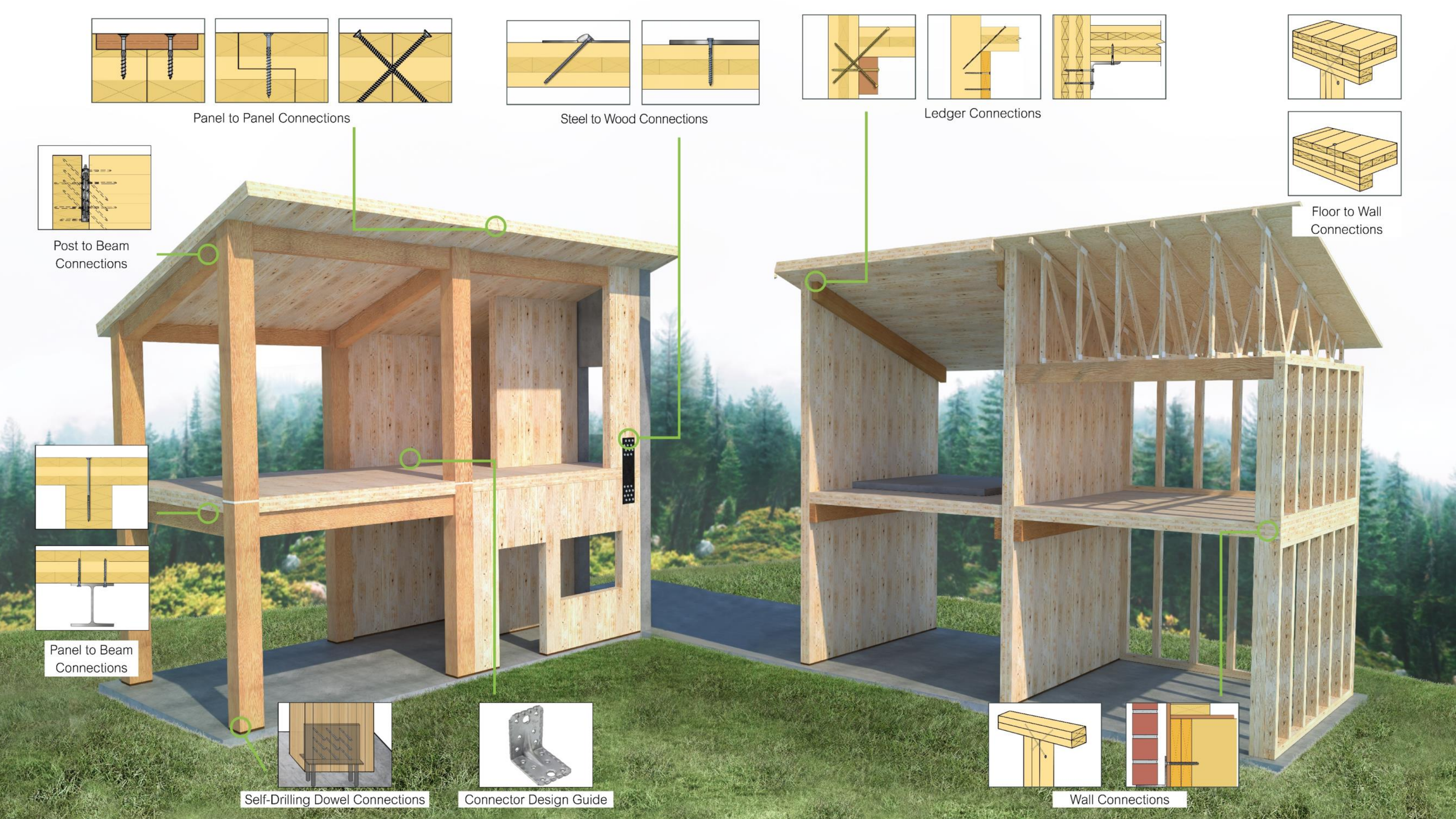
- Structural Fasteners
- Beam Hangers
- Rigging Devices
- Connectors
- Fall Arrest
- Accessories


STANDARDIZING
MASS TIMBER
CONNECTIONS
TESTED & PROVEN
ICC ES
Code Approved Products
Tested Solutions
Cost Competitive Connections
Technical Support
Experience in Key Projects
Detailed Design Guides
MTC SOLUTIONS

# Presentation Outline

1. MTC Solutions Projects
2. Design Guides
3. Example Calculations
4. Working Together




Panel to Panel Connections
Steel to Wood Connections
Ledger Connections
Floor to Wall Connections
Post to Beam Connections
Panel to Beam Connections
Self-Drilling Dowel Connections
Connector Design Guide
Wall Connections


First Tech Credit Union
Hillsboro, Oregon
Courtesy of Swinerton

# Tour Origine

Quebec, Quebec City

Courtesy of Stéphane Groleau

# Tour Origine

Quebec, Quebec City

Courtesy of Stéphane Groleau

# UBC Brock Commons

Vancouver, British Columbia

# Fastener Line

AVAILABLE IN MULTIPLE SIZES

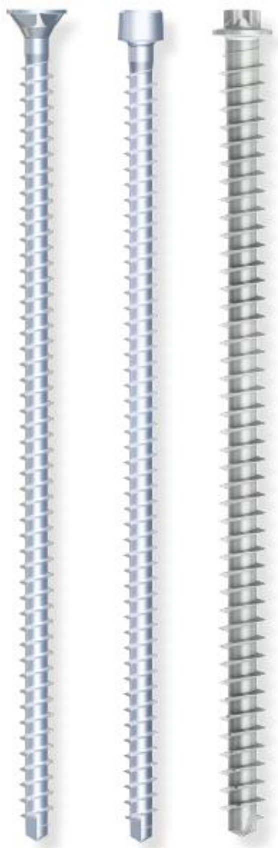
TESTED IN NORTH AMERICA

# Product – ASSY Screws

## Self-Tapping Wood Screws

### Partially Threaded (PT)

### Fully Threaded (FT)



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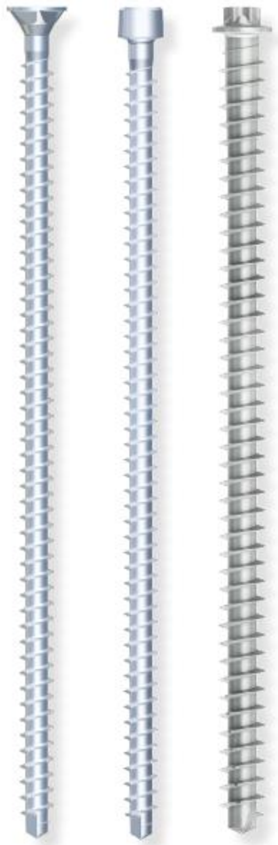
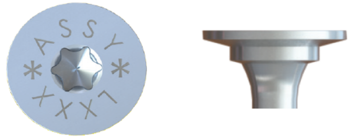


Countersunk Head

Washer Head

Cylinder Head

Reverse Head



Flat Washer Head

Kombi Hex Head

# Product – ASSY Screws

## ICC & CCMC Approval for ASSY Fasteners

### ICC, Fully Threaded Screws

ES ICC EVALUATION SERVICE®

**ICC-ES Evaluation Report** **ESR-3178**

*Reissued October 2020*
*Revised February 2021*
*This report is subject to renewal October 2022.*

www.icc-es.org | (800) 423-6587 | (562) 699-0543 *A Subsidiary of the International Code Council®*

### ICC, Partially Threaded Screws

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### CCMC, All Fasteners

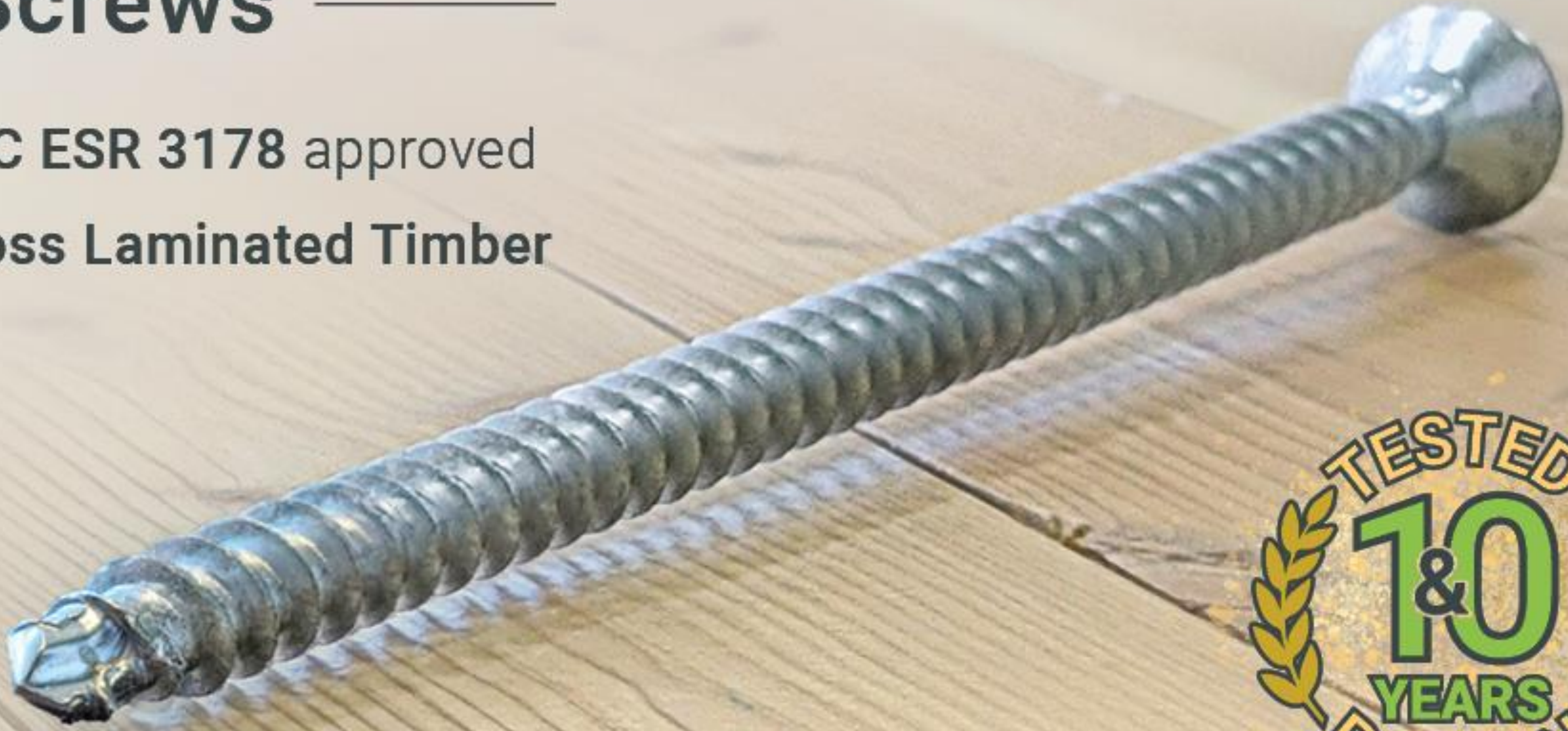
CONSTRUCTION

NRC·CNRC

**Evaluation Report CCMC 13677-R**
**SWG ASSY® VG Plus and SWG ASSY® 3.0 Self-Tapping Wood Screws**

# ASSY Fully Threaded Screws

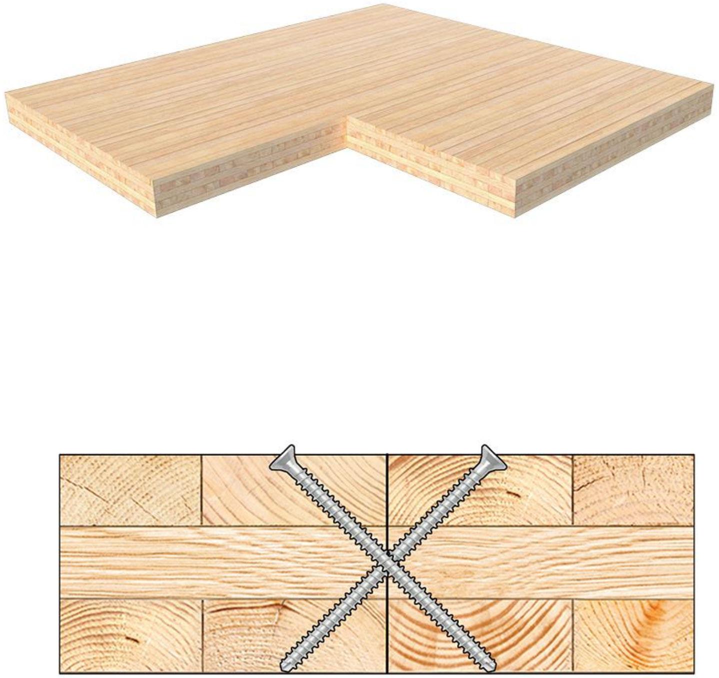
Now also **ICC ESR 3178** approved
for use in **Cross Laminated Timber**



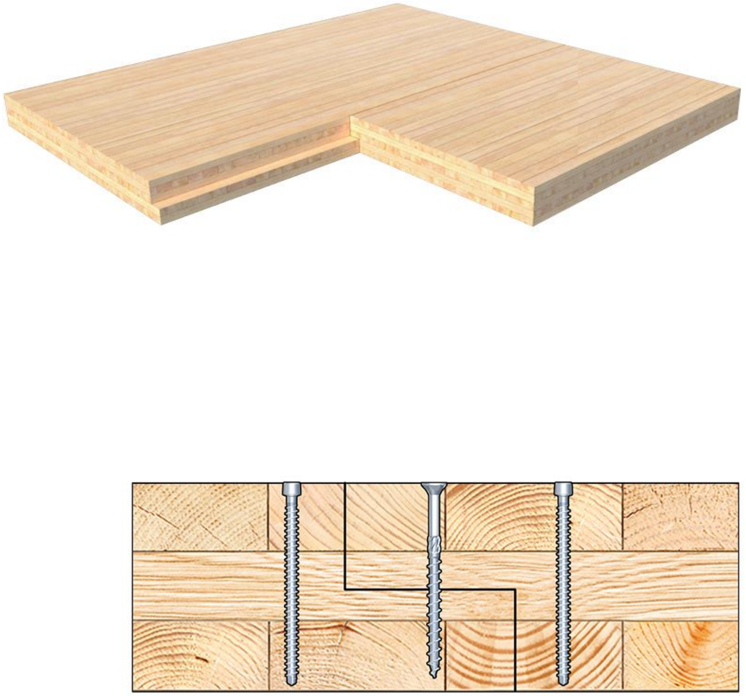
TESTED
10 YEARS
PROVEN

# Panel to Panel Connections

Butt Joint Connection

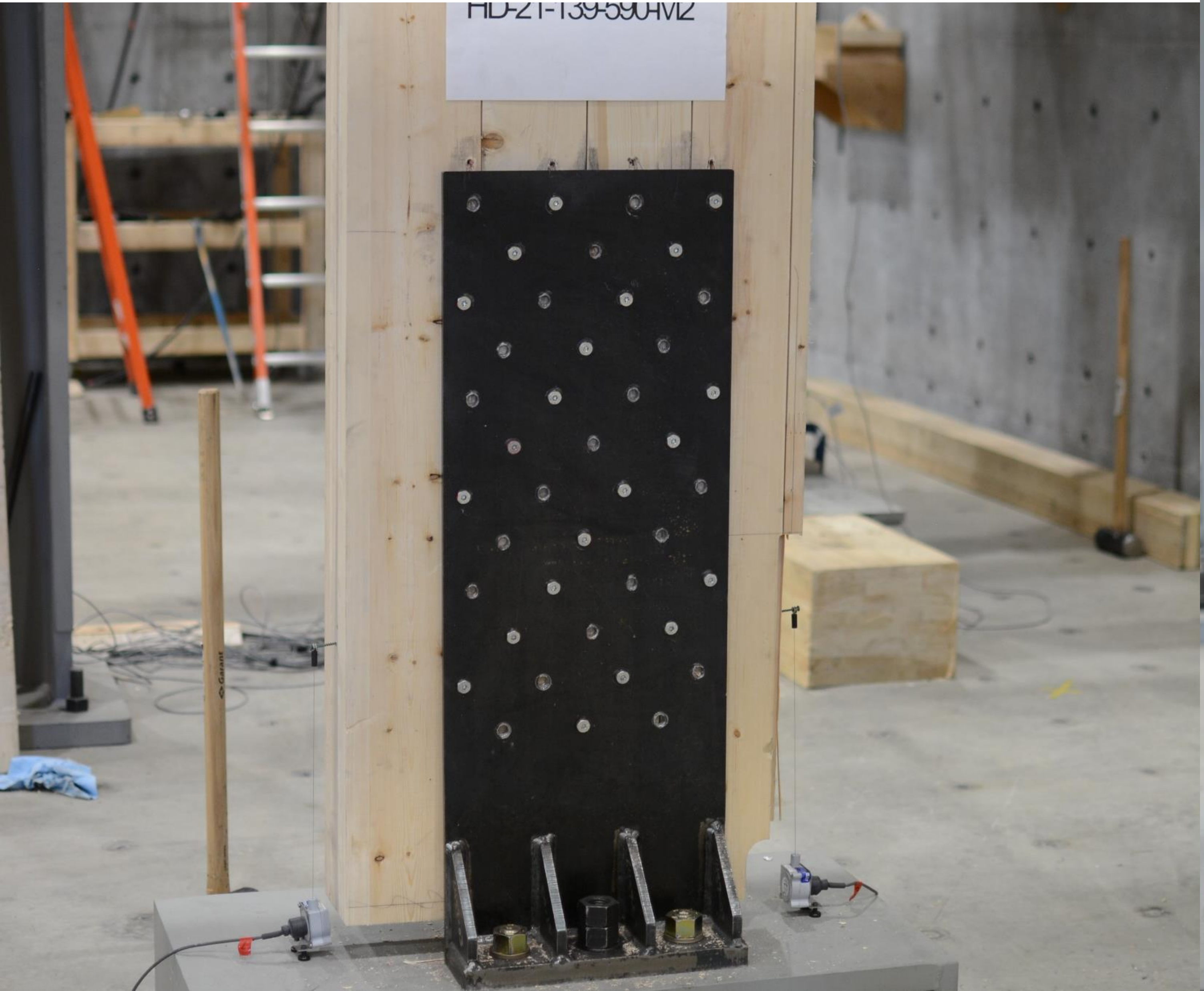


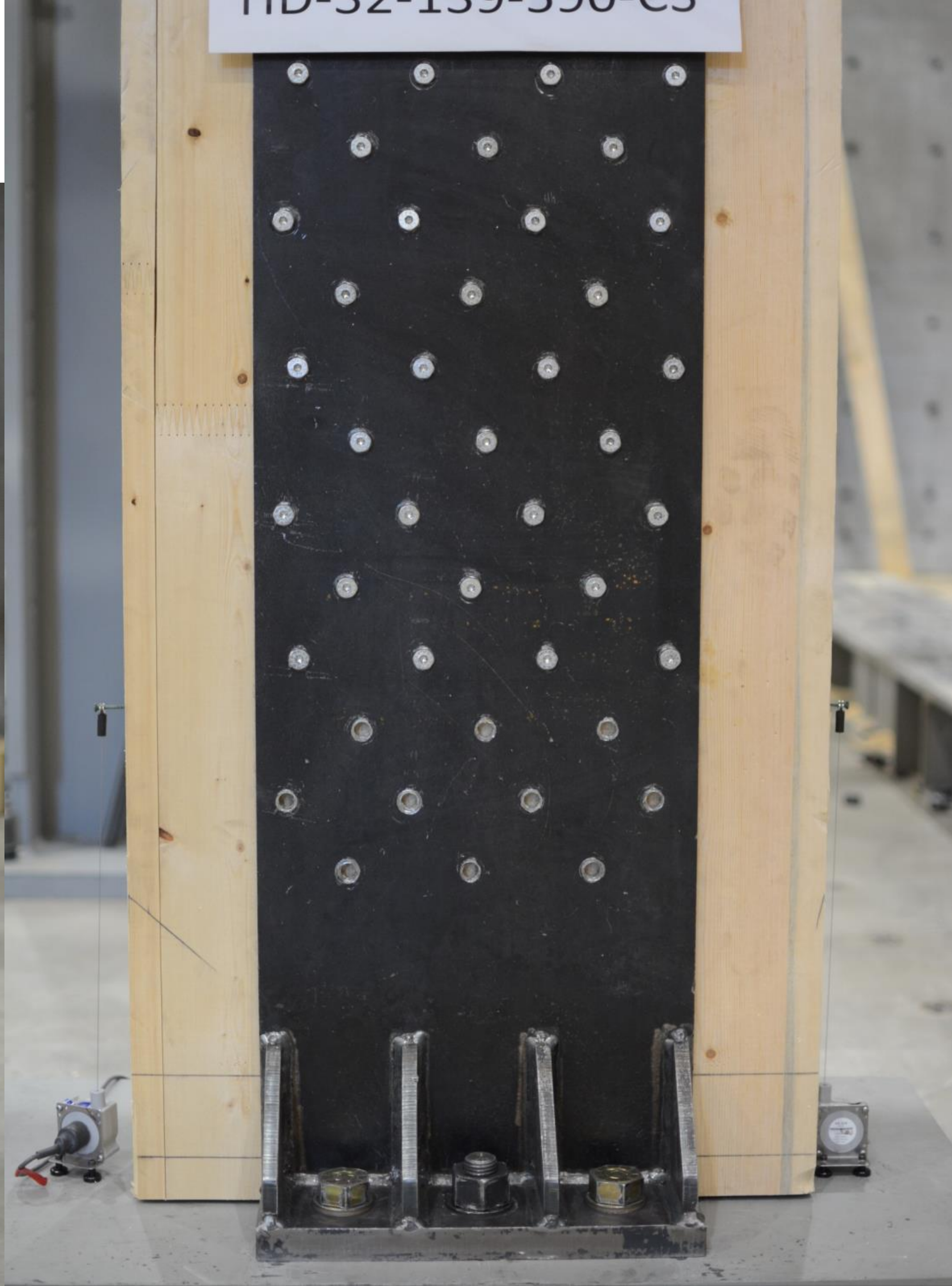
Lap Joint Connection



Plywood Spline Connection

# Mass Timber Hold Downs

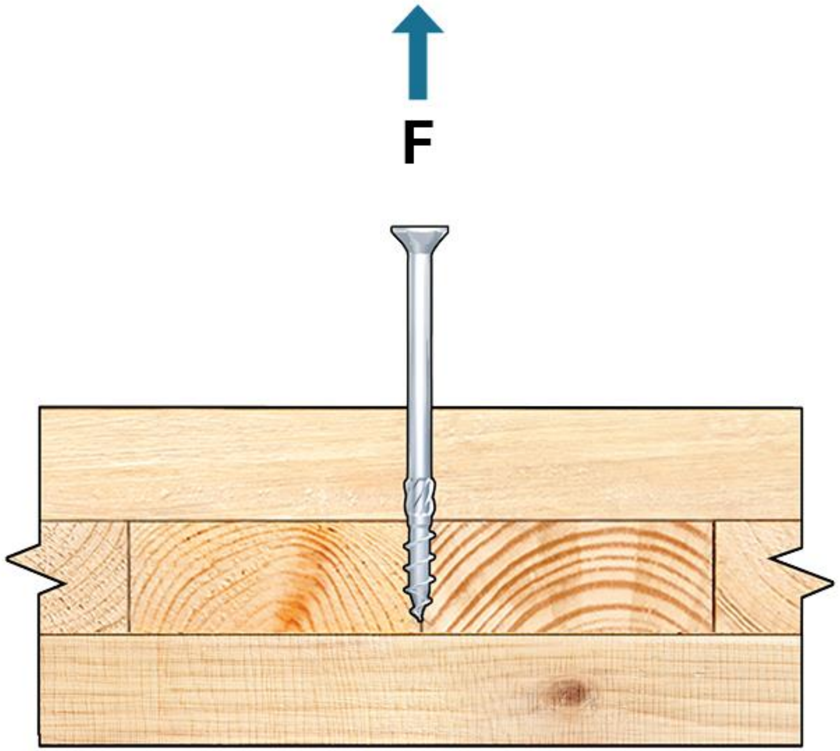




# Structural Screw

## Basic Connections

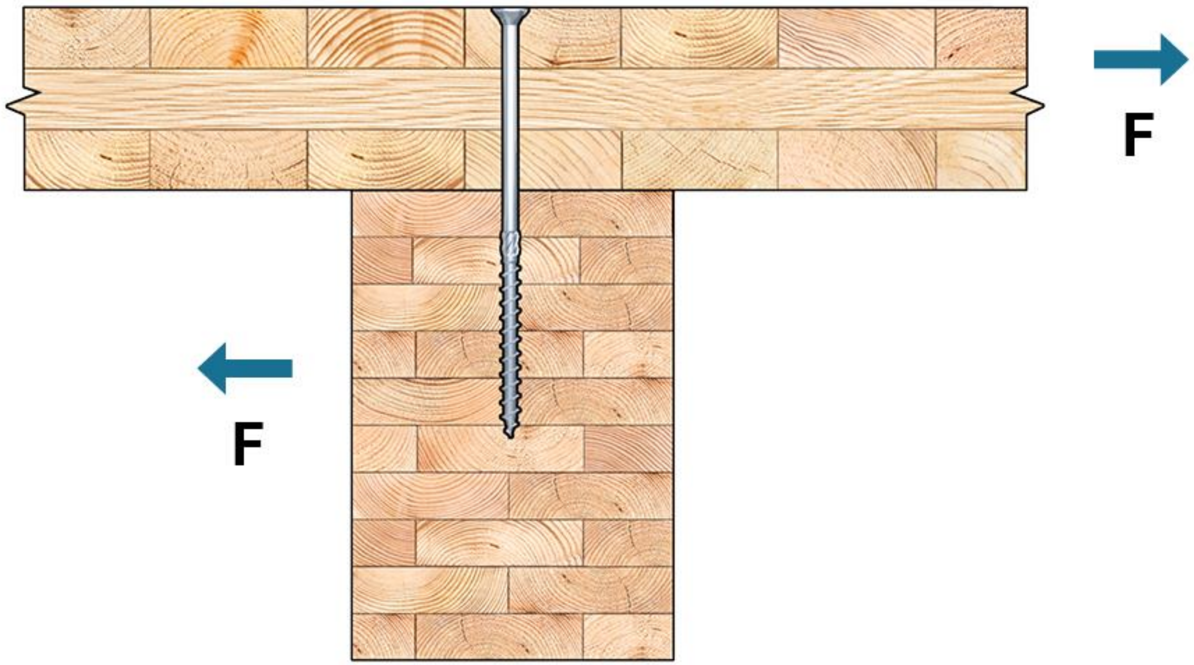
- Axial connection with fastener loaded in withdrawal



# Structural Screw

## Basic Connections

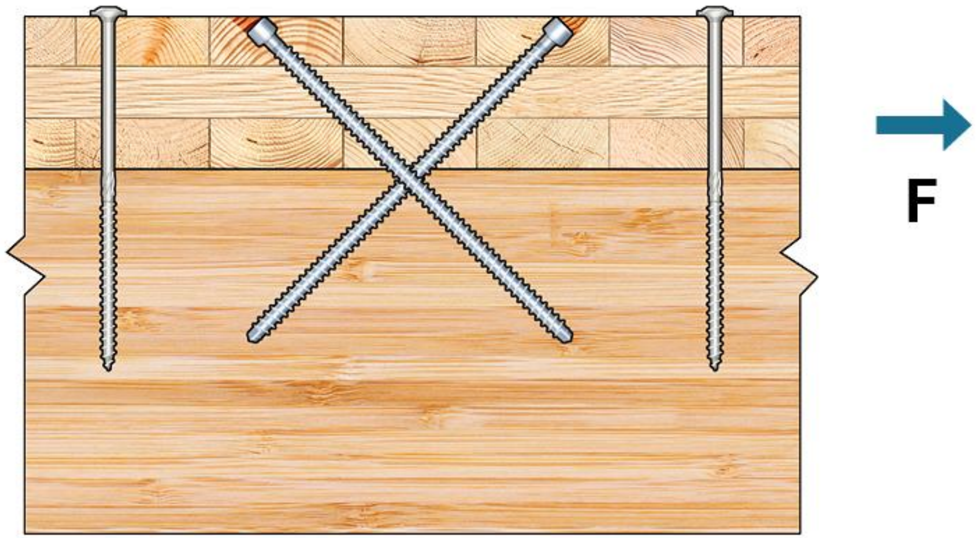
- Axial connection with fastener loaded in withdrawal
- Lateral connection with fastener loaded in shear



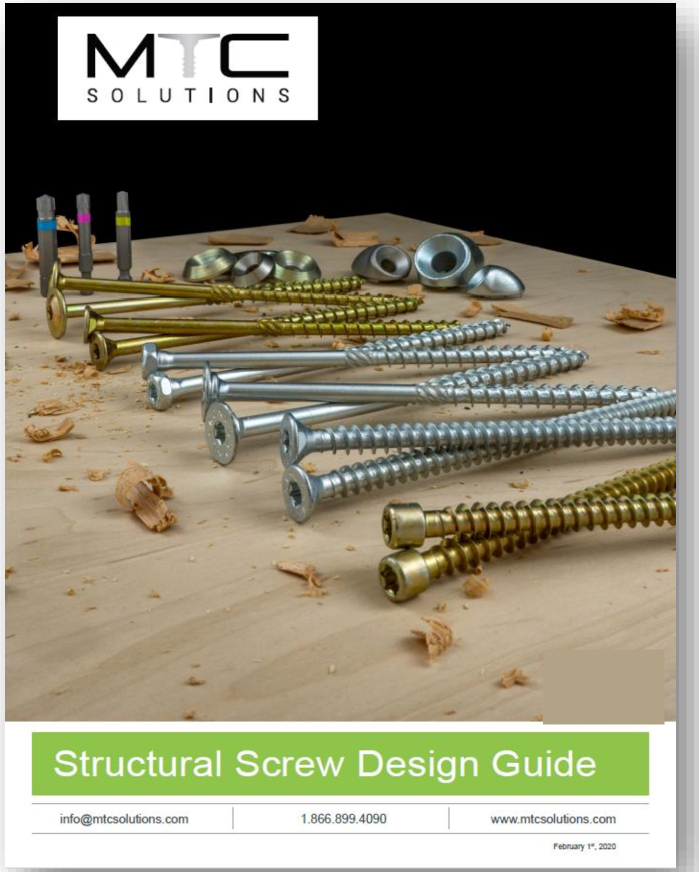
# Structural Screw

## Basic Connections

- Axial connection with fastener loaded in withdrawal
- Lateral connection with fastener loaded in shear
- Lateral connection with fastener loaded in withdrawal



# Knowledge Database - Design Guides




Structural Screw Design Guide


Structural Mass Timber Fastening Design Guide

# Knowledge Database - Design Guides


Structural Screw Design Guide

## ASSY® REFERENCE DESIGN VALUES

## ASSY® Withdrawal Design (**W**)

**Table RDV.1.1, ASSY® Reference Withdrawal Design Values with Angle to Grain of 90° ($W_{90}$)**

| Major Diameter | Reference Withdrawal Design Values with Angle to Grain of 90° ($W_{90}$) lbs/in. | | | | |
|---|---|---|---|---|---|
| (D) | G = 0.35 | G = 0.42 | G = 0.49 | PSL (G ≥ 0.50) | G = 0.55 |
| 1/4” | 137 | 169 | 202 | 156 | 230 |
| 5/16” | 176 | 212 | 248 | 179 | 279 |
| 3/8” | 190 | 237 | 280 | 211 | 317 |
| 1/2” | 211 | 254 | 297 | 223 | 334 |

Note: see notes under the table RDV.1.2.

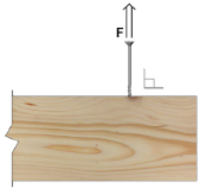
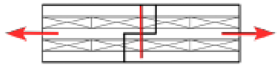
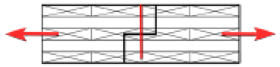


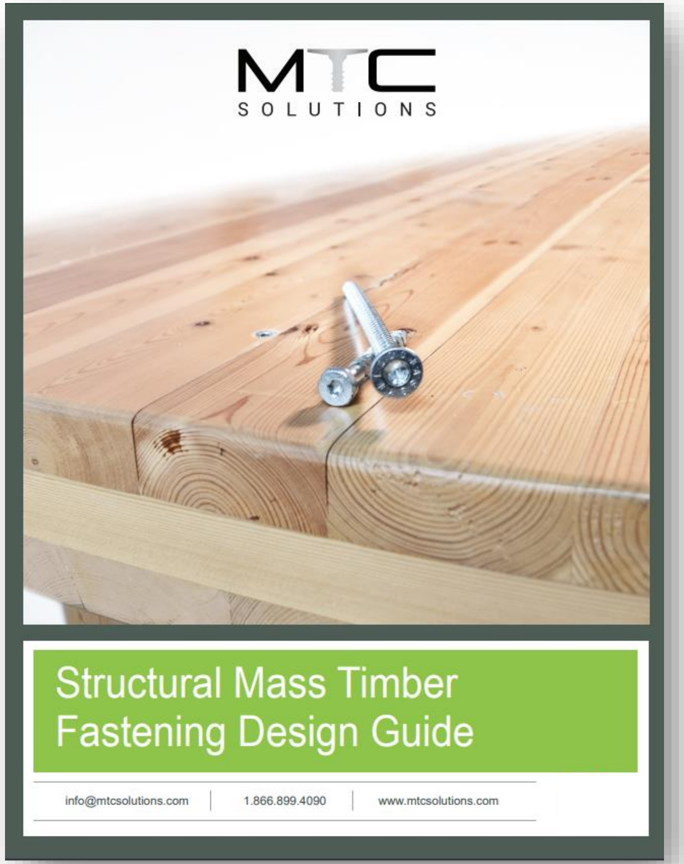

**Table RDV.1.2, ASSY® Angle to Grain Reduction Factor for Withdrawal at an angle of α° ($R_{\alpha}$)**

| tens | ones | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | _9° | _8° | _7° | _6° | _5° | _4° | _3° | _2° | _1° | _0° |
| 9_° | N/A | | | | | | | | | 1.000 |
| 8_° | 1.000 | 1.000 | 0.999 | 0.998 | 0.997 | 0.996 | 0.995 | 0.994 | 0.992 | 0.990 |
| 7_° | 0.988 | 0.986 | 0.983 | 0.981 | 0.978 | 0.975 | 0.972 | 0.969 | 0.966 | 0.962 |
| 6_° | 0.959 | 0.955 | 0.952 | 0.948 | 0.944 | 0.940 | 0.936 | 0.932 | 0.927 | 0.923 |
| 5_° | 0.919 | 0.914 | 0.910 | 0.906 | 0.901 | 0.897 | 0.892 | 0.888 | 0.883 | 0.879 |
| 4_° | 0.875 | 0.870 | 0.866 | 0.861 | 0.857 | 0.853 | 0.849 | 0.845 | 0.840 | 0.836 |
| 3_° | 0.832 | 0.829 | 0.825 | 0.821 | 0.817 | 0.814 | 0.810 | 0.807 | 0.803 | 0.800 |

# Knowledge Database - Design Guides

Table PP.4.2, Reference Design Values for CLT Lap Joints with Inclined Screw Crosses

| Panel & Joint Configuration: Loading | | | Panel Thickness (t) | Fastener Options | Reference Design Values [lbs]: Standard Loading $C_D$ =1.0 | Reference Design Values [lbs]: Short Term Loading $C_D$ =1.6 | Minimum Spacing in a Row ($S_P$) |
|---|---|---|---|---|---|---|---|
| 5 PLY | $Z_{//}$ |  | 5-1/2” | VG CSK 5/16” x 7-1/8” | 190 | 304 | 1-7/8” |
| | | | 6-7/8” | VG CSK 5/16” x 8-5/8” | 190 | 304 | 1-7/8” |
| | | | | VG CSK 3/8” x 8-5/8” | 251 | 402 | 2-1/4” |
| | $Z_{\perp}$ |  | 5-1/2” | VG CSK 5/16” x 7-1/8” | 152 | 243 | 1-7/8” |
| | | | 6-7/8” | VG CSK 5/16” x 8-5/8” | 152 | 243 | 1-7/8” |
| | | | | VG CSK 3/8” x 8-5/8” | 201 | 322 | 2-1/4” |




Structural Mass Timber Fastening Design Guide

# Structural Screw Design Guide

# Structural Screw Design Guide

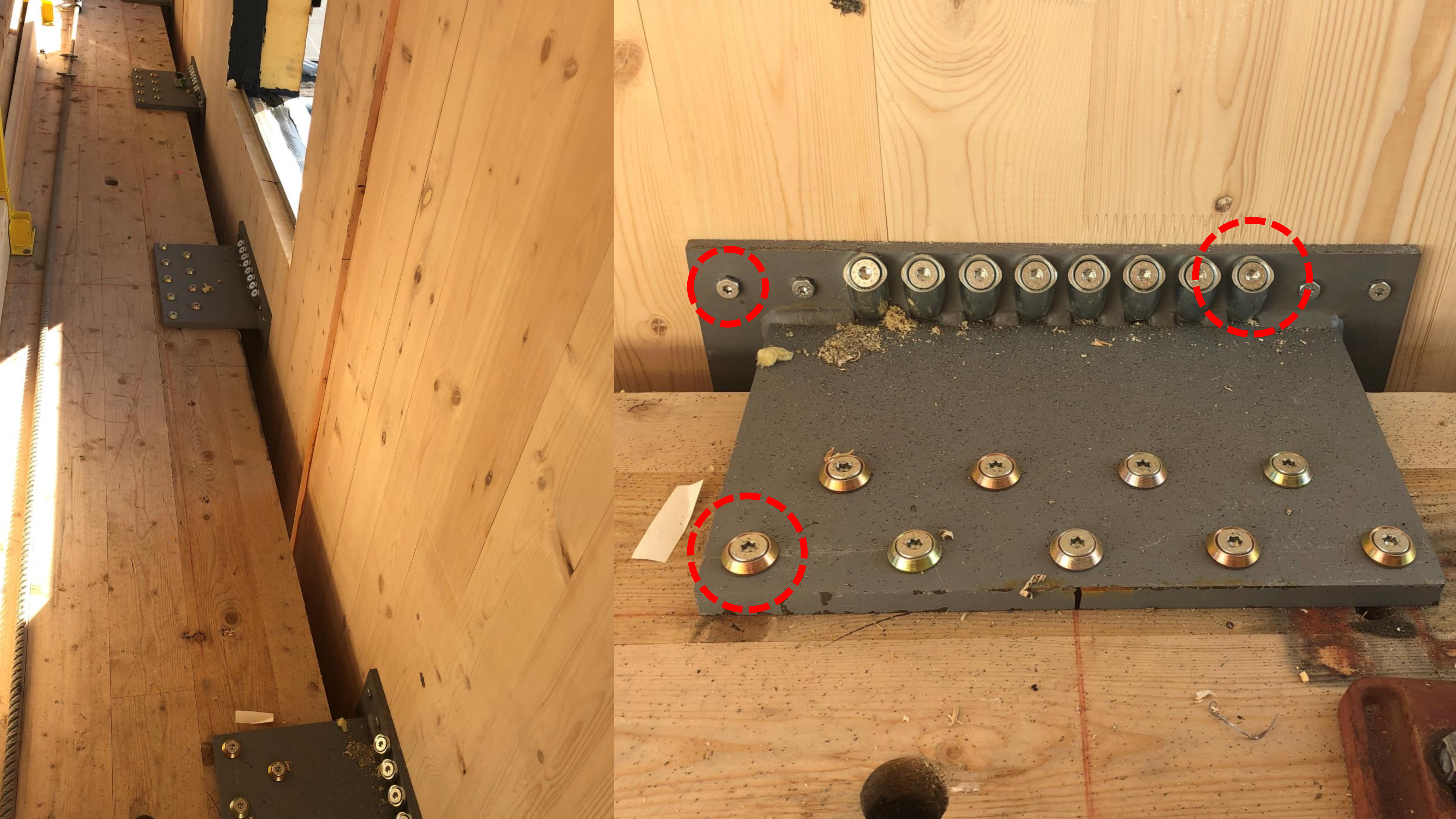
## North American Code Values

- NDS - 2018
- CSA O86 - 2019

CCMC ICC ES

## Custom Design

- All values needed for connection design



# Lateral Connections

## USA vs. CANADA

$$Z' = Z \cdot n_F \cdot n_R \cdot C'$$

$$N_r = N'_r \cdot n_F \cdot n_R \cdot J' \cdot K'$$

### USA

- Chapter 12 of NDS – 2018
- Number of effective fasteners
- Number of fasteners in a row
- Adjustment Factors (per NDS)

### CANADA

- Chapter 12.6 of CSA O86 - 2019
- Number of effective fasteners
- Number of fasteners in a row
- Composite modification factors

# Axially Loaded Connections

## USA vs. CANADA

$$W' = W_{90} \cdot R_{\alpha} \cdot l_{ef} \cdot n_F \cdot C'$$

$$P_{rw} = P'_{rw,90} \cdot R_{\alpha} \cdot L_{ef} \cdot n_F \cdot J' \cdot K'$$

### USA

- Reference Withdrawal Design Values
- Angle to Grain Reduction Factor
- Effective length of embedment
- Number of effective fasteners
- Adjustment Factors (per NDS)

### CANADA

- Unit Factored Withdrawal Resistance
- Angle to Grain Reduction Factor
- Effective length of embedment
- Number of effective fasteners
- Composite modification factors

# Axially Loaded Connections

## USA vs. CANADA

$$W' = W_{90} \cdot R_{\alpha} \cdot l_{ef} \cdot n_F \cdot C'$$

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## USA

| Major Diameter (D) | Reference Withdrawal Design Values with Angle to Grain of 90° ($W_{90}$) lbs/in. | | | | |
|---|---|---|---|---|---|
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| 1/4" | 137 | 169 | 202 | 156 | 230 |
| 5/16" | 176 | 212 | 248 | 179 | 279 |
| 3/8" | 190 | 237 | 280 | 211 | 317 |
| 1/2" | 211 | 254 | 297 | 223 | 334 |

## CANADA

| Major Diameter (d) | | Unit Factored Withdrawal Resistance with Angle to Grain of 90° ($P'_{rw,90}$) N/mm | | | | |
|---|---|---|---|---|---|---|
| in. | [mm] | G = 0.35 | G = 0.42 | G = 0.49 | PSL (G = 0.50) | G = 0.55 |
| 1/4" | [6] | 32 | 46 | 60 | 35 | 76 |
| 5/16" | [8] | 42 | 61 | 80 | 47 | 101 |
| 3/8" | [10] | 53 | 76 | 100 | 59 | 126 |
| 1/2" | [12] | 63 | 91 | 120 | 70 | 151 |
| 9/16" | [14] | 74 | 107 | 140 | 82 | 176 |

# Self-tapping Screw Properties

**Table RDV.3.1, ASSY® Allowable Tensile Strength**

| Major Diameter (D) | ASSY Partial Thread lbs. | ASSY Full Thread (VG) lbs. |
|---|---|---|
| **1/4”** | 1,150 | 1,165 |
| **5/16”** | 1,950 | 1,775 |
| **3/8”** | 2,780 | 2,550 |
| **1/2”** | 3,070 | 3,470 |

**Table RDV.3.2, ASSY® Allowable Shear Strength**

| Major Diameter | ASSY Partial Thread | | ASSY Full Thread (VG) | |
|---|---|---|---|---|
| | Shear | Specified Bending Yield Strength $F_{yb}$ | Shear | Specified Bending Yield Strength $F_{yb}$ |
| (D) | lbs. | psi | lbs. | psi |
| **1/4”** | 685 | 169,500 | 590 | 129,200 |
| **5/16”** | 1,320 | 150,200 | 1,105 | 132,500 |
| **3/8”** | 1,725 | 136,600 | 1,835 | 136,600 |
| **1/2”** | 2,095 | 166,300 | 2,095 | 166,300 |

**Table RDV.3.3, ASSY® Adjusted Torsional Strength**

| Screw Type | Adjusted Torsional Strength lbs·ft — Diameter | | | | |
|---|---|---|---|---|---|
| | **1/4”** | **5/16”** | **3/8”** | **1/2”** | **9/16”** |
| Partially Threaded | 5.90 | 13.57 | 26.55 | 38.50 | N/A |
| Fully Threaded | 5.90 | 13.57 | 26.55 | 44.25 | 67.85 |

# Self-tapping Screw Properties

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l Strength

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ngth

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# Self-tapping Screw Properties

- Tensile strength
- Shear strength
- Torsional strength

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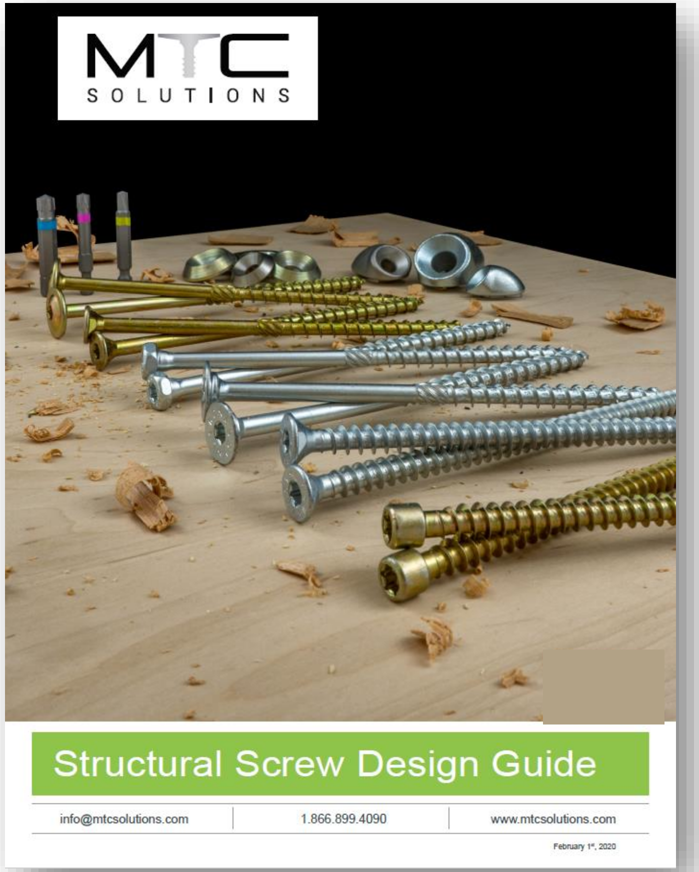
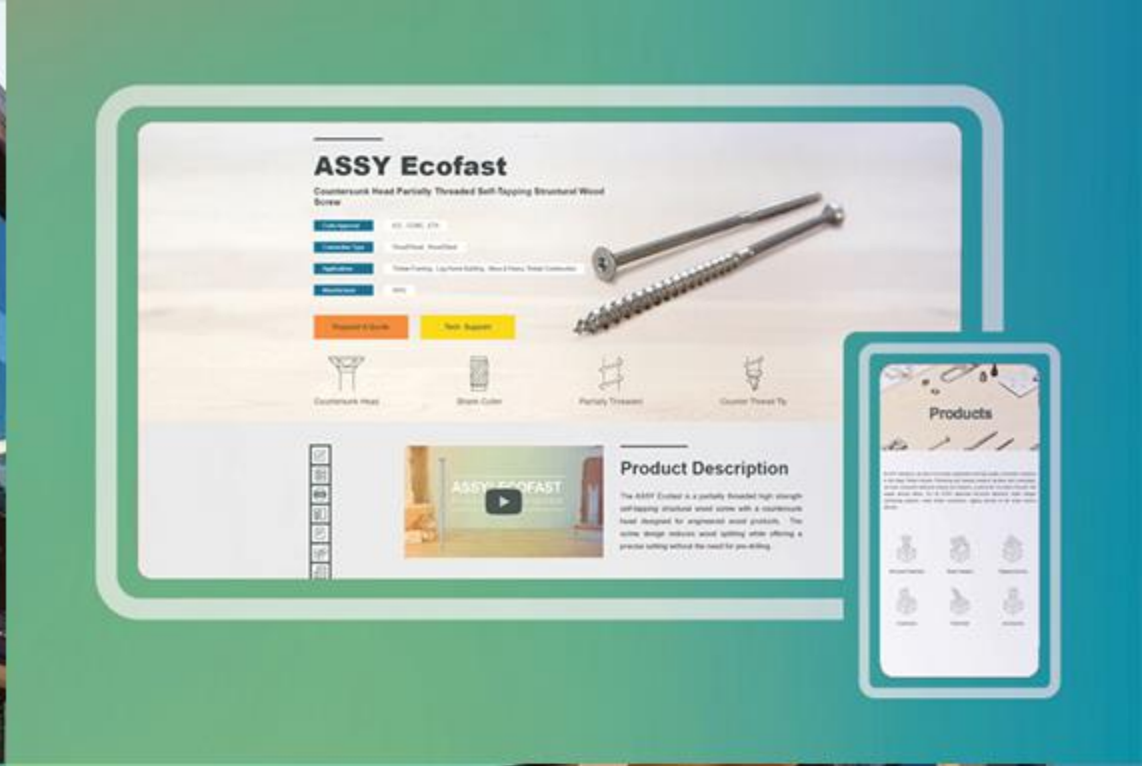
# Knowledge Database - Design Guides

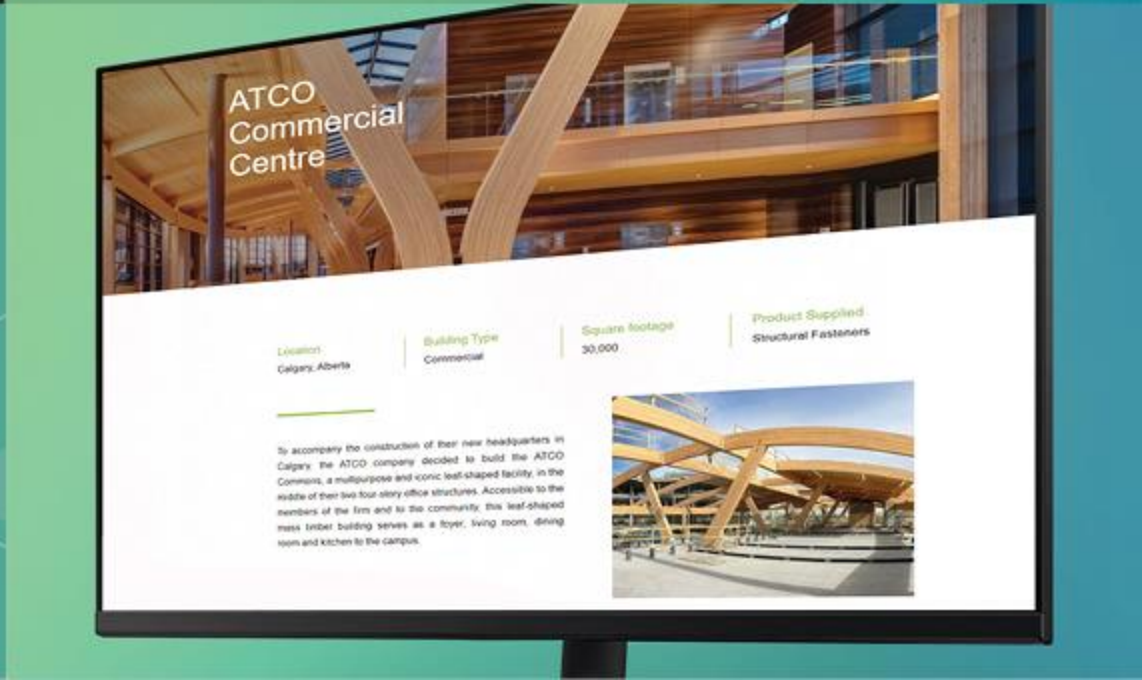



Structural Screw Design Guide

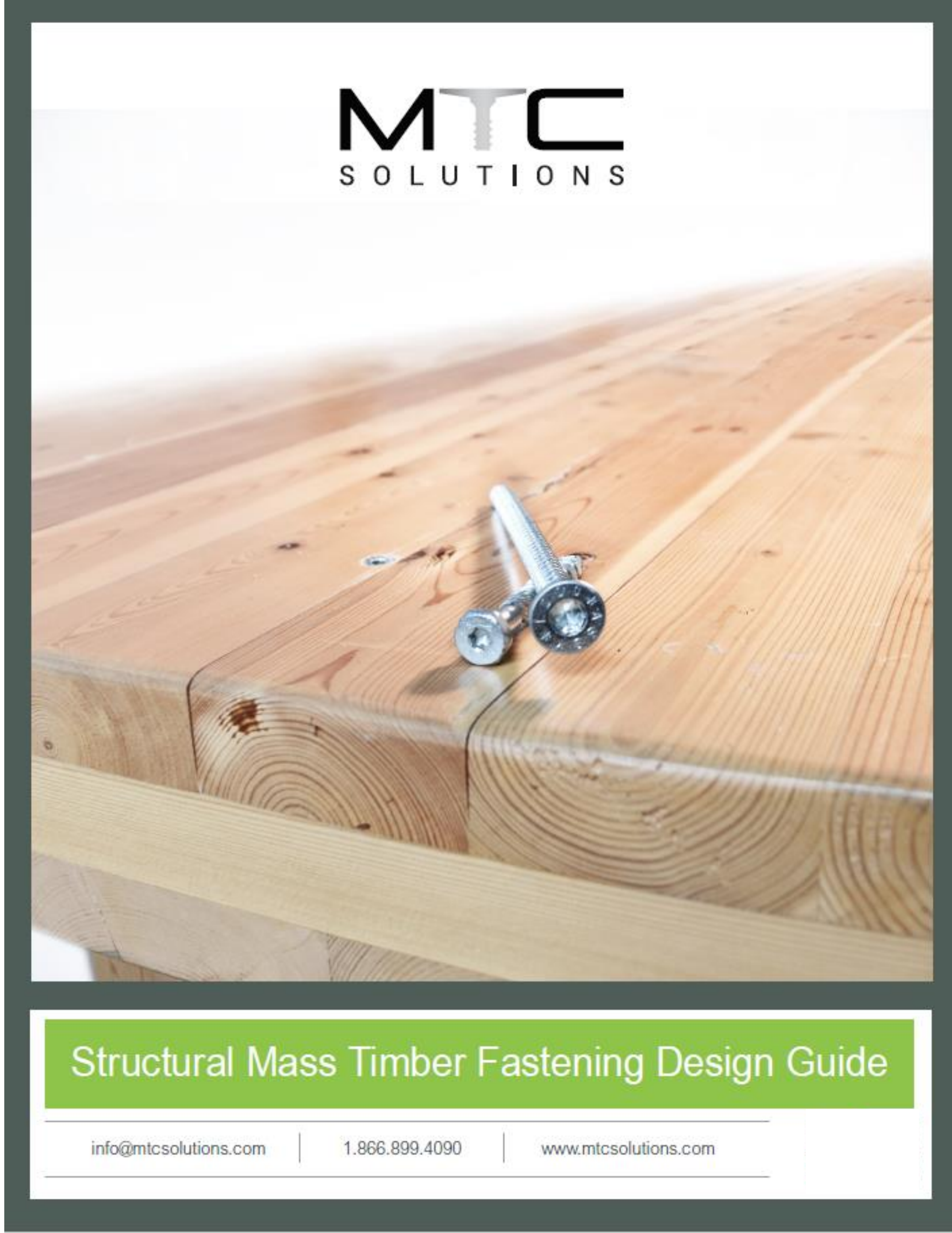

Structural Mass Timber
Fastening Design Guide

# OVER 10 YEARS OF EXPERTISE



# Structural Mass Timber Fastening Design Guide



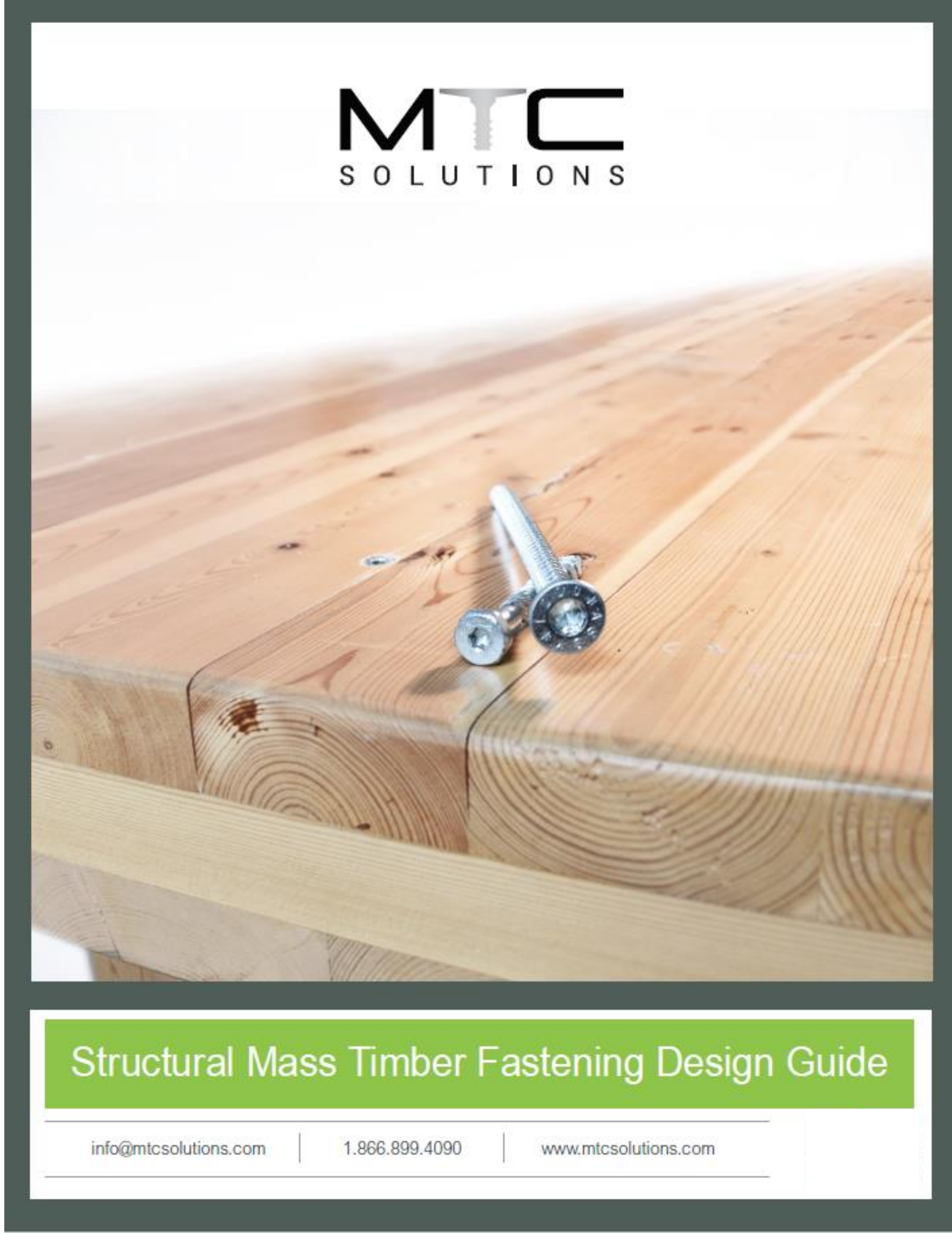
# Structural Mass Timber Fastening Design Guide

## Standardized Connection Solution

- Easy to read tables
- Cost-effective solutions

## North American Values

- USA and CAN design codes
- Tested connection solutions



# How to Use this Guide

## Structural Mass Timber Fastening Guide Overview

$Z' = Z \cdot n_F \cdot n_R \cdot C'$

- $Z$ — Reference design value ($Z_{||}$, $Z_{m,\perp}$, $Z_{s,\perp}$, $Z_{\perp}$, $Z_x$, $Z_{cal}$, $Z_{test}$ or W) given in the provided design tabl calculated in accordance with 12.3.1; NDS-2018
- $n_F$ — Number of effective fasteners in a row: $n_F = \max\{n^{0.9} ; 0.9 \cdot n\}$
- $n$ — Number of screws acting together in a row
- $n_R$ — Number of rows in a connection
- $C'$ — The adjustment factors for the connection, composed of: $C_D$ ; $C_M$ ; $C_t$ ; $C_\Delta$ ; $C_{eg}$ ; $C_{di}$ ; $C_{tn}$

$N_r = N' \cdot n_F \cdot n_R \cdot K'$ $\qquad$ $P_{rw} = P' \cdot n_F \cdot n_R \cdot K'$

- $N_r$ or $P_{rw}$ — Factored lateral strength or withdrawal resistance of a connection
- $N'$ or $P'$ — Factored lateral strength or withdrawal resistance ($N'_{//}$, $N'_{m,\perp}$, $N'_{s,\perp}$, $N'_{\perp}$ or P') given in the provided design tables or calculated in accordance with CSA O86-19 clause 12.6
- $n_F$ — Number of effective fasteners in a row
- $n_R$ — Number of rows in a connection
- $K'$ — The adjustment factors for the connection, composed of: $K_D$ ; $K_{SF}$ ; $K_T$ ; $J_G$ ; $J_{PL}$ ; $J_E$
  The $J_x$ factor for CLT is included in the calculation of the factored resistances.

### USA

- NDS 2018 Chapter 12
- ICC-ESR Report

### CANADA

- CSA O86 2019 Clause 12.6
- CCMC Report

# How to Use this Guide

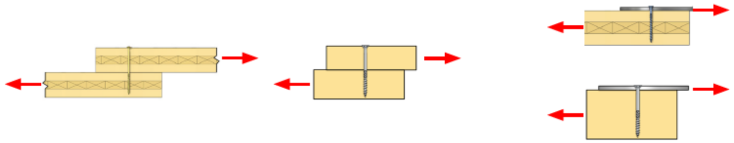
## Structural Mass Timber Fastening Guide Overview

### Specified Load Direction

Wood-to-Wood | Steel-to-Wood

**$Z_{\parallel}$ - Parallel to Grain Loading**

Connection with all wood members loaded parallel to grain.

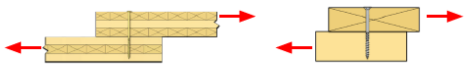


**$Z_{m,\perp}$ - Parallel to Grain Loading of Side Member**

Connection with main member loaded perpendicular to grain and side member loaded parallel to grain.

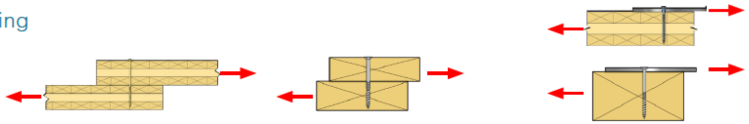
**$Z_{s,\perp}$ - Parallel to Grain Loading of Main Member**

Connection with main member loaded parallel to grain and side member loaded perpendicular to grain.



**$Z_{\perp}$ - Perpendicular to Grain Loading**

Connection with all wood members loaded perpendicular to grain.

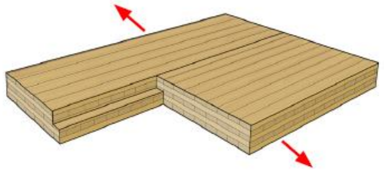


**W - Withdrawal Loading**

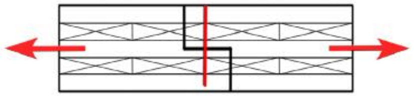
Connection with self-tapping screw loaded in withdrawal through one or two wood members. Reference withdrawal strength in the provided tables is the minimum of the withdrawal, tensile and the head-pull through capacity of the fastener. Other failure modes remain responsibility of the qualified designer.

Load scenarios for different CLT connections are using icons as shown below:

Loading perpendicular to the connection plane:

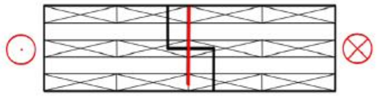


icon:



Loading parallel to the connection plane:

icon:

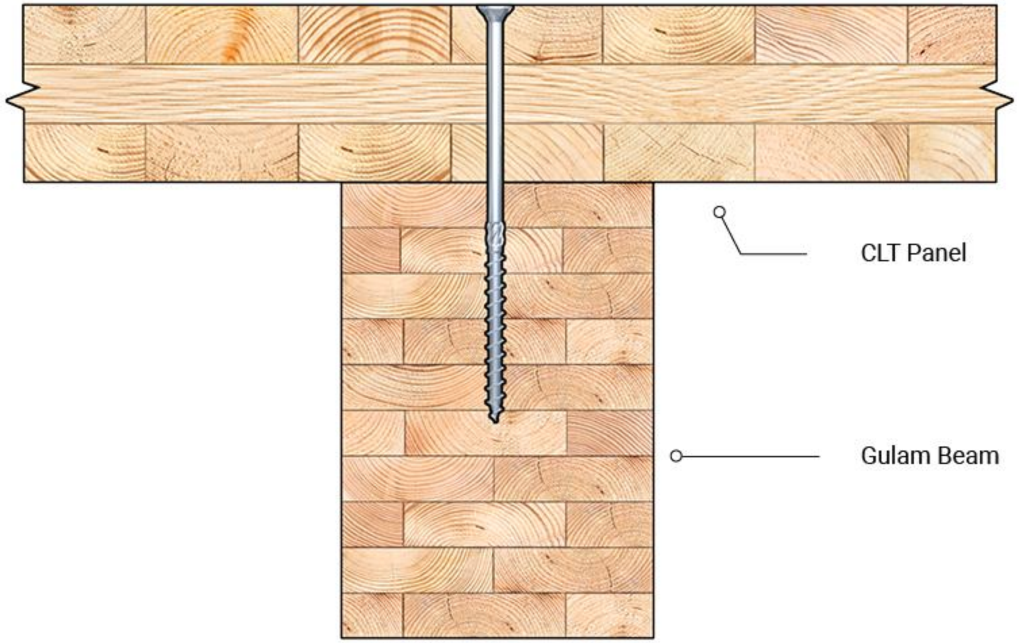


# Example Calculations

# Panel to Beam Connection

## Diaphragm Connections

### CLT Panel to Beam in Shear



# Panel to Beam Connection

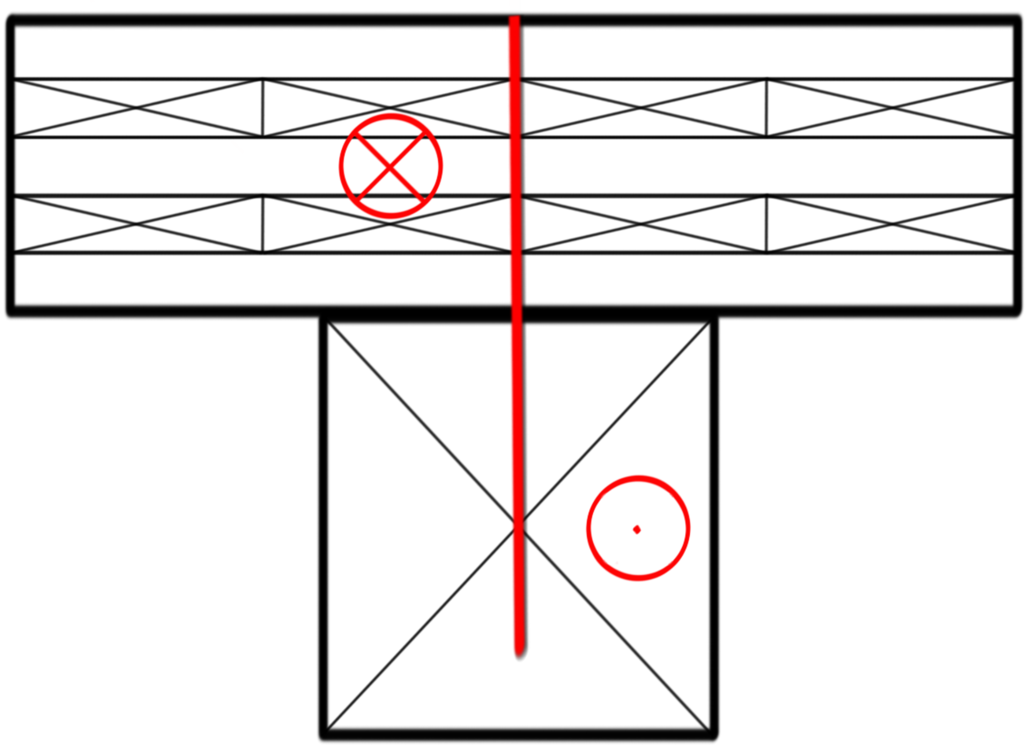
## Diaphragm Connections

### CLT Panel Configurations

- 5-ply CLT panel (6-7/8” thickness)
- SPF G=0.42

### Glulam Beam Configuration

- D.Fir G=0.49
- 16” deep



# Panel to Beam Connection

## Diaphragm Connections

### Shear connection

- Using lateral yield calculations
- Per NDS 2018- Chapter 12.3

### Screw Choice

- Partially Threaded ASSY Ecofast

# Panel to Beam Connection

## Diaphragm Connections

### Shear connection

- Using lateral yield calculations
- Per NDS 2018- Chapter 12.3

Screw: 3/8" x 11-7/8" SWG ASSY SK

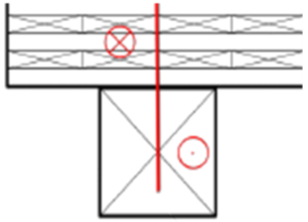
$D = 3/8"$ $D_s = 0.283"$

$L = 11-7/8"$ $L_{Tip} = 0.375"$ $F_{yb} = 136,600 psi$

CLT: 6-7/8" 5-ply CLT $G = 0.42$ (S-P-F)

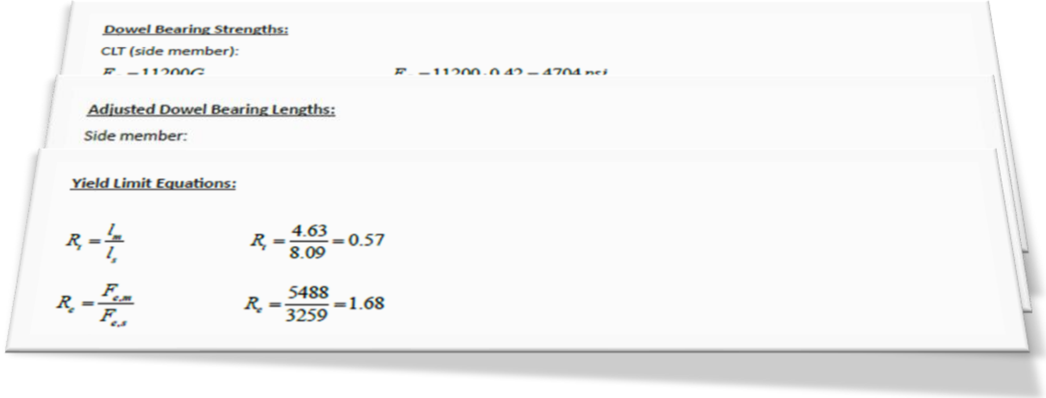
$t_1 = 1-3/8"$ $t_2 = 1-3/8"$ $t_3 = 1-3/8"$ $t_4 = 1-3/8"$ $t_5 = 1-3/8"$

Beam: Glulam $G = 0.49$ (D.Fir-L.)



### Screw Choice

- Partially Threaded ASSY Ecofast



# Panel to Beam Connection

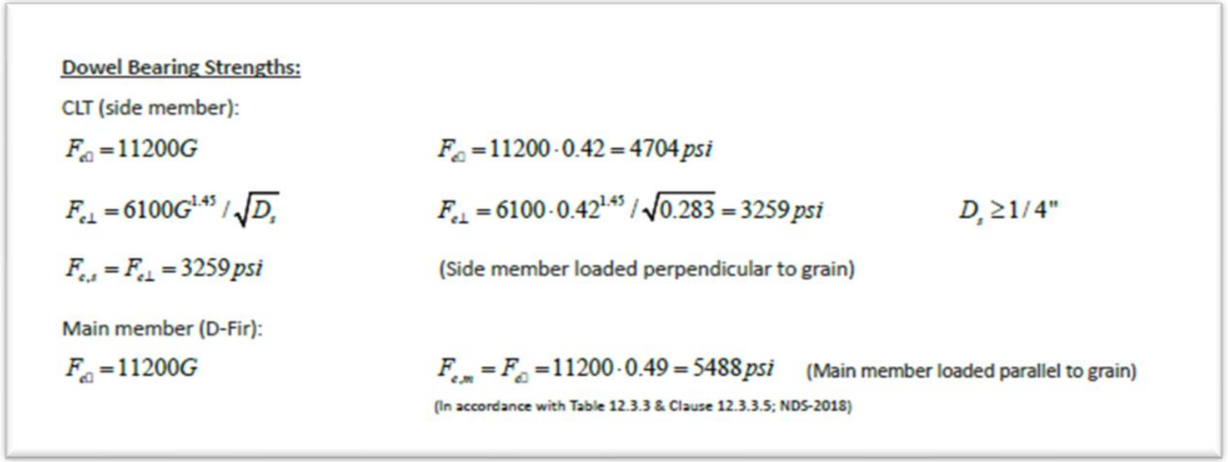
## Diaphragm Connections

### Shear connection

- Using lateral yield calculations
- Per NDS 2018- Chapter 12.3

### Screw Choice

- Partially Threaded ASSY Ecofast



**Dowel Bearing Strengths:**

CLT (side member):

$F_{e\parallel} = 11200G$ $\quad$ $F_{e\parallel} = 11200 \cdot 0.42 = 4704\,psi$

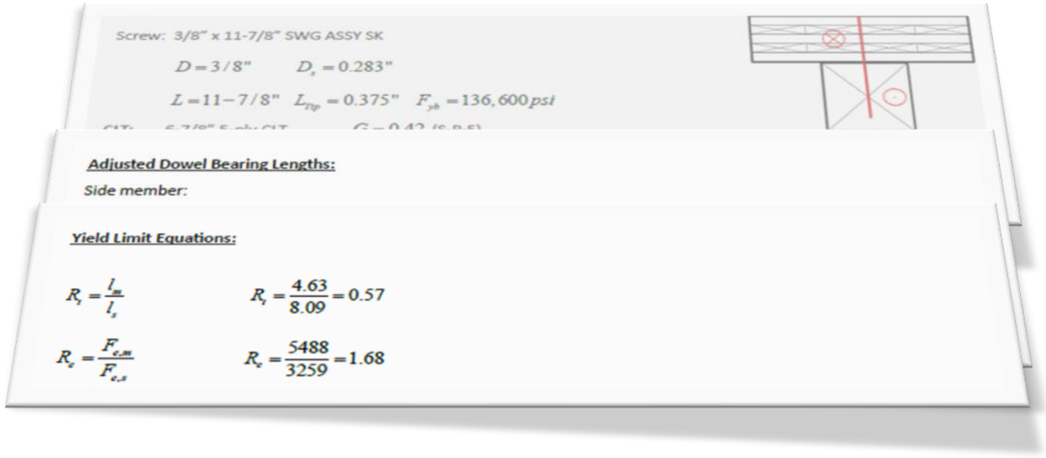
$F_{e\perp} = 6100G^{1.45} / \sqrt{D_s}$ $\quad$ $F_{e\perp} = 6100 \cdot 0.42^{1.45} / \sqrt{0.283} = 3259\,psi$ $\quad$ $D_s \geq 1/4"$

$F_{e,s} = F_{e\perp} = 3259\,psi$ $\quad$ (Side member loaded perpendicular to grain)

Main member (D-Fir):

$F_{e\parallel} = 11200G$ $\quad$ $F_{e,m} = F_{e\parallel} = 11200 \cdot 0.49 = 5488\,psi$ $\quad$ (Main member loaded parallel to grain)

(In accordance with Table 12.3.3 & Clause 12.3.3.5; NDS-2018)



# Panel to Beam Connection

## Diaphragm Connections

### Shear connection

- Using lateral yield calculations
- Per NDS 2018- Chapter 12.3

**Adjusted Dowel Bearing Lengths:**

Side member:

$$l_s = t_1 + t_2 \cdot \frac{F_{e\parallel}}{F_{e\perp}} + t_3 + t_4 \cdot \frac{F_{e\parallel}}{F_{e\perp}} + t_5 \qquad l_s = 1\tfrac{3}{8} + 1\tfrac{3}{8} \cdot \frac{4704}{3259} + 1\tfrac{3}{8} + 1\tfrac{3}{8} \cdot \frac{4704}{3259} + 1\tfrac{3}{8} = 8.09"$$

Main member:

$$l_m = L - t_{CLT} - L_{Tip} \qquad l_m = 11\tfrac{7}{8} - 6\tfrac{7}{8} - 0.375 = 4.63"$$

(Bearing length of crossing plies adjusted with as primary loading direction is perpendicular to grain (θ = 90°); in accordance with Clause C12.3.5.2; NDS-2018)

### Screw Choice

- Partially Threaded ASSY Ecofast

Screw: 3/8" x 11-7/8" SWG ASSY SK

**Dowel Bearing Strengths:**

CLT (side member):

$F_{e\parallel} = 11200G$ $\qquad F_{e\parallel} = 11200 \cdot 0.42 = 4704\,psi$

$F_{e\perp} = 6100G^{1.45} / \sqrt{D_s}$ $\qquad F_{e\perp} = 6100 \cdot 0.42^{1.45} / \sqrt{0.283} = 3259\,psi$ $\qquad D_s \geq 1/4"$

$F_{e,s} = F_{e\perp} = 3259\,psi$ $\qquad$ (Side member loaded perpendicular to grain)

**Yield Limit Equations:**

$$R_t = \frac{l_m}{l_s} \qquad R_t = \frac{4.63}{8.09} = 0.57$$

$$R_e = \frac{F_{e,m}}{F_{e,s}} \qquad R_e = \frac{5488}{3259} = 1.68$$

# Panel to Beam Connection

## Diaphragm Connections

### Shear connection

- Using lateral yield calculations
- Per NDS 2018- Chapter 12.3

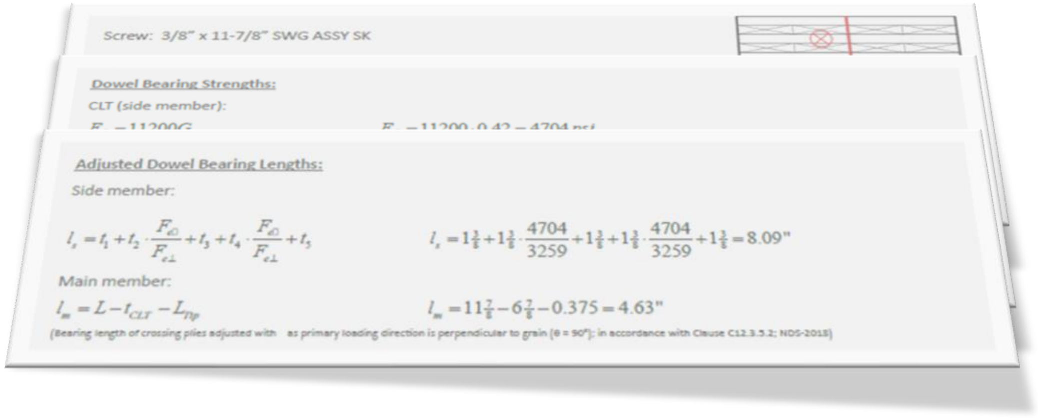
**Yield Limit Equations:**

$$R_t = \frac{l_m}{l_s} \qquad R_t = \frac{4.63}{8.09} = 0.57$$

$$R_e = \frac{F_{e,m}}{F_{e,s}} \qquad R_e = \frac{5488}{3259} = 1.68$$

### Screw Choice

- Partially Threaded ASSY Ecofast



# Panel to Beam Connection

## Diaphragm Connections

### Shear connection

- Using lateral yield calculations
- Per NDS 2018- Chapter 12.3

### Screw Choice

- Partially Threaded ASSY Ecofast

$k_1 = 0.409$ $\qquad k_1 = \dfrac{\sqrt{R_e + 2R_e^2(1+R_t+R_t^2)+R_t^2R_e^3} - R_e(1+R_t)}{(1+R_e)}$

$k_2 = 1.374$ $\qquad k_2 = -1 + \sqrt{2(1+R_e) + \dfrac{2F_{yb}(1+2R_e)D_s^2}{3F_{e,m}l_m^2}}$

$k_3 = 0.806$ $\qquad k_3 = -1 + \sqrt{\dfrac{2(1+R_e)}{R_e} + \dfrac{2F_{yb}(2+R_e)D_s^2}{3F_{e,m}l_s^2}}$

(In accordance with Table 12.3.1A; NDS-2018)

Reduction Term $R_d$:

| | | | |
|---|---|---|---|
| $1/4" \le D_s \le 1"$ ; | $\rightarrow I_m, I_s$ | $\rightarrow R_d = 4K_\theta$ | $\rightarrow R_d = 5.0$ |
| | $\rightarrow II$ | $\rightarrow R_d = 3.6K_\theta$ | $\rightarrow R_d = 4.5$ |
| | $\rightarrow III_m, III_s, IV$ | $\rightarrow R_d = 3.2K_\theta$ | $\rightarrow R_d = 4$ |

$K_\theta = 1 + 0.25(\theta/90)$ $\qquad \theta = 90°$ $\qquad K_\theta = 1.25$

(In accordance with Table 12.3.1B & Clause 12.3.3.5; NDS-2018)

| | | | |
|---|---|---|---|
| $I_m$ | $Z = \dfrac{D_s l_m F_{e,m}}{R_d}$ | (12.3-1) | $Z = 1{,}438 lbs.$ |
| $I_s$ | $Z = \dfrac{D_s l_s F_{e,s}}{R_d}$ | (12.3-2) | $Z = 1{,}492 lbs.$ |
| $II$ | $Z = \dfrac{k_1 D_s l_s F_{e,s}}{R_d}$ | (12.3-3) | $Z = 678 lbs.$ |
| $III_m$ | $Z = \dfrac{k_2 D_s l_m F_{e,m}}{(1+2R_e)R_d}$ | (12.3-4) | $Z = 566 lbs.$ |
| $III_s$ | $Z = \dfrac{k_3 D_s l_s F_{e,m}}{(2+R_e)R_d}$ | (12.3-5) | $Z = 688 lbs.$ |
| $IV$ | $Z = \dfrac{D_s^2}{R_d}\sqrt{\dfrac{2F_{e,m}F_{yb}}{3(1+R_e)}}$ | (12.3-6) | $Z = 273 lbs.$ MIN $Z = 273 lbs.$ |

# Panel to Beam Connection

## Diaphragm Connections

### Shear connection

- Using lateral yield calculations
- Per NDS 2018- Chapter 12.3

### Screw Choice

- Partially Threaded ASSY Ecofast

$k_1 = 0.409$ $\quad k_1 = \dfrac{\sqrt{R_e + 2R_e^2(1+R_t+R_t^2)+R_t^2R_e^3} - R_e(1+R_t)}{(1+R_e)}$

$k_2 = 1.374$ $\quad k_2 = -1 + \sqrt{2(1+R_e) + \dfrac{2F_{yb}(1+2R_e)D_s^2}{3F_{e,m}l_m^2}}$

$k_3 = 0.806$ $\quad k_3 = -1 + \sqrt{\dfrac{2(1+R_e)}{R_e} + \dfrac{2F_{yb}(2+R_e)D_s^2}{3F_{e,m}l_s^2}}$

(In accordance with Table 12.3.1A; NDS-2018)

Reduction Term $R_d$:

| | | | |
|---|---|---|---|
| $1/4" \le D_s \le 1"$ ; | $\rightarrow I_m, I_s$ | $\rightarrow R_d = 4K_\theta$ | $\rightarrow R_d = 5.0$ |
| | $\rightarrow II$ | $\rightarrow R_d = 3.6K_\theta$ | $\rightarrow R_d = 4.5$ |
| | $\rightarrow III_m, III_s, IV$ | $\rightarrow R_d = 3.2K_\theta$ | $\rightarrow R_d = 4$ |

$K_\theta = 1 + 0.25(\theta/90)$ $\quad \theta = 90°$ $\quad K_\theta = 1.25$

(In accordance with Table 12.3.1B & Clause 12.3.3.5; NDS-2018)

| | | | |
|---|---|---|---|
| $I_m$ | $Z = \dfrac{D_s l_m F_{e,m}}{R_d}$ | (12.3-1) | $Z = 1{,}438 lbs.$ |
| $I_s$ | $Z = \dfrac{D_s l_s F_{e,s}}{R_d}$ | (12.3-2) | $Z = 1{,}492 lbs.$ |
| $II$ | $Z = \dfrac{k_1 D_s l_s F_{e,s}}{R_d}$ | (12.3-3) | $Z = 678 lbs.$ |
| $III_m$ | $Z = \dfrac{k_2 D_s l_m F_{e,m}}{(1+2R_e)R_d}$ | (12.3-4) | $Z = 566 lbs.$ |
| $III_s$ | $Z = \dfrac{k_3 D_s l_s F_{e,m}}{(2+R_e)R_d}$ | (12.3-5) | $Z = 688 lbs.$ |
| $IV$ | $Z = \dfrac{D_s^2}{R_d}\sqrt{\dfrac{2F_{e,m}F_{yb}}{3(1+R_e)}}$ | (12.3-6) | $Z = 273 lbs.$ |

$Z = 273 lbs.$

# Standardized Tables

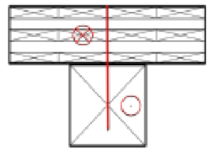
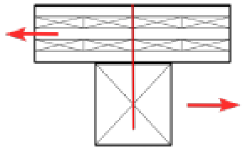
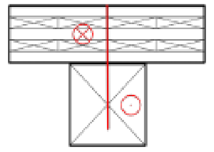
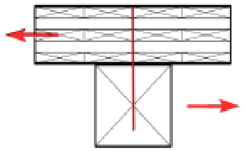
## Mass Timber Fastening Design Guide

### Lateral Calculations

- Calculations already done
- Tables suggest most economical option

### Solutions

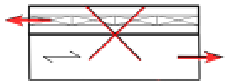
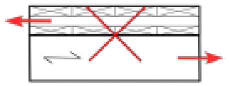
- Ecofast 5/16” x 11-7/8”
- Ecofast 3/8” x 11-7/8”

| CLT Panel & Beam Configuration | | | | | Fastener Options | Reference Design Values [lbs] | | Minimum Spacing in a Row ($S_P$) |
|---|---|---|---|---|---|---|---|---|
| Loading | | | Beam Type | Panel Thickness (t) | | Standard Loading $C_D$ =1.0 | Short Term Loading $C_D$ =1.6 | |
| 5 PLY | $Z_{//}$ |  | D-Fir (0.49) | 5-1/8"<br>5-1/2" | Eco 5/16" x 9-1/2" | 259 | 414 | 3-3/8" |
| | | | | 6-7/8" | Eco 5/16" x 11-7/8" | 259 | 414 | 3-3/8" |
| | | | | | Eco 3/8" x 11-7/8" | 380 | 608 | 4" |
| | $Z_{m,\perp}$ |  | | 5-1/8"<br>5-1/2" | Eco 5/16" x 9-1/2" | 207 | 331 | 3-3/8" |
| | | | | 6-7/8" | Eco 5/16" x 11-7/8" | 207 | 331 | 3-3/8" |
| | | | | | Eco 3/8" x 11-7/8" | 282 | 451 | 4" |
| | $Z_{s,\perp}$ |  | | 5-1/8"<br>5-1/2" | Eco 5/16" x 9-1/2" | 207 | 331 | 3-3/8" |
| | | | | 6-7/8" | Eco 5/16" x 11-7/8" | 207 | 331 | 3-3/8" |
| | | | | | Eco 3/8" x 11-7/8" | 273 | 451 | 4" |
| | $Z_{\perp}$ |  | | 5-1/8"<br>5-1/2" | Eco 5/16" x 9-1/2" | 207 | 331 | 3-3/8" |
| | | | | 6-7/8" | Eco 5/16" x 11-7/8" | 207 | 331 | 3-3/8" |
| | | | | | Eco 3/8" x 11-7/8" | 257 | 451 | 4" |

# Panel to Beam Connection

## Diaphragm Connections

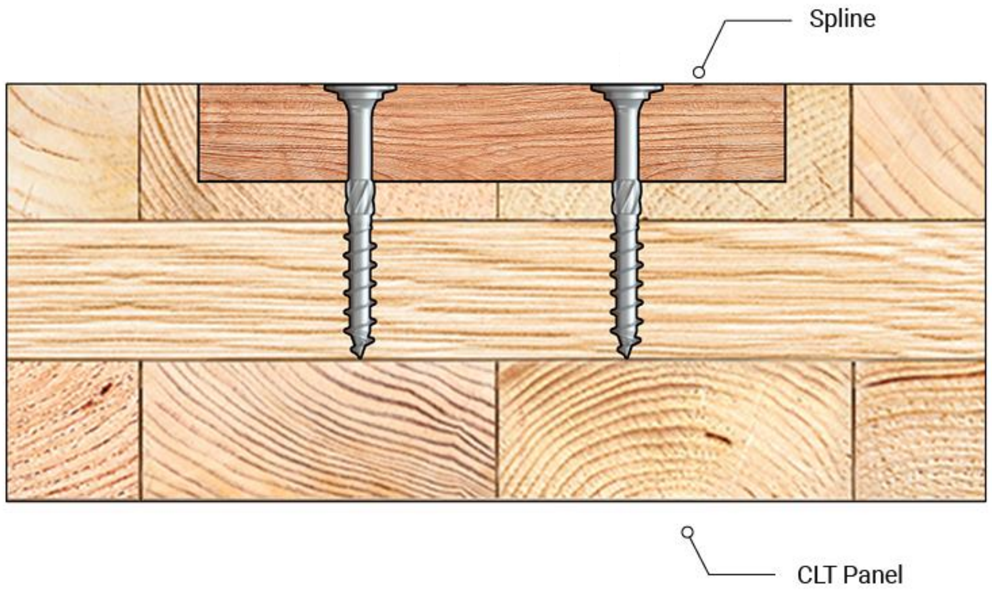
### CLT Panel to Beam with Inclined Screws

| CLT Panel & Joint Configuration | | | | | Fastener Options | Reference Design Values per Screw Cross [lbs] | | Minimum Spacing in a Row ($S_P$) |
|---|---|---|---|---|---|---|---|---|
| Loading | | | Beam Type | Panel Thickness (t) | | Standard Loading $C_D$ =1.0 | Short Term Loading $C_D$ =1.6 | |
| 3 PLY | $Z_{x//}$ |  | D-Fir (0.49) | 3-1/8" | VG CSK 5/16" x 8-5/8" | 1,171 | 1,874 | 4-3/4" |
| | | | | 3-3/8" | VG CSK 5/16" x 9-1/2" | 1,283 | 2,053 | 4-3/4" |
| | | | | 4-1/8" | VG CSK 5/16" x 11-7/8" | 1,582 | 2,510* | 4-3/4" |
| | | | | | VG CSK 3/8" x 11-7/8" | 1,769 | 2,830 | 5-5/8" |
| | $Z_{x\perp}$ |  | D-Fir (0.49) | 3-1/8" | VG CSK 5/16" x 8-5/8" | 1,171 | 1,874 | 4-3/4" |
| | | | | 3-3/8" | VG CSK 5/16" x 9-1/2" | 1,308 | 2,093 | 4-3/4" |
| | | | | 4-1/8" | VG CSK 5/16" x 11-7/8" | 1,666 | 2,510* | 4-3/4" |
| | | | | | VG CSK 3/8" x 11-7/8" | 1,862 | 2,979 | 5-5/8" |

# Panel to Panel Connection

## Diaphragm Connections

### CLT Spline Connection in Shear

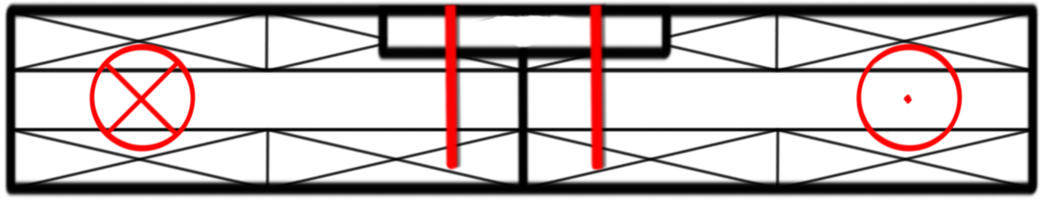



# Panel to Panel Connection

## Diaphragm Connections

### CLT Panels Configurations

- 3-ply CLT panel (4-1/8" thickness)
- SPF G=0.42
- Plywood spline



# Panel to Panel Connection

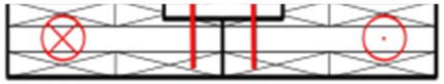
## Diaphragm Connections

### Shear connection

- Using lateral yield calculations
- Per NDS 2018- Chapter 12.3

### Screw Choice

- Partially Threaded ASSY Ecofast



Screw: 1/4” x 3-1/8” SWG ASSY Ecofast

$D = 1/4"$  $D_r = 0.173"$

$L = 3{-}1/8"$  $L_{Tip} = 0.250"$  $F_{yb} = 169{,}500\,psi$

CLT: 4-1/8” 3-ply CLT  $G = 0.42$ (S-P-F)

$t_1 = 1{-}3/8"$  $t_2 = 1{-}3/8"$  $t_3 = 1{-}3/8"$

Spline: $t_s = 1"$  $G = 0.42$ (Plywood)

Dowel Bearing Strengths:

Adjusted Dowel Bearing Lengths:

Yield Limit Equations:

$R_t = \frac{l_m}{l_s}$  $R_t = \frac{1.88}{1.00} = 1.88$

$R_e = \frac{F_{e,m}}{F_{e,s}}$  $R_e = \frac{3364}{3364} = 1.00$

$k_1 = 0.642$  $k_1 = \frac{\sqrt{R_e + 2R_e^2(1+R_t+R_t^2) + R_t^2R_e^3} - R_e(1+R_t)}{(1+R_e)}$

$k_2 = 1.204$  $k_2 = -1 + \sqrt{2(1+R_e) + \frac{2F_{yb}(1+2R_e)D_r^2}{3F_{e,m}l_m^2}}$

# Panel to Panel Connection

## Diaphragm Connections

### Shear connection

- Using lateral yield calculations
- Per NDS 2018- Chapter 12.3

**Adjusted Dowel Bearing Lengths:**

Side member:

$l_s = t_s = 1.00"$

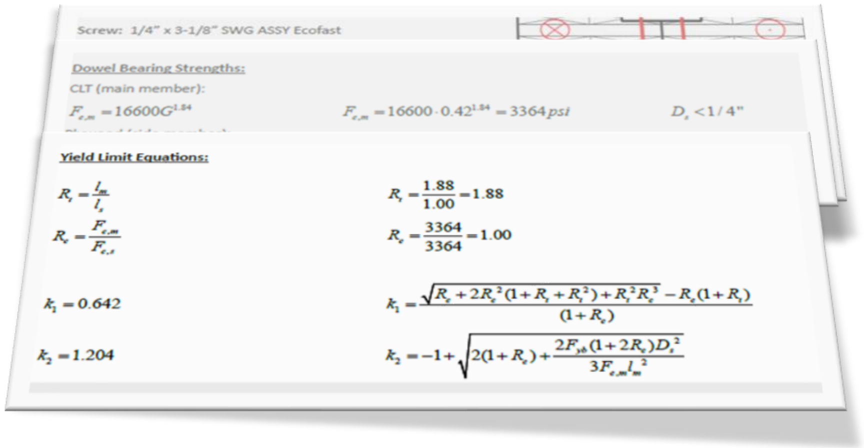
Main member:

$l_m = L - L_{Tip} - t_s$

$l_m = 3\frac{1}{8} - 0.250 - 1.00 = 1.88"$

### Screw Choice

- Partially Threaded ASSY Ecofast


Screw: 1/4" x 3-1/8" SWG ASSY Ecofast

Dowel Bearing Strengths:

CLT (main member):

$F_{e,m} = 16600G^{1.84}$ $F_{e,m} = 16600 \cdot 0.42^{1.84} = 3364 psi$ $D_s < 1/4"$

Yield Limit Equations:

$R_t = \frac{l_m}{l_s}$ $R_t = \frac{1.88}{1.00} = 1.88$

$R_e = \frac{F_{e,m}}{F_{e,s}}$ $R_e = \frac{3364}{3364} = 1.00$

$k_1 = 0.642$ $k_1 = \frac{\sqrt{R_e + 2R_e^2(1+R_t+R_t^2) + R_t^2R_e^3} - R_e(1+R_t)}{(1+R_e)}$

$k_2 = 1.204$ $k_2 = -1 + \sqrt{2(1+R_e) + \frac{2F_{yb}(1+2R_e)D_s^2}{3F_{e,m}l_m^2}}$

# Panel to Panel Connection

## Diaphragm Connections

### Shear connection

- Using lateral yield calculations
- Per NDS 2018- Chapter 12.3

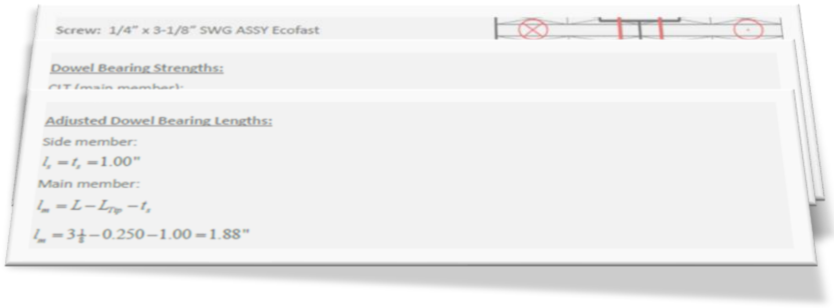
**Yield Limit Equations:**

$$R_t = \frac{l_m}{l_s} \qquad R_t = \frac{1.88}{1.00} = 1.88$$

$$R_e = \frac{F_{e,m}}{F_{e,s}} \qquad R_e = \frac{3364}{3364} = 1.00$$

$$k_1 = 0.642 \qquad k_1 = \frac{\sqrt{R_e + 2R_e^2(1 + R_t + R_t^2) + R_t^2 R_e^3} - R_e(1 + R_t)}{(1 + R_e)}$$

$$k_2 = 1.204 \qquad k_2 = -1 + \sqrt{2(1 + R_e) + \frac{2F_{yb}(1 + 2R_e)D_s^2}{3F_{e,m} l_m^2}}$$




### Screw Choice

- Partially Threaded ASSY Ecofast

# Panel to Panel Connection

## Diaphragm Connections

### Shear connection

- Using lateral yield calculations
- Per NDS 2018- Chapter 12.3

### Screw Choice

- Partially Threaded ASSY Ecofast

$k_3 = 1.649$

$$k_3 = -1 + \sqrt{\frac{2(1+R_e)}{R_e} + \frac{2F_{yb}(2+R_e)D_s^2}{3F_{e,m}l_s^2}}$$

(In accordance with Table 12.3.1A; NDS-2018)

Reduction Term $R_d$:

$D_s < 1/4"$ ; $D < 1/4"$ $\quad \rightarrow I_m, I_s, II, III_m, III_s, IV \quad \rightarrow R_d = K_D$

$K_D = 10D_s + 0.5$ $\quad$ for $0.17" < D_s < 1/4"$

$K_D = 2.23$

(In accordance with Table 12.3.1B; NDS-2018)

| | | | | | |
|---|---|---|---|---|---|
| $I_m$ | $Z = \frac{D_s l_m F_{e,m}}{R_d}$ | (12.3-1) | $Z = 489 lbs.$ | | |
| $I_s$ | $Z = \frac{D_s l_s F_{e,s}}{R_d}$ | (12.3-2) | $Z = 261 lbs.$ | | |
| $II$ | $Z = \frac{k_1 D_s l_s F_{e,s}}{R_d}$ | (12.3-3) | $Z = 168 lbs.$ | | |
| $III_m$ | $Z = \frac{k_2 D_s l_m F_{e,m}}{(1+2R_e)R_d}$ | (12.3-4) | $Z = 196 lbs.$ | | |
| $III_s$ | $Z = \frac{k_3 D_s l_s F_{e,m}}{(2+R_e)R_d}$ | (12.3-5) | $Z = 143 lbs.$ | MIN → | $Z = 143 lbs.$ |
| $IV$ | $Z = \frac{D_s^2}{R_d}\sqrt{\frac{2F_{e,m}F_{yb}}{3(1+R_e)}}$ | (12.3-6) | $Z = 185 lbs.$ | | |

# Panel to Panel Connection

## Diaphragm Connections

### Shear connection

- Using lateral yield calculations
- Per NDS 2018- Chapter 12.3

### Screw Choice

- Partially Threaded ASSY Ecofast

$k_3 = 1.649$

$$k_3 = -1 + \sqrt{\frac{2(1+R_e)}{R_e} + \frac{2F_{yb}(2+R_e)D_s^2}{3F_{e,m}l_s^2}}$$

(In accordance with Table 12.3.1A; NDS-2018)

Reduction Term $R_d$:

$D_s < 1/4"$ ; $D < 1/4"$ $\rightarrow I_m, I_s, II, III_m, III_s, IV$ $\rightarrow R_d = K_D$

$K_D = 10D_s + 0.5$ for $0.17" < D_s < 1/4"$

$K_D = 2.23$

(In accordance with Table 12.3.1B; NDS-2018)

| | | | |
|---|---|---|---|
| $I_m$ | $Z = \frac{D_s l_m F_{e,m}}{R_d}$ | (12.3-1) | $Z = 489 lbs.$ |
| $I_s$ | $Z = \frac{D_s l_s F_{e,s}}{R_d}$ | (12.3-2) | $Z = 261 lbs.$ |
| $II$ | $Z = \frac{k_1 D_s l_s F_{e,s}}{R_d}$ | (12.3-3) | $Z = 168 lbs.$ |
| $III_m$ | $Z = \frac{k_2 D_s l_m F_{e,m}}{(1+2R_e)R_d}$ | (12.3-4) | $Z = 196 lbs.$ |
| $III_s$ | $Z = \frac{k_3 D_s l_s F_{e,m}}{(2+R_e)R_d}$ | (12.3-5) | $Z = 143 lbs.$ |
| $IV$ | $Z = \frac{D_s^2}{R_d}\sqrt{\frac{2F_{e,m}F_{yb}}{3(1+R_e)}}$ | (12.3-6) | $Z = 185 lbs.$ |

$Z = 143 lbs.$

# Standardized Tables

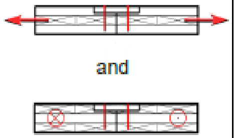
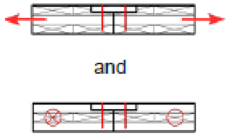
## Mass Timber Fastening Design Guide

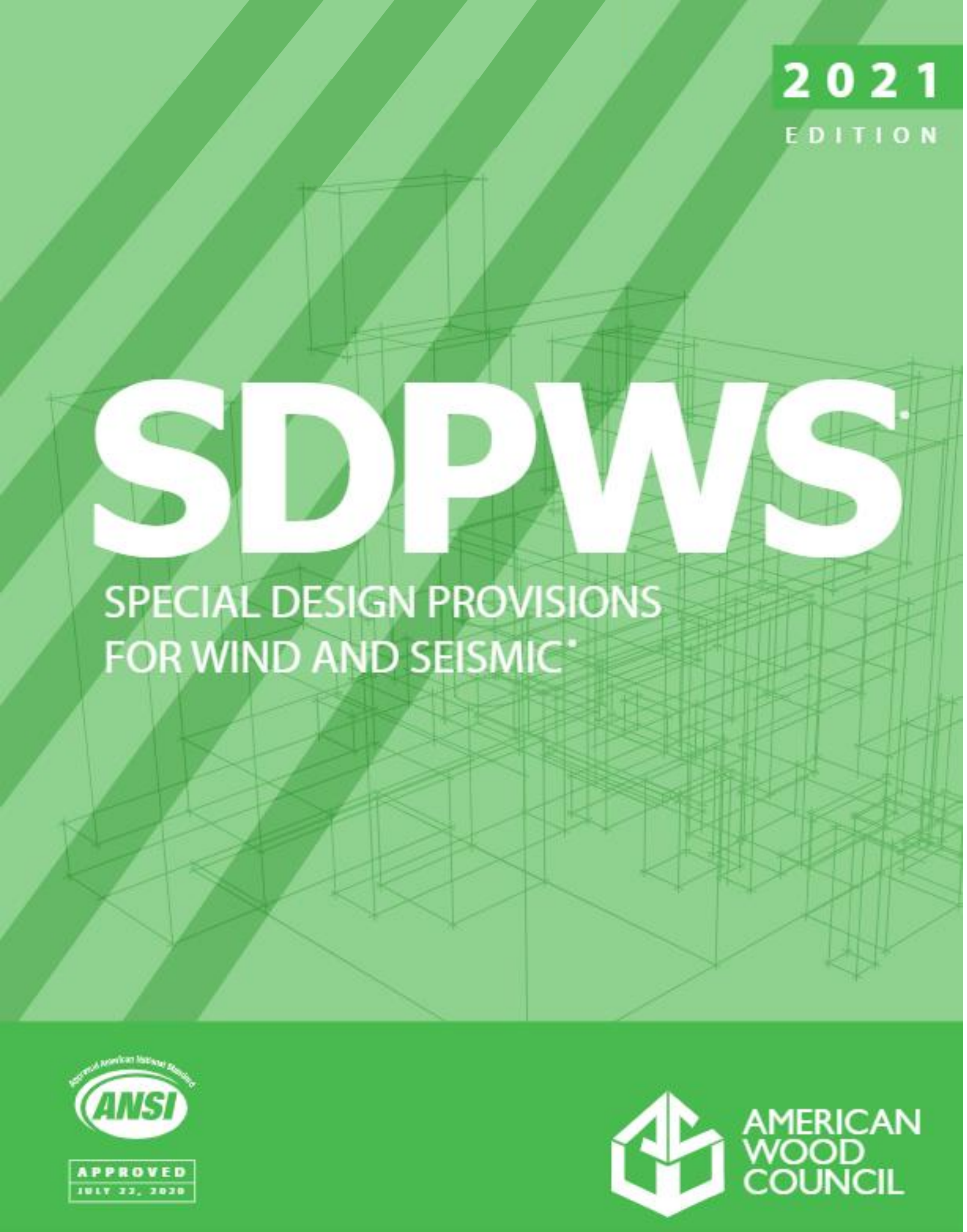
### Lateral Calculations

- Calculations already done
- Tables suggest most economical option

### Solutions

- Ecofast ¼" x 3-1/8"
- Ecofast ¼" x 3-1/2"

| Panel & Spline Configuration | | | | | Fastener Options | Reference Design Values [lbs] | | Minimum Spacing in a Row ($S_P$) |
|---|---|---|---|---|---|---|---|---|
| Loading | | | Spline Thickness | Panel Thickness (t) | | Standard Loading $C_D$ =1.0 | Short Term Loading $C_D$ =1.6 | |
| 3 PLY | $Z_{//}$ |  and | 1/2" | 3-1/8" | Eco 1/4" x 2-3/4" | 130* | 208* | 1-3/4" |
| | | | | 3-3/8" | Eco 1/4" x 3-1/8" | | | |
| | | | | 4-1/8" | | | | |
| | | | 3/4" | 3-1/8" | Eco 1/4" x 2-3/4" | 134 | 214 | |
| | | | | 3-3/8" | Eco 1/4" x 3-1/8" | | | |
| | | | | 4-1/8" | Eco 1/4" x 3-1/8" | | | |
| | | | | | Eco 5/16" x 3-1/2" | 172 | 275 | 2-1/4" |
| | | | 1" | 4-1/8" | Eco 1/4" x 3-1/8" | 143 | 229 | 1-3/4" |
| | | | | | Eco 5/16" x 3-1/2" | 178 | 285 | 2-1/4" |
| | $Z_{\perp}$ |  and | 1/2" | 3-1/8" | Eco 1/4" x 2-3/4" | 130* | 208* | 1-3/4" |
| | | | | 3-3/8" | Eco 1/4" x 3-1/8" | | | |
| | | | | 4-1/8" | | | | |
| | | | 3/4" | 3-1/8" | Eco 1/4" x 2-3/4" | 134 | 214 | |
| | | | | 3-3/8" | Eco 1/4" x 3-1/8" | | | |
| | | | | 4-1/8" | Eco 1/4" x 3-1/8" | | | |
| | | | | | Eco 5/16" x 3-1/2" | 138 | 221 | 2-1/4" |
| | | | 1" | 4-1/8" | Eco 1/4" x 3-1/8" | 143 | 229 | 1-3/4" |
| | | | | | Eco 5/16" x 3-1/2" | 143 | 229 | 2-1/4" |




# Yield modes

## Special Design Provisions For Wind and Seismic

### SDPWS - 2021

- Requires a yield mode IV or IIIs
- Clause 4.5.4

# Values from testing

## How can you use them?

### Where do they come from?

- Specific testing done using ASSY Screws
- Available for certain connection types

**Values Determined by Testing**

When compared to testing, lateral design values determined by the yield equations presented in the NDS will lead to conservative design values for ASSY screw. Approval bodies, such as ICC-ES are providing guidelines to extract reference design values based on a database with controlled design parameters.

This CLT Connection Design Guide contains reference lateral design values determined by testing. These values are derived from testing of the configurations illustrated herein. Tested reference lateral design values ($Z_{test}$) are based on a minimum factor of safety of 5.0, as per AC 233 clause 3.4.3. A slip modulus ($k_{test}$) is included for the purpose of estimating joint displacement. Tested reference lateral design values ($Z_{test}$) in this guide apply to the specific configurations tested only.

Utilising tested reference lateral design values ($Z_{test}$) can result in more economical design and promotes installation and hardware cost savings.

Includes a minimum factor of safety of 5

# Values from testing

How can you use them?

## Advantages

- Can use for performance based design

## Limitations

- Must only use the same configurations listed
- Cannot change geometry parameters

## Tested Connection

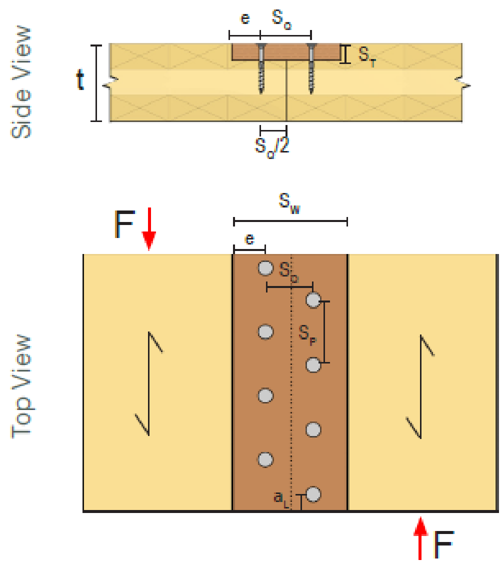
Table TPP.5, Tested Reference Lateral Design Values for CLT Surface Spline Joints Loaded in Shear

| Panel & Spline Configuration | | | | | | | | | Reference Design Values [lbs] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Panel Type | Thicknesses: Panel | Thicknesses: Spline | Spline Width | Tested Connection Geometry Specification | | | | Fastener Options | Calculated Standard Loading $C_D$ =1.0 | Tested Standard Loading $C_D$ =1.0 | Tested Short Term Loading $C_D$ =1.6 | Estimated Stiffness [in. / kips] |
| | (t) | ($S_T$) | ($S_W$) | ($a_L$) | (e) | ($S_Q$) | ($S_P$) | | $Z_{//}$ | $Z_{// test}$ | | $K_{test}$ |
| 3 PLY (SPF) | 4-1/8" | 3/4" | 3-3/8" | 2-3/8" | 7/8" | 1-5/8" | 4-3/4" | Eco 5/16" x 3-1/8" | 172 | 292 | 467 | 0.17 |
| 3 PLY (D. Fir) | 4-1/8" | 1" | 11" | 6" | 2-3/4" | 5-1/2" | 6" | Eco 3/8" x 4" | 269 | 387 | 619 | 0.2 |
| 5 PLY (SPF) | 6-7/8" | 3/4" | 5-1/2" | 6" | 1-3/8" | 2-3/4" | 6" | Eco 1/4" x 6-1/4" | 134 | 198 | 317 | 0.3 |
| 5 PLY (SPF) | 6-7/8" | 1" | 5-1/2" | 6" | 1-3/8" | 2-3/4" | 6" | Eco 5/16" x 6-1/4" | 243 | 444 | 710 | 0.17 |

Notes:

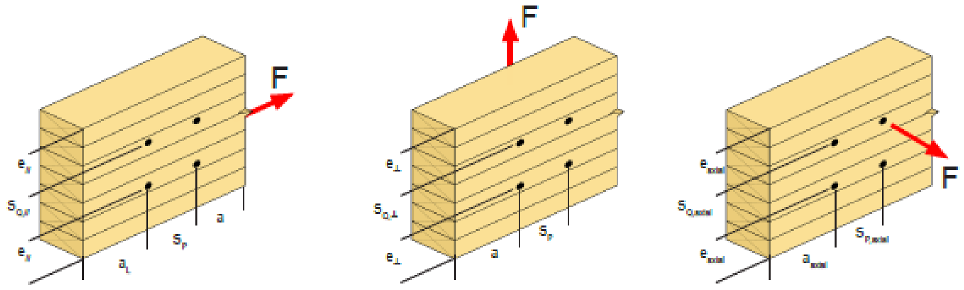
1. Tested reference design values apply to a single fastener, conforming to the connection geometry and loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA.
3. Allowable listed loads are only valid for listed ASSY screws.
4. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
5. Tested reference lateral design values ($Z_{test}$) presented apply to the specific configurations tested only.
6. Testing was done with fasteners installed in pair, one screw in each CLT panel in order to transmit the load through the spline connection.
7. CLT panels ply thickness tested were 1-3/8 [35 mm].
8. It is recommended to stagger the screws across the line of the joint, as illustrated in the Tested Connection Geometry Specification on this page.

Tested Connection Geometry Requirements



# Connection Detailing

Geometry Requirements for ASSY Screws




Lateral loading parallel to grain

Lateral loading perpendicular to grain

Axial loading

Table S.2.1, Timber Connection Geometry Requirements without Pre-drilling

| Fastener Thread Type | Specific Gravity | End Distance | | Edge Distance | | | Spacing Between Fasteners in a Row | | Spacing Between Rows | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $a / a_{\perp}$ | $a_{axial}$ | $e_{\parallel}$ | $e_{\perp}$ | $e_{axial}$ | $S_{p}$ | $S_{p,axial}$ | $S_{Q\perp} / S_{Q\parallel}$ | $S_{Q,axial}$ |
| Partial Thread | $G \leq 0.42$ | 10 D | 10 D | 5 D | 10 D | 5 D | 5 D | 5 D | 5 D | 5 D |
| | $0.42 < G \leq 0.55$ | 15 D | 15 D | 7 D | 12 D | 7 D | 7 D | 7 D | 7 D | 7 D |
| | D. Fir, G = 0.49 | 22.5 D | 22.5 D | 7 D | 12 D | 7 D | 10.5 D | 10.5 D | 7 D | 7 D |
| Full Thread | $G \leq 0.42$ | 7 D | 5 D | 3 D | 7 D | 3 D | 7 D | 5 D | 5 D | 2.5 D |
| | $0.42 < G \leq 0.55$ | 7 D | 5 D | 3 D | 7 D | 3 D | 7 D | 5 D | 5 D | 2.5 D |
| | D. Fir, G = 0.49 | 10.5 D | 10.5 D | 3 D | 7 D | 3 D | 10.5 D | 7.5 D | 5 D | 2.5 D |

## Geometry Requirements

- Values listed for each connection type
- Easy to read to diagrams

## Other Detailing Requirements

- Pre-drilling recommendations
- Torque limit


Panel to Panel Connections
Steel to Wood Connections
Ledger Connections
Floor to Wall Connections
Post to Beam Connections
Panel to Beam Connections
Self-Drilling Dowel Connections
Connector Design Guide
Wall Connections

# Why MTC Solutions

# What Differentiates MTC Solutions

- Expertise
- Commitment
- NORTH AMERICAN – Tailored Products

# What Differentiates MTC Solutions

Expertise

- We Bring **+ Value** to Our Customers
- We Provide **Exceptional Assets**
  - **Products & Services**
- We **Educate** & Elevate Knowledge in **The Mass Timber Industry**

# What Differentiates MTC Solutions

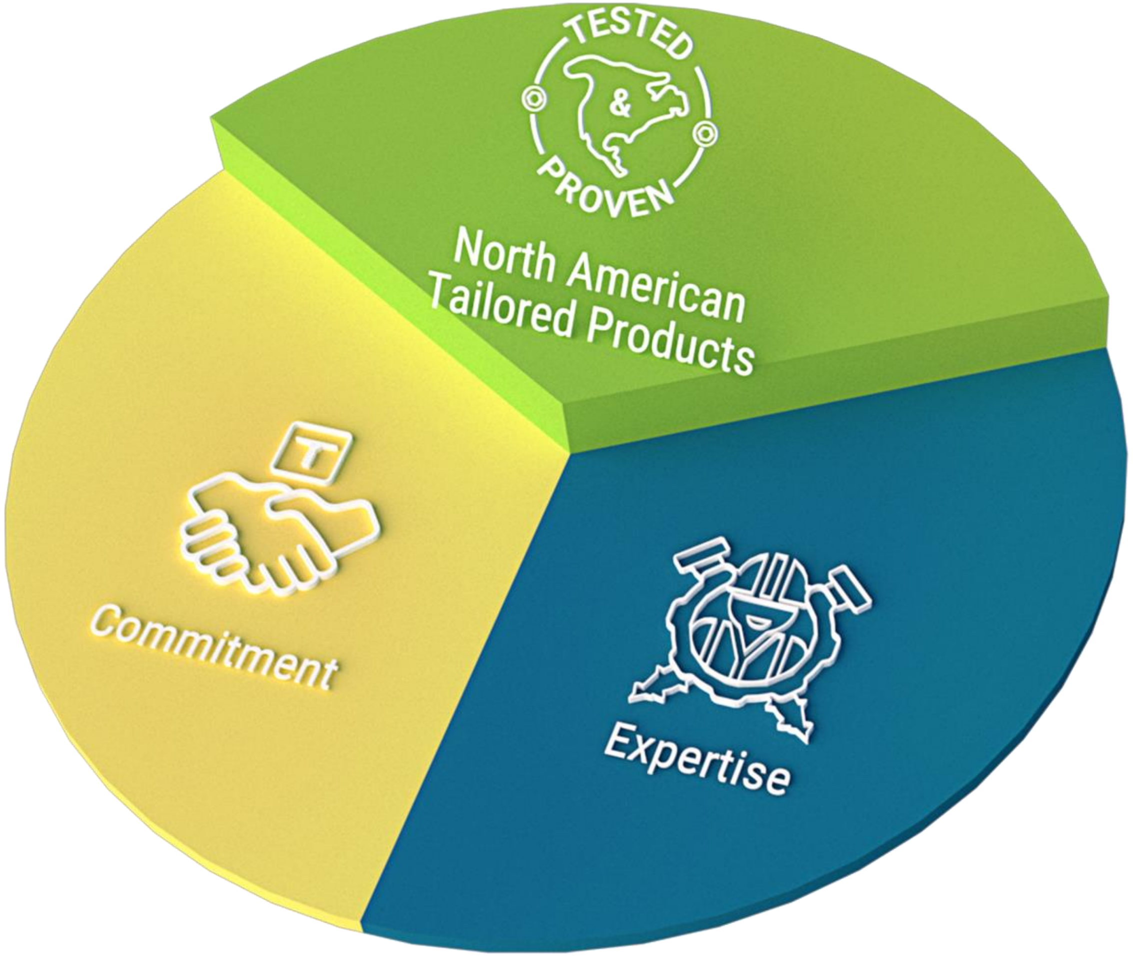
## Commitment

- Solution Oriented
- Flexibility
- Fast Reaction Time

# What Differentiates MTC Solutions

NORTH AMERICAN – Tailored Products

- High-Capacity Connectors
- Designed and Code Approved for North America
- Extensively Tested



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