MTC SOLUTIONS

Structural Screw Connection Design Guide

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Carbon 12

Portland, Oregon

Courtesy of Andrew Poque

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Mass Timber Hardware Specialist

At MTC Solutions, our core focus is to supply structural hardware for modern mass timber applications in commercial, industrial, and residential projects. We are proud to partner with leading industry experts, providing solutions and tools to design code-compliant buildings that are pushing the boundaries of the North American construction industry.

Our in-house team of mass timber specialists support professionals in designing connections that are tailored to the specific needs of each project, resulting in truly innovative and cost-efficient solutions. We are recognized as experts, moving the industry forward with tested and proven solutions.

Expertise

We provide the knowledge and tools to help our customers build cutting-edge and code-compliant mass timber projects while pushing the boundaries of the North American construction industry.

Commitment

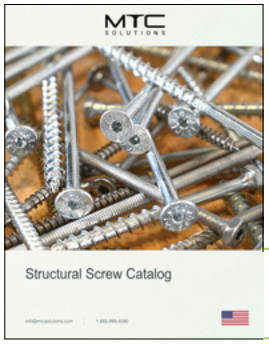
We are dedicated to making your project a success, from design and installation support to delivering high quality products with speed and accuracy.

North American Tailored Products

We partner with leading research facilities across North America to ensure our products are tested and customized to fit the unique needs of the market, from seismic considerations to solutions for large post and beam structures in various climates.

Find Your Connection Solution

MTC Solutions provide the right tools to design code-compliant buildings, educating the mass timber industry on connection solutions.



Structural Screw Catalog

Structural Screw Connection Design Guide

Structural Fasteners

Accessories

Beam Hangers Design Guide

Beam Hangers

Connector Design Guide

Connectors

Rigging Design Guide

Rigging Devices

Fall Arrest Anchor Design Guide

Fall Arrest

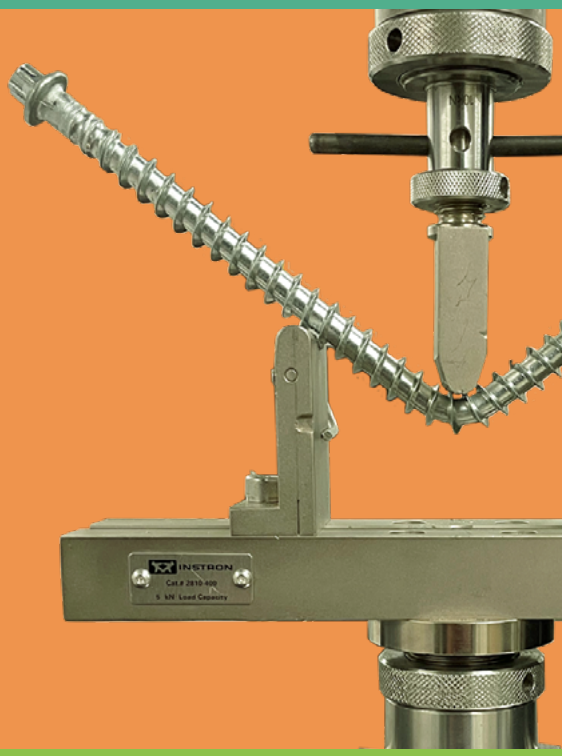
WHO ARE WE?

YOUR MASS TIMBER HARDWARE SUPPLIER

Rely on our distribution team to deliver your North American projects with speed and accuracy.

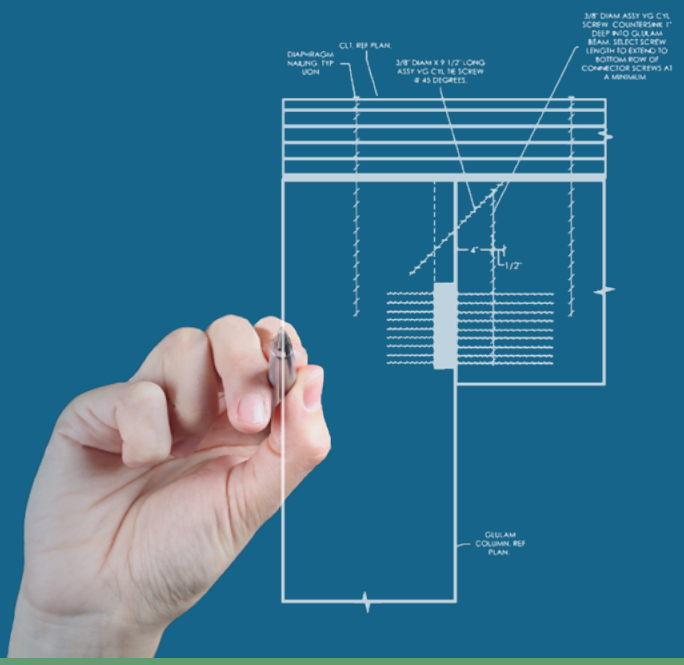
LEADING WITH INNOVATION & RESEARCH

We are leading the mass timber industry with cutting edge connection solutions and partnering with renowned research facilities.



WE MAKE YOU THE EXPERT

Learn about the right solutions for your projects and Mass Timber connections with our technical resources & support team!



CONNECTIONS DESIGN SUPPORT

Reach out to the technical team for design support, from early design stages to ongoing iterative changes. We help find the most efficient connection solutions.

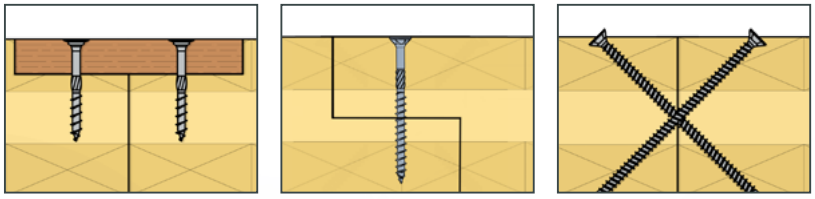
MANUFACTURERS' HELP DESK

Use our comprehensive & practical resources to find the most cost-effective solutions for your structural elements.

TESTED & PROVEN SOLUTIONS

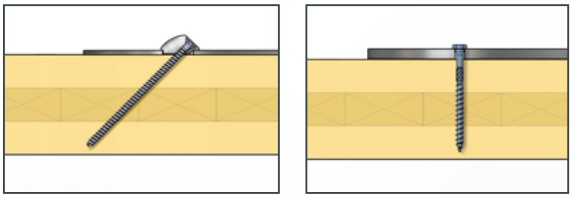
Count on MTC Solutions' 10+ years of expertise, providing tested & proven ICC approved solutions, support, and resources.

General Information



Panel to Panel Connections

p. 19 - 35



Steel to Wood Connections

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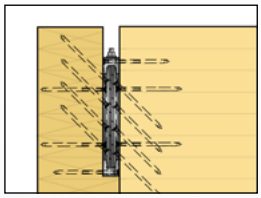

Post to Beam Connections

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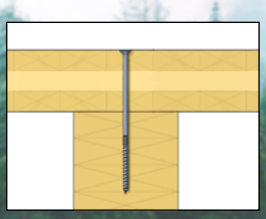

Panel to Beam Connections

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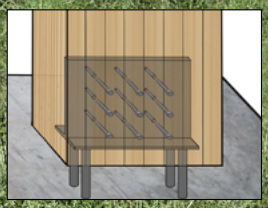
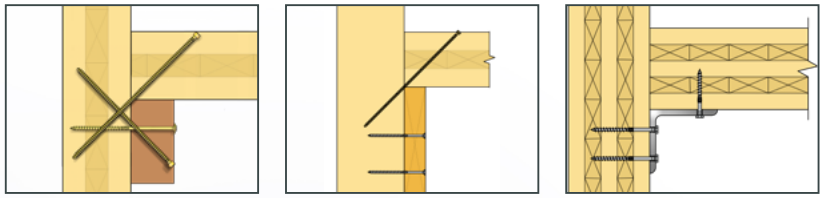


Self-Drilling Dowel Connections

Design Guide

Connector Design Guide

Design Guide



Ledger Connections

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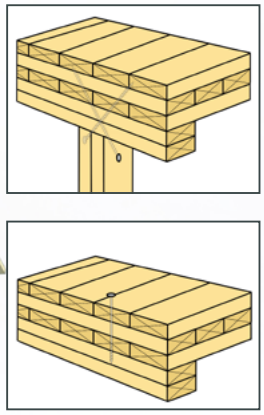

Floor to Wall Connections

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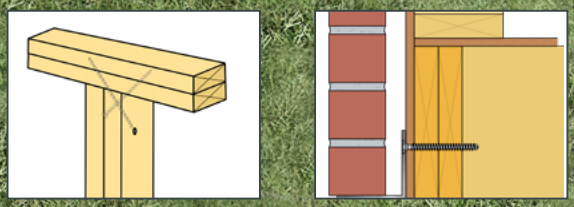

Wall Connections

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The Structural Mass Timber Fastening Design Guide

This guide is the result of years of research in the North American mass timber market, industry partnerships and hands-on engineering experience. The solutions presented in this guide are found to be efficient and practical.

These solutions are achieved by using high quality hardware, evaluated through testing. This effort makes this guide the ultimate tool for designer to refer to.

Research and Testing

Designers can have peace of mind knowing that the values listed in this guide are confirmed through testing. Testing is conducted in collaboration with universities across North America using North American wood species that are readily available on the market. All testing follows applicable standards for the United States and Canada.

Certifications

Code-approved and reliable, ASSY fasteners were awarded with ICC-ESR approval in the US and by the Canadian Construction Materials Centre (CCMC) in Canada.

Our suppliers follow the strictest manufacturing processes and are under third party quality control by North American authorities. Our high-quality product comes with a commitment to high-quality service through our team of product consultants and technical advisors.

Fastener Line

Our self-tapping fasteners, constructed of hardened steel are engineered to fit the special needs of the North American mass timber market. Available in a wide variety of shapes and sizes, our fastener line provides viable mass timber connection solutions for all structural timber systems.

AVAILABLE IN MULTIPLE SIZES

TESTED IN NORTH AMERICA

Engineered Head

Multiple head types available

Shank

Large selection of diameters and lengths available

Case Hardened Steel

Up to 3 times the bending yield strength of generic lag screws

Shank Cutter

Reduces torque during installation

Large Thread

Provides high withdrawal resistance

Self Tapping Tip

Eliminates the need for pre-drilling and provide easy installation

CERTIFICATIONS

ICC EVALUATION SERVICE
ICC-ESR-3178
ICC-ESR-3179

CCMC
13677-R

ISO 50001

ETA

Information about Mass Timber

Wood Failure Modes and Reinforcing Solutions

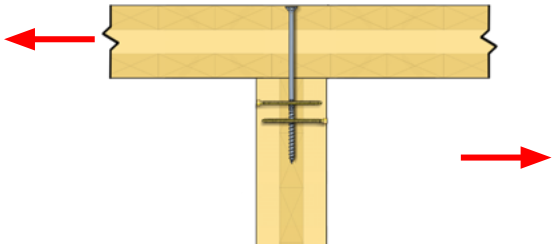
The high withdrawal resistance and tensile strength of fully threaded self-tapping screws can be used in many ways to compensate for low strength loading directions in timber or CLT. Some common failure modes and reinforcing solutions are explained below.

In conventional timber design, tensile stresses perpendicular to grain are generally avoided. North American design standards do not provide designers with capacities in this loading direction due to the brittle failures that occur. For CLT, perpendicular to grain tensile loading is a typical loading direction for fasteners installed on the narrow edge of CLT panels. In some cases, these fasteners have the capacity to over-stress the CLT if it is loaded out of plane.

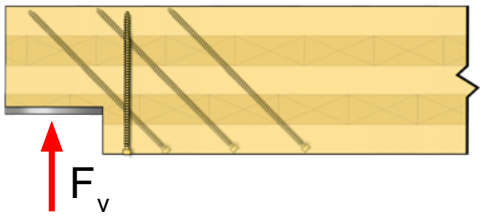
Notches at the tension face of bending members can also overstress the CLT members. In many cases, fully threaded fasteners can be designed to transfer the tensile load components, preventing accidental brittle failure modes.

Compressive stresses perpendicular to the grain typically do not cause brittle failure modes, however, timber strength in this direction is low. Designers can compensate for this low strength by using fully threaded screws and taking advantage of their high axial resistance. Compressive load components are transmitted into the panel through the screws, where the stresses are then diffused. Transferring the compressive loads through the screws increases the effective bearing area resulting in more effective force distribution.

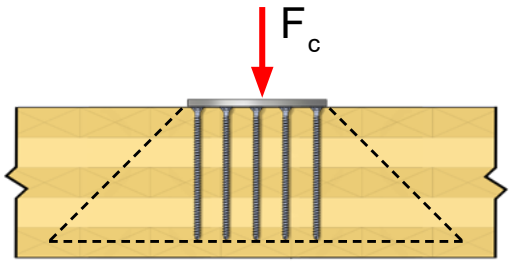
CLT can sometimes be limited by the relatively low rolling shear strength and stiffness of the crossing plies. Reducing the thickness of cross layers may mitigate this issues of low rolling shear strength and stiffness. Fully threaded screws can be used to reinforce the CLT against shear stresses activated by panel bending as well as point loads.



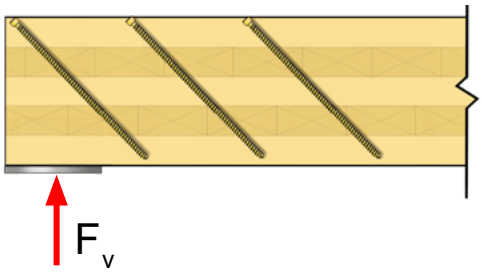
CLT floor to wall connection reinforcement to minimize risk of brittle failures



CLT notch reinforcement with a full thread screws



CLT bearing reinforcement with full thread screws to increase the virtual bearing area



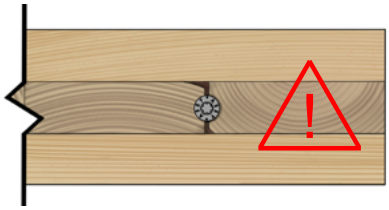
CLT rolling shear reinforcement using inclined full thread screws

Withdrawal Design in Narrow Panel Edge

For fasteners installed on the narrow edge of the panel loaded in withdrawal, an end grain reduction factor of C_{eg} = 0.75 is assigned to reference withdrawal design values, as per Clause 12.2.1.5 (exceptions may apply; see C12.2.1.5).

Designers should be mindful of the possibility of gaps on the narrow edge of CLT, as there is a risk they will run parallel to the screw axis.

Long term loading of fasteners in withdrawal from the narrow edge of CLT is not recommended if the fastener is installed parallel to grain. Screws can be installed at an angle of 75° to the edge surface to counteract the presence of both end grain and gaps. Long length screws (at least 20D penetration) are recommended over short screws.



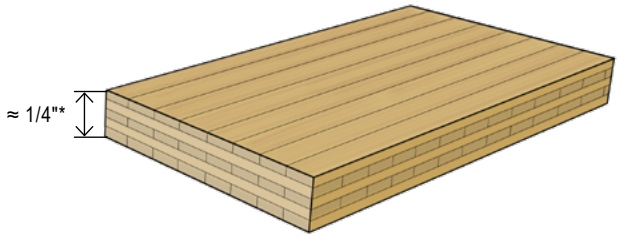
Screw Installed in a Gap in the Narrow Edge

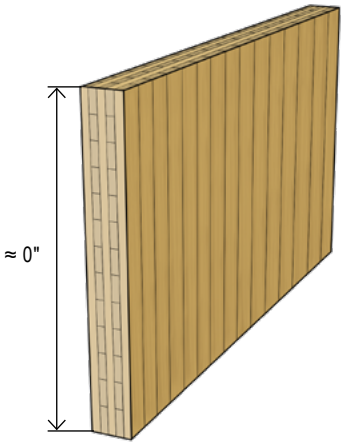
Screw Installed in the Narrow Edge

Swelling and Shrinkage of CLT

According to Clause 10.1.5 of NDS-2018, cross-laminated timber is specified for dry service conditions unless specifically permitted by the manufacturer. Nonetheless, there is a chance CLT panels may be exposed to the elements during construction.

CLT is considered dimensionally stable, for the most part, against swelling and shrinking in-plane if changes in moisture occur. However, designers should consider the effects of swelling and shrinkage perpendicular to the panel plane, as this can affect connection integrity.





Notes:

1. For a 4-1/8" 3 ply S.P.F.panel to a 12" S.P.F. panel, swelling and shrinkage may vary from ≈ 1/16" to ≈ 1/2".

* 1/4" is for a 6-7/8" 5 ply CLT panel.

How to Use this Guide

About this Guide

This connection design guide will help designers to get an overview of connection design with CLT in accordance with applicable design standards. State-of-the-art structural details are visualized in an easy-to-read table format.

All Reference Design Values presented in this document have been estimated following applicable provisions in the 2018 National Design Specification (NDS) for Wood Construction or derived from testing following ICC-ESR AC233 data analysis guideline.

Design Table Guidelines

CLT Loading Conditions
Summary figure of the CLT panels orientation and load direction
(See page 15)

Panel Thickness (t)
The overall panel thickness is shown by "t". The thickness for each individual layer is also shown as "t_i"

Fastener Information
Description of the fastener applicable for the given connection parameters, including diameter and length

Reference Design Values
Fastener(s) reference strength in the loading directions applicable to the connection
(See page 15)

Panel & Joint Configuration				Fastener Options	Reference Design Values [lbs]		Minimum Spacing in a Row (S_P)
Loading			Panel Thickness		Standard Loading C_D =1.0	Short Term Loading C_D =1.6	
3 PLY	$Z_{//}$		4-1/8"	VG Cyl 1/4" x 5-1/2"	123	197	1"

Specific Gravity (G)
The assigned specific gravity of the material used for the calculations are the following:


S-P-F
G = 0.42


Douglas Fir
G = 0.49

Tables Color Code
The colors represents the diameter of the fastener used in the connection:

- 1/4" screw
- 5/16" screw
- 3/8" screw
- 1/2" screw

Adjusted Design Value Calculation (Z')

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

- Z Reference design value ($Z_{||}$, $Z_{m,\perp}$, $Z_{s,\perp}$, $Z_{\perp}$, Z_{cal}, Z_{test} or W) given in the provided design tables or 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_Δ ; C_{eg} ; C_{di} ; C_{tn} ; C_g

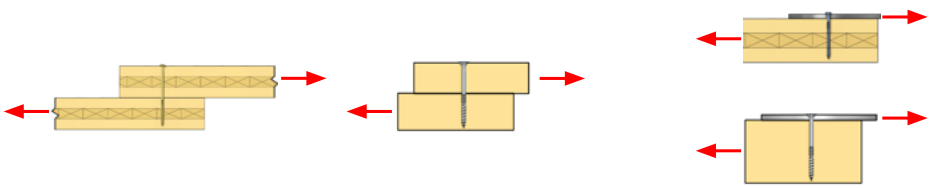
Connection Design

The load relation to grain orientation is based on the plie's orientation in the shear plane.

Wood-to-Wood | Steel-to-Wood

$Z_{||}$ - Parallel to Grain Loading

Connection with all wood members loaded parallel to grain.

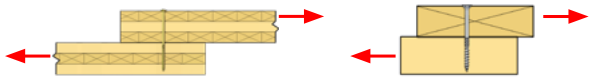


$Z_{m,\perp}$ - Parallel to Grain Loading of Side Member

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

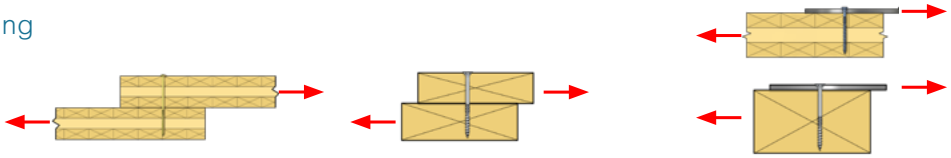
$Z_{s,\perp}$ - Parallel to Grain Loading of Main Member

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.

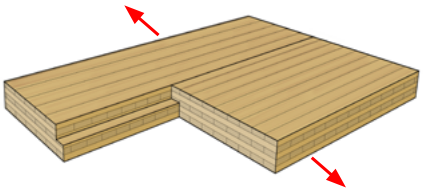


W - Withdrawal Loading

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:



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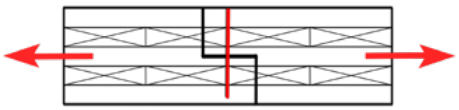
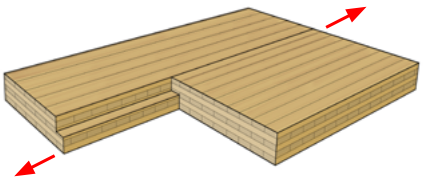
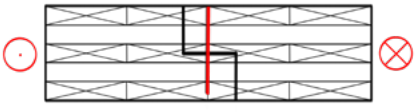


Loading parallel to the connection plane:



icon:



General Notes To The Designer

1. Reference design values presented in this design guide are based on the NDS-2018; ICC-ESR 3178-2018; ICC-ESR 3179-2019; and boundary conditions outlined in ETA-11/0190 unless noted otherwise.
2. For tested reference lateral design values (Z_{test}) determined by testing, all connection design must meet all relevant requirements of the General Notes for Reference Design Values (Z_{test}) section.
3. All suggestions and details shown are to be treated as general and cannot be assumed to be valid for all construction requirements and specific site conditions.
4. Connections must respect the geometry requirements as specified in the Detailing Section of this guide and the NDS.
5. Reference design values must be adjusted in accordance with all applicable adjustment factors of the NDS, Section 12.
6. Maximum allowable drive in torque of the fasteners must be respected, see the Detailing Section, Table S.4.
7. Carbon steel ASSY screws are intended to be used in untreated wood under dry service conditions and temperatures below 100°F such that C_M=1.0 and C_t=1.0.
8. For standard term loading, load duration factor is C_D=1. For short term loading, load duration factor is C_D=1.6, as per 11.3.2; NDS-2018.
9. For connection with inclined axially loaded screws, the listed reference design values are given along the line of the force. The vector has already been projected from the screw's axis to the shear plane of the connection.
10. Listed reference lateral design values (Z) apply to different timber species according to their respective specific gravities (G).
11. A pilot hole may be used to facilitate the installation of long self-tapping screws. Pilot holes of at least 3" (76mm) in depth should be used when screws are installed near the edge of the wood member or in the end grain. Pilot hole diameter must not exceed the minor diameter of the fastener.
12. The designer must ensure that all possible stress limits in the wood members, such as the shear capacity, the rolling shear capacity of the Cross Laminated Timber (CLT) or other material properties, are not exceeded, and continuous load path is assured.
13. A load bearing connection shall consist of at least two (2) ASSY screws.
14. For CLT connections, listed reference design values apply to CLT with G = 0.42 or higher.
15. In wood species sensitive to splitting, minimum geometry requirements may be required to be increased.
16. Example details do not show all required nails or other fasteners for clarity.
17. With approval from a design professional;

    ASSY VG Cyl screws may be replaced with ASSY VG CSK

    ASSY Ecofast screws may be replaced with ASSY SK screws.

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 3.4.2. 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.

Umass Design Building

Amherst, Massachusetts

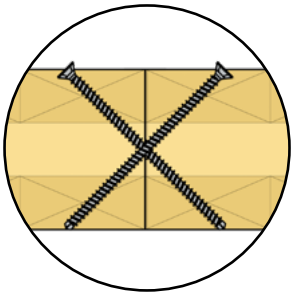
Courtesy of Alex Schreyer

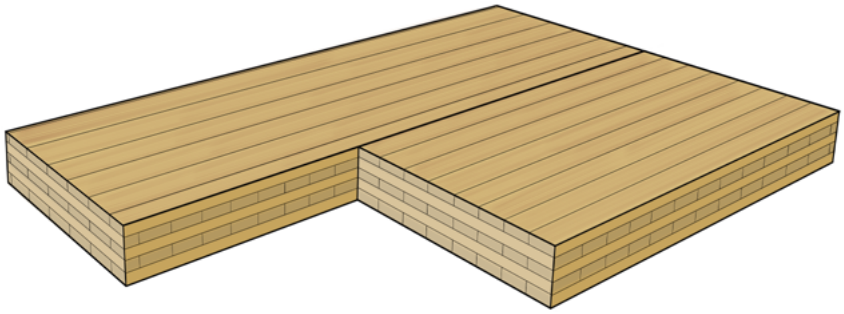
Typical Panel to Panel Connections

Floor-to-floor connections are mainly designed to transfer in-plane shear forces, with the panels acting as a diaphragm. Several joint types are used in construction, offering differences in application, price, capacity and ease of installation. In the following section, the three most common floor-to-floor joints are presented.

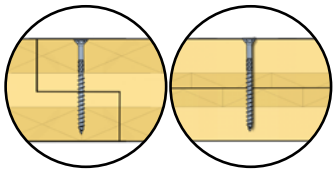
- **The Butt joint** is the simplest connection type from a fabrication point of view, as the panels are simply cut straight at the edges. It requires short machining time and less material is lost during production.
- **Lap joints** require more prefabrication than butt joints. For this, part of the panel width is removed when installed. Lap joints offer the largest variety of connection performances.
- **Spline joints** are similar to butt joints, but rather than installing the fastener at an incline, sections of the CLT are cut out to accept splines usually made from standard plywood.

Butt Joint Connection

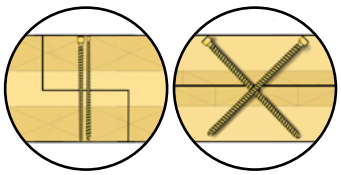




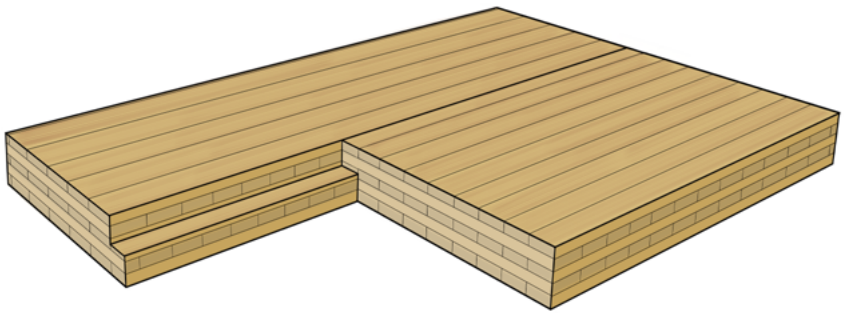
Lap Joint Connection



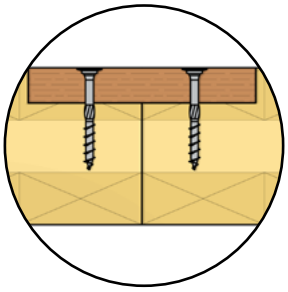
Lap Joint Connection in Shear

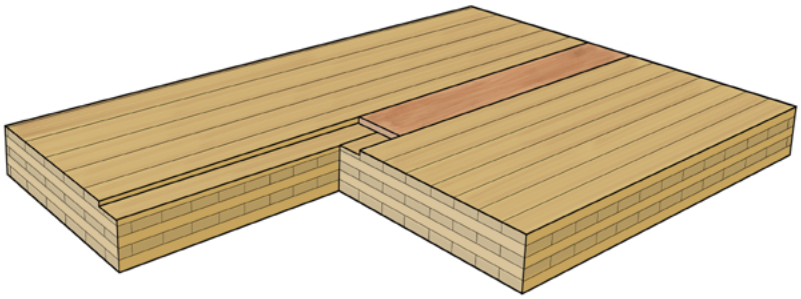


Lap Joint Connection with Inclined Screws



Surface Spline Connection



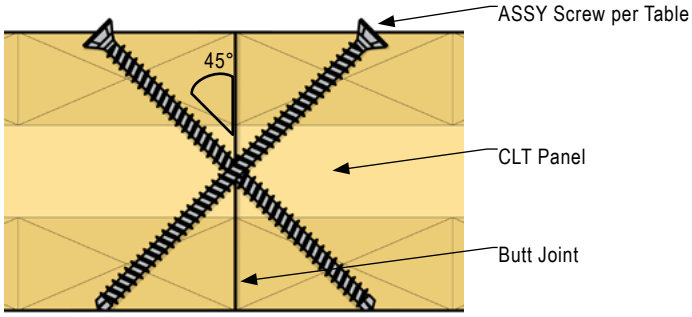


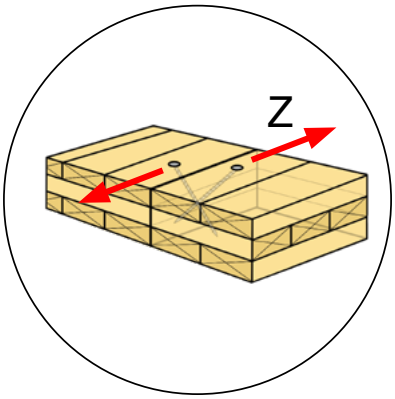
CLT Butt Joint Connection in Shear

The simple butt joint is one of the most cost effective methods of transferring in-plane shear between CLT panels because they only require square edge faces to be connected. Screws are installed at a 45° angle to the edge face, creating a mechanical connection at a depth of half the panel thickness.

Pre-drill jigs can be used to create short lead holes which help to assure consistent angle of installation between screws.

Due to minimum penetration requirements, butt joint connections can only be used for panel thicknesses of 4-1/8" and above.





Tested Connection

Table TPP.1, Tested Reference Lateral Design Values for CLT Butt Joints Loaded in Shear

Panel Configuration		Tested Connection Geometry Specification			Fastener Options	Reference Design Values [lbs]			Estimated Stiffness [in. / kips]
Type	Panel Thickness					Calculated Standard Loading C_D =1.0	Tested Standard Loading C_D =1.0	Tested Short Term Loading C_D =1.6	
	(t)	(a_L)	(t/2)	(S_P)		$Z_{//}$	$Z_{// test}$		K_{test}
3 PLY (SPF)	4-1/8"	3"	2"	2-1/2"	VG CSK 5/16" x 5-1/2"	123	306	490	0.26

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 and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Tested reference lateral design values (Z_{test}) presented apply to the specific configurations tested only.
5. Screws are installed at a 45° angle to the surface of the panel, intersecting the joint at 1/2 the panel thickness, such that the screws are loaded perpendicular to their longitudinal axis.
6. CLT panels ply thickness tested were 1-3/8 [35 mm].
7. Testing was done with loading parallel-to-grain at the shear plane unless noted otherwise.

Tested Connection Geometry Requirements

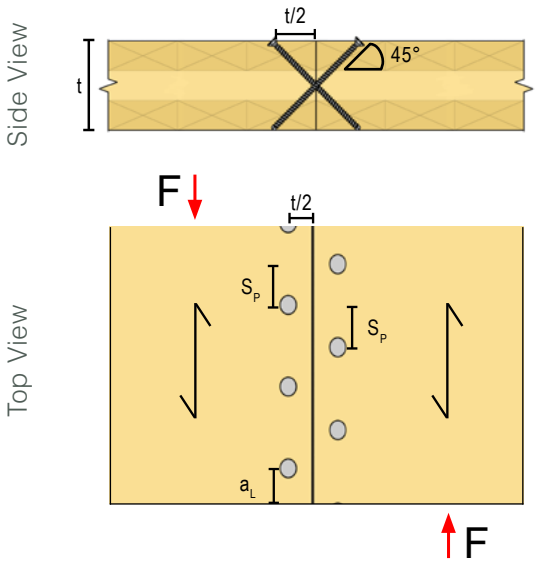
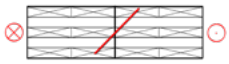
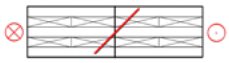


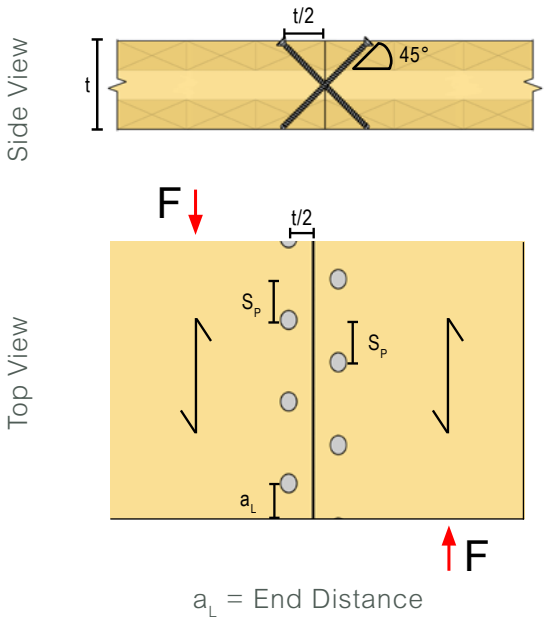
Table PP.1.1, Reference Lateral Design Values for CLT Butt Joints Loaded in Shear

Panel & Joint Configuration				Fastener Options	Reference Design Values [lbs]		Minimum Spacing in a Row (S_P)
Loading			Panel Thickness (t)		Standard Loading C_D =1.0	Short Term Loading C_D =1.6	
3 PLY	$Z_{//}$		4-1/8”	VG Cyl 1/4” x 5-1/2”	123	197	1”
	$Z_{\perp}$						
5 PLY	$Z_{//}$		5-1/2”	VG CSK 5/16” x 7-1/8”	190	304	1-1/4”
			6-7/8”	VG CSK 5/16” x 8-5/8”	190	304	1-1/4”
				VG CSK 3/8” x 8-5/8”	251	402	1-1/2”
	$Z_{\perp}$		5-1/2”	VG CSK 5/16” x 7-1/8”	152	243	1-1/4”
			6-7/8”	VG CSK 5/16” x 8-5/8”	152	243	1-1/4”
				VG CSK 3/8” x 8-5/8”	201	322	1-1/2”

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners are installed at a 45° angle intersecting the shear plane at half the panel thickness.
6. The angle between force and fastener axis is 90°.
7. Adjustment for narrow edge loading of CLT (C_{eg}) shall be considered, following NDS-2018 clause 12.5.2.
8. $Z_{//}$ Angle between loading direction and wood grain in the shear plane ϴ = 0°.
   $Z_{\perp}$ Angle between loading direction and wood grain in the shear plane ϴ = 90°.

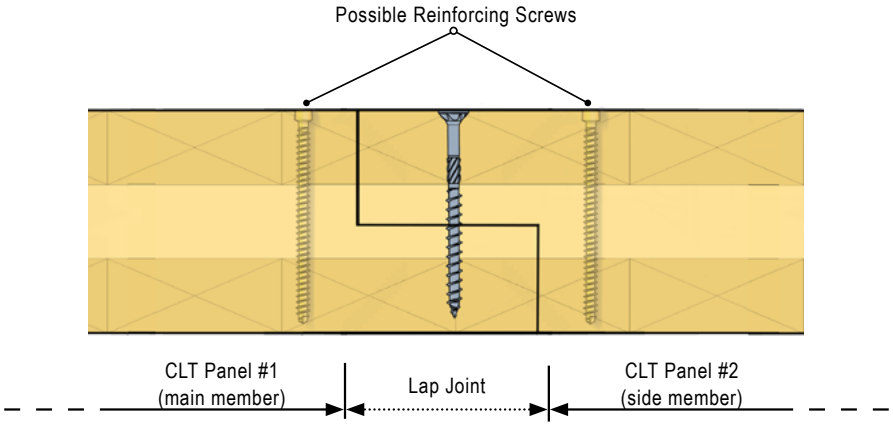
Geometry Requirements

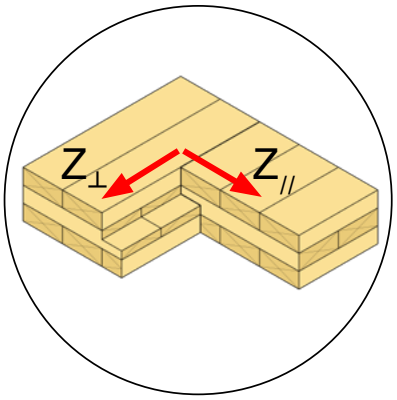


a_L = End Distance

CLT Lap Joint Connection in Shear

The lap joint is a common panel-to-panel connection employed with CLT panels, largely due to ease of installation Reinforcing screws can be considered to strengthen the panel across the grain (similar to notch reinforcement) where out of plane load transfer is anticipated across the joint. As with any lateral connection design with CLT, the grain direction at the shear plane is used as a base of reference.





Tested Connection

Table TPP.2, Tested Reference Lateral Design Values for CLT Lap Joints Loaded in Shear

Panel Configuration		Tested Connection Geometry Specification				Fastener Options	Reference Design Values [lbs]			Estimated Stiffness [in. / kips]
Type	Panel Thickness						Calculated Standard Loading C_D =1.0	Tested Standard Loading C_D =1.0	Tested Short Term Loading C_D =1.6	
	(t)	(a_L)	(e)	(b_{lap})	(S_P)		$Z_{//}$	$Z_{// test}$		K_{test}
3 PLY (SPF)	4-1/8"	3"	1-5/8"	3-1/8"	2-1/2"	Eco 5/16" x 3-1/2"	183	288	461	0.14
5 PLY (SPF)	6-7/8"	6"	1-1/4"	2-5/8"	6"	Eco 1/4" x 6-1/4"	185	341 *	546 *	0.14
		3"	1-5/8"	3-1/8"	2-1/2"	Eco 5/16" x 6-1/4"	243	486	778	0.14

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 and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. It is recommended that panel-to-panel CLT lap joint connections be reinforced if potential loads may occure in a direction promoting CLT notch failures.
5. Tested reference lateral design values (Z_{test}) presented apply to the specific configurations tested only.
6. CLT panels ply thickness tested were 1-3/8 [35 mm].
7. Lap joint notch reinforcement may be required and remains responsibility of the designer.
8. Testing was done with loading parallel-to-grain at the shear plane unless noted otherwise.

*Testing was done with loading perpendicular-to-grain at the shear plane.

Tested Connection Geometry Requirements

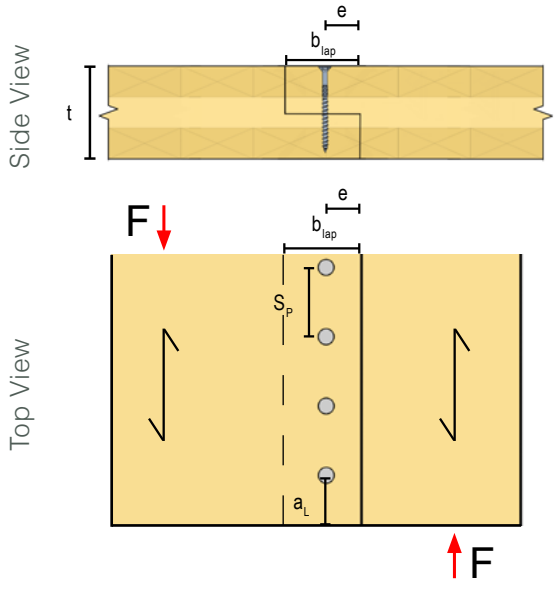
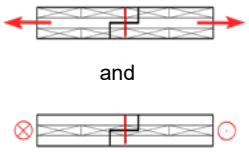
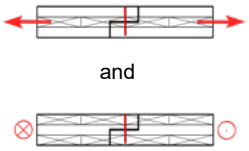


Table PP.2.1, Reference Lateral Design Values for CLT Lap Joints Loaded in Shear

Panel & Joint Configuration				Fastener Options	Reference Design Values [lbs]		Minimum Spacing in a Row (S_P)
Loading			Panel Thickness (t)		Standard Loading C_D =1.0	Short Term Loading C_D =1.6	
	$Z_{//}$		4-1/8”	Eco 1/4” x 3-1/2”	153	245	1”
			4-1/8”	Eco 5/16” x 4”	209	334	1-1/4”
	$Z_{\perp}$		4-1/8”	Eco 1/4” x 3-1/2”	153	245	1”
			4-1/8”	Eco 5/16” x 4”	167	267	1-1/4”

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. It is recommended that panel-to-panel CLT lap joint connections be reinforced if potential loads may occure in a direction promoting CLT notch failures.
6. Fasteners are installed at a 90° angle intersecting the shear plane at half the panel thickness.
7. The angle between force and fastener axis is 90°.
8. Reference lateral design values may be applied to parallel and perpendicular loading towards the panel joint considering grain directions and minimum spacing requirements.
9. $Z_{||}$ Angle between loading direction and wood grain in the shear plane $\Theta = 0°$.
   $Z_{\perp}$ Angle between loading direction and wood grain in the shear plane $\Theta = 90°$.

Geometry Requirements

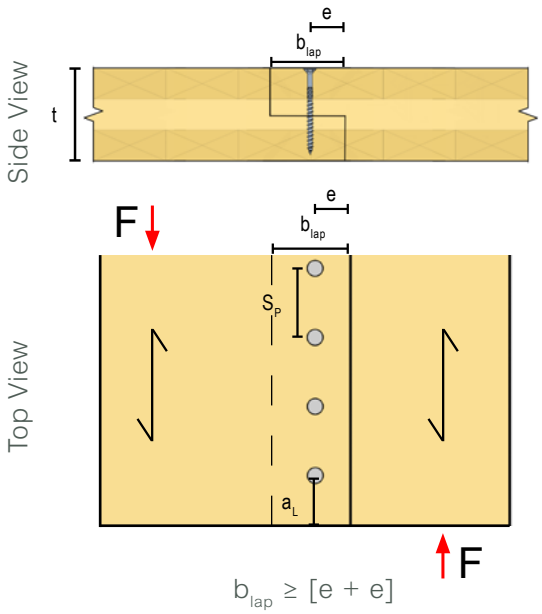
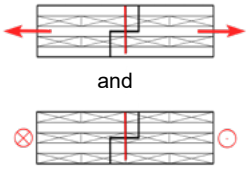
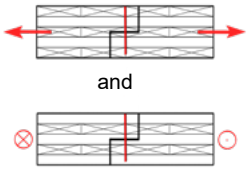
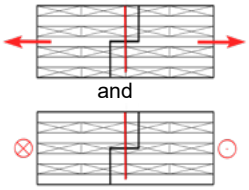
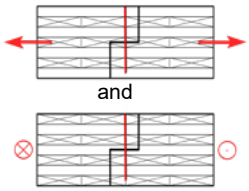


Table PP.2.2, Reference Lateral Design Values for CLT Lap Joints Loaded in Shear

Panel & Joint Configuration				Fastener Options	Reference Design Values [lbs]		Minimum Spacing in a Row (S_P)
Loading			Panel Thickness (t)		Standard Loading C_D =1.0	Short Term Loading C_D =1.6	
5 PLY	$Z_{//}$		5-1/8"	Eco 1/4" x 4-3/4"	185	296	1"
			5-1/2"				
			6-7/8"	Eco 5/16" x 6-1/4"	243	389	1-1/4"
				Eco 3/8" x 6-1/4"	354	566	1-1/2"
	$Z_{//}$		5-1/8"	Eco 1/4" x 4-3/4"	185	296	1"
			5-1/2"				
			6-7/8"	Eco 5/16" x 6-1/4"	194	310	1-1/4"
				Eco 3/8" x 6-1/4"	244	390	1-1/2"
7 PLY	$Z_{//}$		7-1/2"	Eco 5/16" x 7-1/8"	243	389	1-1/4"
				Eco 3/8" x 7-1/8"	366	586	1-1/2"
			8-5/8"	Eco 5/16" x 7-7/8"	243	389	1-1/4"
				Eco 3/8" x 7-7/8"	366	586	1-1/2"
			9-5/8"	Eco 5/16" x 8-5/8"	243	389	1-1/4"
				Eco 3/8" x 8-5/8"	366	586	1-1/2"
	$Z_{\perp}$		7-1/2"	Eco 5/16" x 7-1/8"	194	310	1-1/4"
				Eco 3/8" x 7-1/8"	244	390	1-1/2"
			8-5/8"	Eco 5/16" x 7-7/8"	194	310	1-1/4"
				Eco 3/8" x 7-7/8"	244	390	1-1/2"
			9-5/8"	Eco 5/16" x 8-5/8"	194	310	1-1/4"
				Eco 3/8" x 8-5/8"	244	390	1-1/2"

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. It is recommended that panel-to-panel CLT lap joint connections be reinforced if potential loads may occure in a direction promoting CLT notch failures.
6. Fasteners are installed at a 90° angle intersecting the shear plane at half the panel thickness.
7. The angle between force and fastener axis is 90°.
8. Reference lateral design values may be applied to parallel and perpendicular loading towards the panel joint considering grain directions and minimum spacing requirements.
9. $Z_{||}$ Angle between loading direction and wood grain in the shear plane $\Theta = 0°$.
   $Z_{\perp}$ Angle between loading direction and wood grain in the shear plane $\Theta = 90°$.

CLT Lap Joint Notch Reinforcement

Floor to floor connections are typically designed to transfer in-plane diaphragm forces acting parallel to the line of the joint. Design of the floor system will typically minimize vertical load transfer caused by out-of-plane forces.

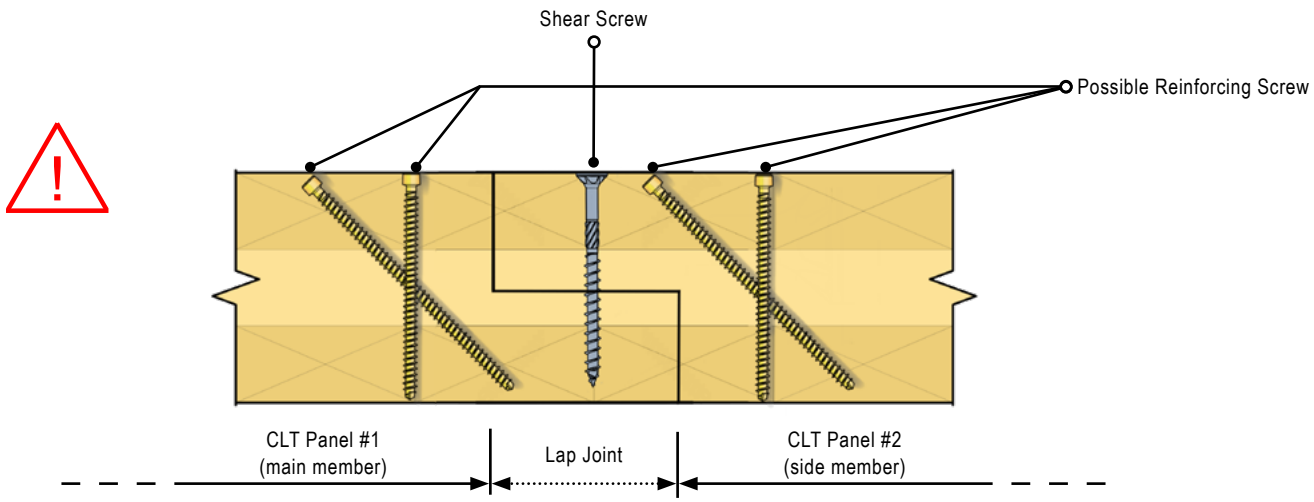
Coding standards, including the NDS-2018, do not provide directives for notches on the tension side of CLT panels. Therefore, there are no fully developed procedures outlining the unique material characteristics, stress distribution patterns and crack propagation path along the unglued lamella edges within the CLT.

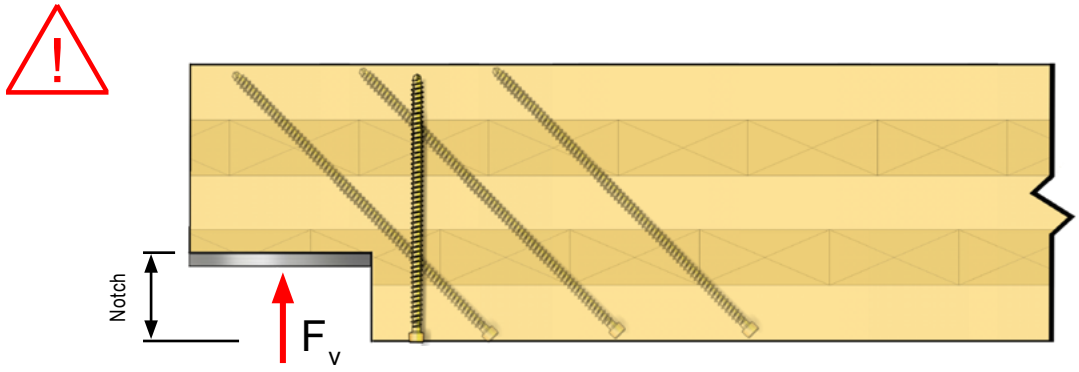
Designers are asked to be more conservative when designing notches with out of plane loading or to avoid them whenever possible.

Reinforcing notched members with fully threaded self-tapping fasteners may prevent brittle failure mode through the screws high axial capacity.

For Glued Laminated Timber, notches shall not exceed the lesser of 1/10 of the beam depth or 3" as per 5.4.5.1; NDS-2018.

CLT Lap joint connections are two notched members connected together

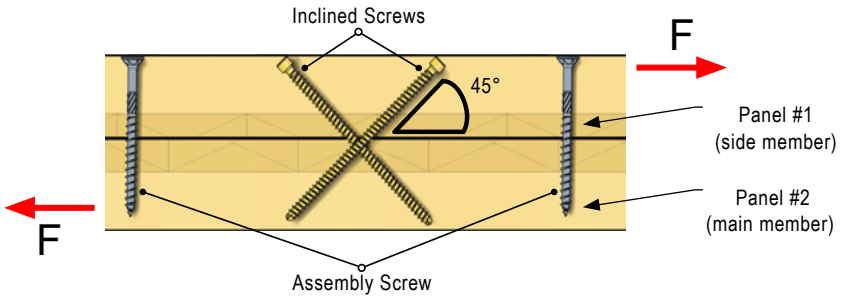




CLT Lap Joint with Inclined Screws

Similar to butt joints, a mechanical connection can be made across a lap joint using screws inclined at a 45°angle. Inclined screws tend to produce stiffer connections with higher loading capacities. Short pilot holes may be pre-drilled with the help of drill jigs to ensure consistent angle placement.

Reference design values provided below refer to the case of forces acting parallel to the line of joint. Generally, all other characteristics of the lap joint loaded in shear apply.



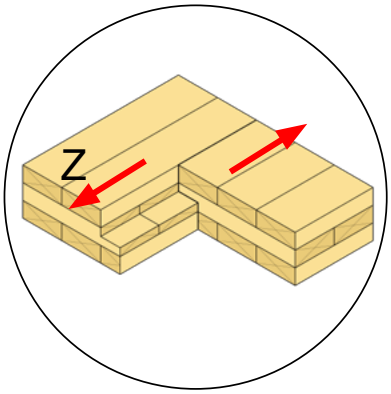


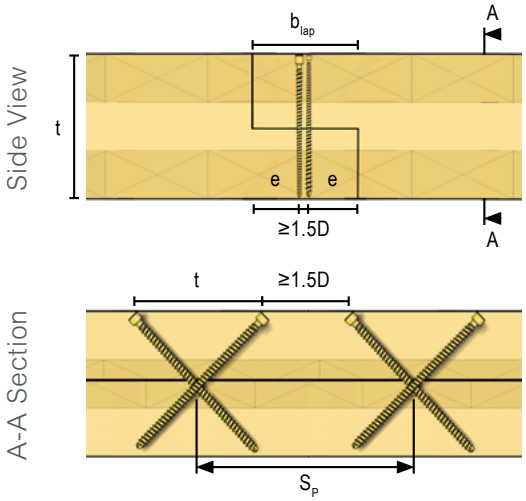
Table PP.3.1, Reference Design Values for CLT Lap Joints with Inclined Screw Crosses

Panel & Joint Configuration				Fastener Options	Reference Design Values per Screw Cross [lbs]		Minimum Spacing in a Row (S_P)
Loading			Panel Thickness (t)		Standard Loading C_D =1.0	Short Term Loading C_D =1.6	
3 PLY	$Z_{//}$		4-1/8"	VG Cyl 1/4" x 5-1/2"	511	818	1-1/2"
	$Z_{\perp}$				524	838	

Notes:

1. Reference design values apply to two fasteners in a screw cross configuration, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. It is recommended that panel-to-panel CLT lap joint connections be reinforced if potential loads may occure in a direction promoting CLT notch failures.
6. Fasteners are installed at a 45° angle intersecting the shear plane at half the panel thickness.
7. The angle between force and fastener axis is 45°.
8. Reference lateral design values only apply to parallel loading along the panel joint.
9. Due to stiffness differences, assembly screws may not be assumed to take any load. They are only there to facilitate installation and insure a tight fit panel joint.
10. The upper limit of the adjusted withdrawal resistance is set by the allowable fastener tensile strength, no further increase are allowed.
11. $Z_{//}$ Reference lateral design value per screw cross in tension with panel joint along major span direction of CLT panel.
    $Z_{\perp}$ Reference lateral design value per screw cross in tension with panel joint along minor span direction of CLT panel.

Geometry Requirements



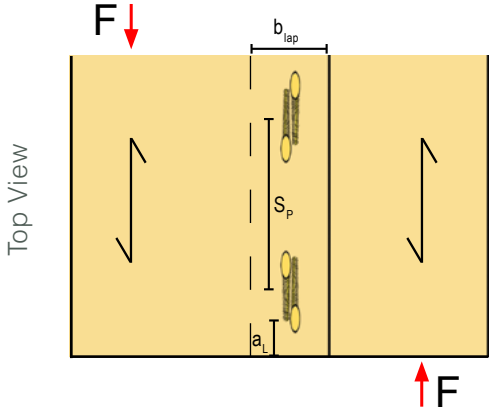
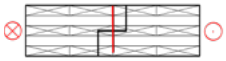
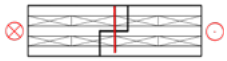
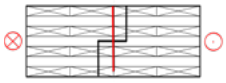
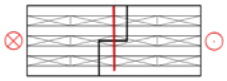


Table PP.3.2, Reference Design Values for CLT Lap Joints with Inclined Screw Crosses

Panel & Joint Configuration				Fastener Options	Reference Design Values per Screw Cross [lbs]		Minimum Spacing in a Row (S_P)
Loading			Panel Thickness (t)		Standard Loading C_D =1.0	Short Term Loading C_D =1.6	
5 PLY	$Z_{//}$		5-1/2”	VG CSK 5/16” x 7-1/8”	798	1,277	1-7/8”
			6-7/8”	VG CSK 5/16” x 8-5/8”	970	1,552	1-7/8”
				VG CSK 3/8” x 8-5/8”	1,067	1,707	2-1/4”
	$Z_{\perp}$		5-1/2”	VG CSK 5/16” x 7-1/8”	843	1,349	1-7/8”
			6-7/8”	VG CSK 5/16” x 8-5/8”	951	1,552	1-7/8”
				VG CSK 3/8” x 8-5/8”	1,043	1,669	2-1/4”
7 PLY	$Z_{//}$		7-1/2”	VG CSK 5/16” x 10-1/4”	1,250	2,000	1-7/8”
				VG CSK 3/8” x 10-1/4”	1,379	2,206	2-1/4”
			8-5/8”	VG CSK 5/16” x 10-1/4”	1,055	1,688	1-7/8”
				VG CSK 3/8” x 10-1/4”	1,158	1,853	2-1/4”
			9-5/8”	VG CSK 5/16” x 11-7/8”	1,343	2,149	1-7/8”
				VG CSK 3/8” x 11-7/8”	1,480	2,368	2-1/4”
	$Z_{\perp}$		7-1/2”	VG CSK 5/16” x 10-1/4”	1,326	2,122	1-7/8”
				VG CSK 3/8” x 10-1/4”	1,462	2,339	2-1/4”
			8-5/8”	VG CSK 5/16” x 10-1/4”	1,059	1,694	1-7/8”
				VG CSK 3/8” x 10-1/4”	1,165	1,864	2-1/4”
			9-5/8”	VG CSK 5/16” x 11-7/8”	1,306	2,090	1-7/8”
				VG CSK 3/8” x 11-7/8”	1,442	2,307	2-1/4”

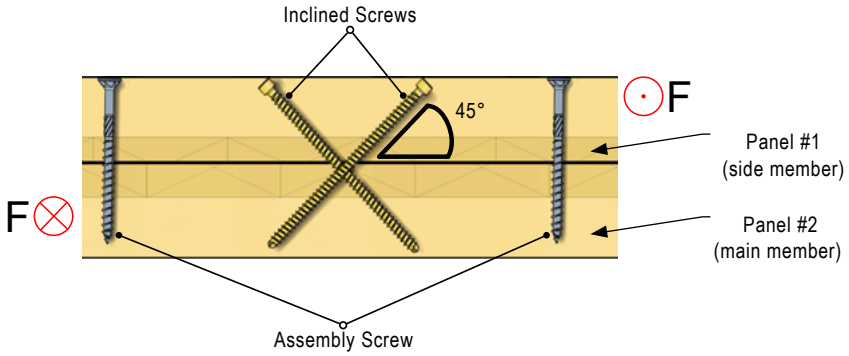
Notes:

1. Reference design values apply to two fasteners in a screw cross configuration, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. It is recommended that panel-to-panel CLT lap joint connections be reinforced if potential loads may occure in a direction promoting CLT notch failures.
6. Fasteners are installed at a 45° angle intersecting the shear plane at half the panel thickness.
7. The angle between force and fastener axis is 45°.
8. Reference lateral design values only apply to parallel loading along the panel joint.
9. Due to stiffness differences, assembly screws may not be assumed to take any load. They are only there to facilitate installation and insure a tight fit panel joint.
10. The upper limit of the adjusted withdrawal resistance is set by the allowable fastener tensile strength, no further increase are allowed.
11. $Z_{//}$ Reference lateral design value per screw cross in tension with panel joint along major span direction of CLT panel.
    $Z_{\perp}$ Reference lateral design value per screw cross in tension with panel joint along minor span direction of CLT panel.

CLT Lap Joint with Inclined Screws in Shear

Loading parallel to the panel joint will result in the screws being loaded by a force component along the axis. The lateral reference design value is calculated according to the lateral component of the withdrawal or tensile strength of the fastener.

Loading perpendicular to the panel joint of an inclined screw application in a lap joint will result in the screw being loaded perpendicular to the axis. In this case, connection strength is calculated in accordance with the Yield Limit Equations in NDS.



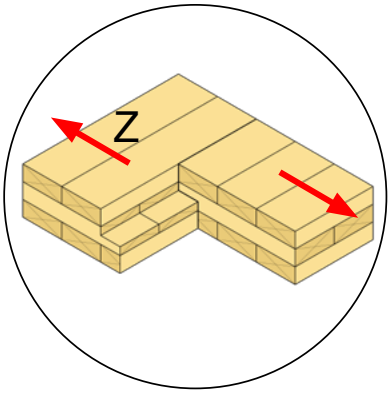


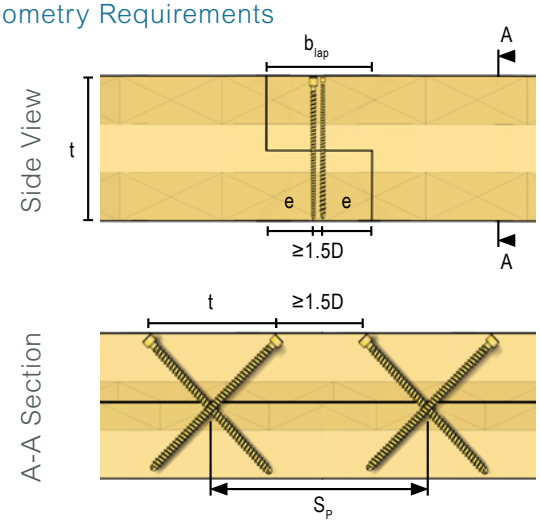
Table PP.4.1, Reference Design Values for CLT Lap Joints with Inclined Screw Crosses

Panel & Joint Configuration			Fastener Options	Reference Design Values [lbs]		Minimum Spacing in a Row (S_P)
Loading		Panel Thickness (t)		Standard Loading C_D =1.0	Short Term Loading C_D =1.6	
3 PLY	$Z_{\parallel}$	4-1/8"	Eco 1/4" x 5-1/2"	123	194	1-1/2"
	$Z_{\perp}$					

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Due to stiffness differences, assembly screws may not be assumed to take any load. They are only there to facilitate installation and insure a tight fit panel joint.
6. It is recommended that panel-to-panel CLT lap joint connections be reinforced if potential loads may occure in a direction promoting CLT notch failures.
7. Fasteners are installed at a 45° angle intersecting the shear plane at half the panel thickness.
8. The angle between force and fastener axis is 90°.
9. Reference lateral design values only apply to perpendicular loading towards the panel joint considering grain directions and minimum spacing requirements.
10. $Z_{\parallel}$ Angle between loading direction and wood grain in the shear plane $\Theta = 0°$.
    $Z_{\perp}$ Angle between loading direction and wood grain in the shear plane $\Theta = 90°$.

Geometry Requirements



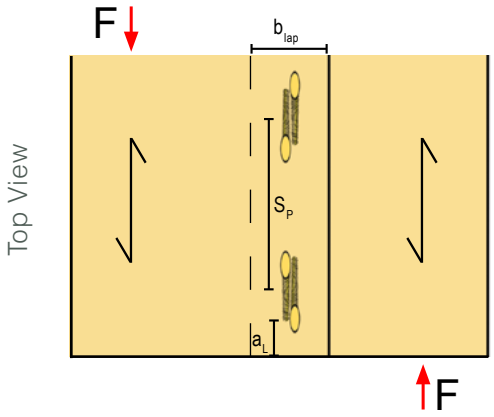
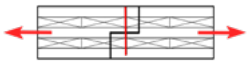
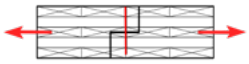
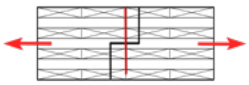
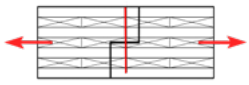


Table PP.4.2, Reference Design Values for CLT Lap Joints with Inclined Screw Crosses

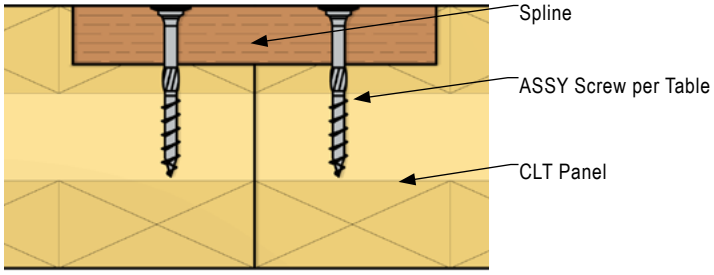
Panel & Joint Configuration				Fastener Options	Reference Design Values [lbs]		Minimum Spacing in a Row (S_P)
Loading			Panel Thickness (t)		Standard Loading C_D =1.0	Short Term Loading C_D =1.6	
5 PLY	$Z_{\parallel}$		5-1/2”	VG CSK 5/16” x 7-1/8”	190	304	1-7/8”
			6-7/8”	VG CSK 5/16” x 8-5/8”	190	304	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”
7 PLY	$Z_{\parallel}$		7-1/2”	VG CSK 5/16” x 10-1/4”	190	304	1-7/8”
				VG CSK 3/8” x 10-1/4”	251	402	2-1/4”
			8-5/8”	VG CSK 5/16” x 10-1/4”	190	304	1-7/8”
				VG CSK 3/8” x 10-1/4”	251	402	2-1/4”
			9-5/8”	VG CSK 5/16” x 11-7/8”	190	304	1-7/8”
				VG CSK 3/8” x 11-7/8”	251	402	2-1/4”
	$Z_{\perp}$		7-1/2”	VG CSK 5/16” x 10-1/4”	152	243	1-7/8”
				VG CSK 3/8” x 10-1/4”	201	322	2-1/4”
			8-5/8”	VG CSK 5/16” x 10-1/4”	152	243	1-7/8”
				VG CSK 3/8” x 10-1/4”	201	322	2-1/4”
			9-5/8”	VG CSK 5/16” x 11-7/8”	152	243	1-7/8”
				VG CSK 3/8” x 11-7/8”	201	322	2-1/4”

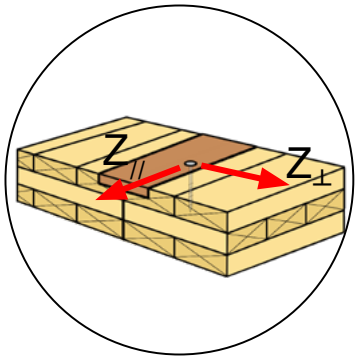
Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. It is recommended that panel-to-panel CLT lap joint connections be reinforced if potential loads may occure in a direction promoting CLT notch failures.
6. Due to stiffness differences, assembly screws may not be assumed to take any load. They are only there to facilitate installation and insure a tight fit panel joint.
7. Fasteners are installed at a 45° angle intersecting the shear plane at half the panel thickness.
8. The angle between force and fastener axis is 90°.
9. Reference lateral design values only apply to perpendicular loading towards the panel joint considering grain directions and minimum spacing requirements.
10. $Z_{\parallel}$ Angle between loading direction and wood grain in the shear plane $\Theta = 0°$.
    $Z_{\perp}$ Angle between loading direction and wood grain in the shear plane $\Theta = 90°$.

CLT Surface Spline Connection in Shear

Surface spline connections are made using standard plywood placed into a routed section on the panel surface across the joint. Spline connections require additional machining compared to butt joints, although there is less material loss in terms of panel thickness compared to half-lap joints.





Tested Connection

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

Panel & Spline Configuration				Tested Connection Geometry Specification				Fastener Options		Reference Design Values [lbs]			Estimated Stiffness [in. / kips]
Panel Type	Thicknesses		Spline Width							Calculated Standard Loading C_D =1.0	Tested Standard Loading C_D =1.0	Tested Short Term Loading C_D =1.6	
	Panel	Spline											
	(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
		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 and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Tested reference lateral design values (Z_{test}) presented apply to the specific configurations tested only.
5. Testing was done with fasteners installed in pair, one screw in each CLT panel in order to transmit the load through the spline connection.
6. CLT panels ply thickness tested were 1-3/8 [35 mm].
7. 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

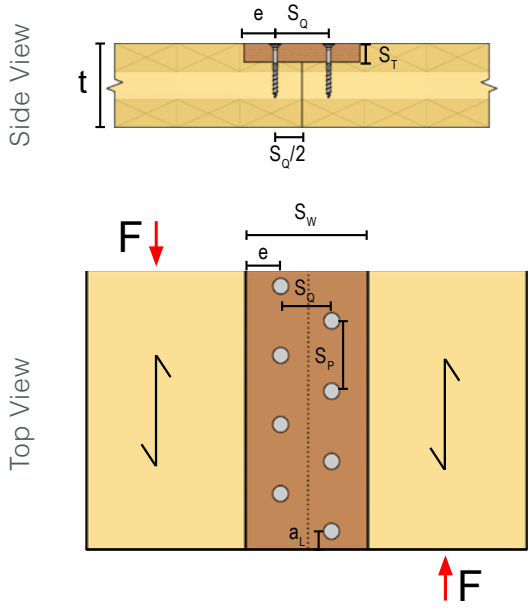
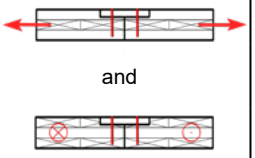
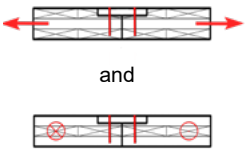


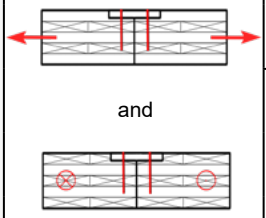
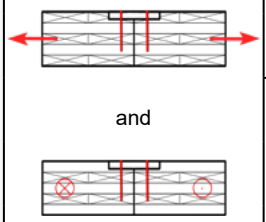
Table PP.5.1, Reference Lateral Design Values for CLT Surface Spline Joints Loaded in Shear

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"

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Reference lateral design values presented in the table above provide failure mode IIIs or IV except if otherwise identified with an asterisk (*) in which case the failure mode is not IIIs or IV.
3. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
4. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
5. The angle between force and fastener axis is 90°.
6. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
7. Fasteners are installed at a 90° angle, intersecting the shear plane in the CLT panel at a depth equal to the spline thickness.
8. Reference lateral design values may be applied to parallel and perpendicular loading towards the panel joint considering grain directions and minimum spacing requirements.
9. $Z_{||}$ Angle between loading direction and wood grain in the shear plane $\Theta = 0°$.
   $Z_{\perp}$ Angle between loading direction and wood grain in the shear plane $\Theta = 90°$.

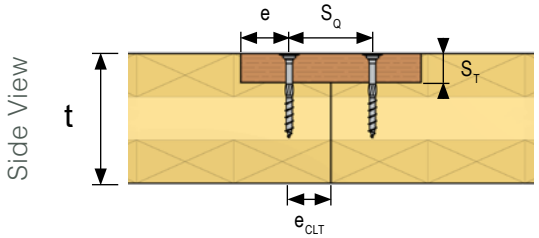
Table PP.5.2, Reference Lateral Design Values for CLT Surface Spline Joints Loaded in Shear

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	
5 PLY	$Z_{//}$		3/4”	5-1/8”	Eco 5/16” x 4-3/4”	172	275	2-1/4”
				5-1/2”				
				6-7/8”				
			1”	5-1/8”	Eco 5/16” x 4-3/4”	178	285	
				5-1/2”				
				6-7/8”	Eco 5/16” x 4-3/4”			
					Eco 3/8” x 4-3/4”	269	430	2-5/8”
	$Z_{\perp}$		3/4”	5-1/8”	Eco 5/16” x 4-3/4”	138	221	2-1/4”
				5-1/2”				
				6-7/8”				
			1”	5-1/8”	Eco 5/16” x 4-3/4”	143	229	
				5-1/2”				
				6-7/8”	Eco 5/16” x 4-3/4”			
					Eco 3/8” x 4-3/4”	197	315	2-5/8”

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Reference lateral design values presented in the table above provide failure mode IIIs or IV except if otherwise identified with an asterisk (*) in which case the failure mode is not IIIs or IV.
3. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
4. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
5. The angle between force and fastener axis is 90°.
6. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
7. Fasteners are installed at a 90° angle, intersecting the shear plane in the CLT panel at a depth equal to the spline thickness.
8. Reference lateral design values may be applied to parallel and perpendicular loading towards the panel joint considering grain directions and minimum spacing requirements.
9. $Z_{||}$ Angle between loading direction and wood grain in the shear plane $\Theta = 0°$.
   $Z_{\perp}$ Angle between loading direction and wood grain in the shear plane $\Theta = 90°$.

Geometry Requirements



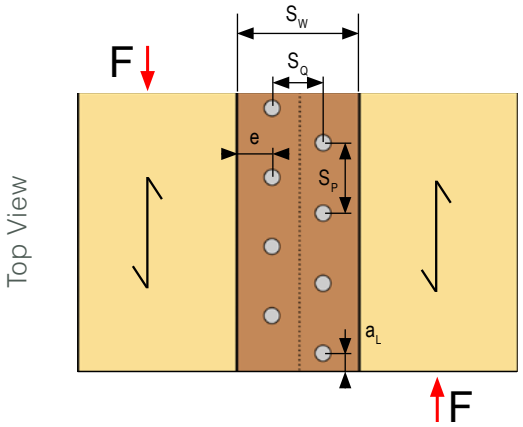
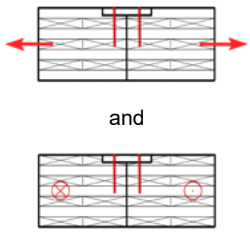
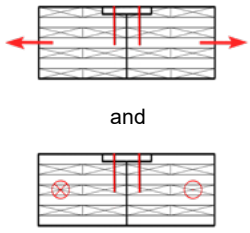


Table PP.5.3, Reference Lateral Design Values for CLT Surface Spline Joints Loaded in Shear

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	
7 PLY	$Z_{//}$		3/4”	7-1/2”	Eco 5/16” x 5-1/2”	172	275	2-1/4”
				8-5/8”				
				9-5/8”				
			1”	7-1/2”	VG CSK 5/16” x 5-1/2”	178	285	2-1/4”
					VG CSK 3/8” x 5-1/2”	269	430	2-5/8”
				8-5/8”	VG CSK 5/16” x 5-1/2”	178	285	2-1/4”
					VG CSK 3/8” x 5-1/2”	269	430	2-5/8”
				9-5/8”	VG CSK 5/16” x 5-1/2”	178	285	2-1/4”
					VG CSK 3/8” x 5-1/2”	269	430	2-5/8”
	$Z_{\perp}$		3/4”	7-1/2”	Eco 5/16” x 5-1/2”	138	221	2-1/4”
				8-5/8”				
				9-5/8”				
			1”	7-1/2”	VG CSK 5/16” x 5-1/2”	143	229	2-1/4”
					VG CSK 3/8” x 5-1/2”	197	315	2-5/8”
				8-5/8”	VG CSK 5/16” x 5-1/2”	143	229	2-1/4”
					VG CSK 3/8” x 5-1/2”	197	315	2-5/8”
				9-5/8”	VG CSK 5/16” x 5-1/2”	143	229	2-1/4”
					VG CSK 3/8” x 5-1/2”	197	315	2-5/8”

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Reference lateral design values presented in the table above provide failure mode IIIs or IV except if otherwise identified with an asterisk (*) in which case the failure mode is not IIIs or IV.
3. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
4. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
5. The angle between force and fastener axis is 90°.
6. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
7. Fasteners are installed at a 90° angle, intersecting the shear plane in the CLT panel at a depth equal to the spline thickness.
8. Reference lateral design values may be applied to parallel and perpendicular loading towards the panel joint considering grain directions and minimum spacing requirements.
9. $Z_{||}$ Angle between loading direction and wood grain in the shear plane $\Theta = 0°$.
   $Z_{\perp}$ Angle between loading direction and wood grain in the shear plane $\Theta = 90°$.

NLT Butt Joint Connection in Shear

The simple butt joint is one of the most cost-effective methods of transferring in-plane shear between NLT or DLT panels. The screws are installed at a 45° angle to the edge face, creating a mechanical connection at a depth of half the panel thickness.

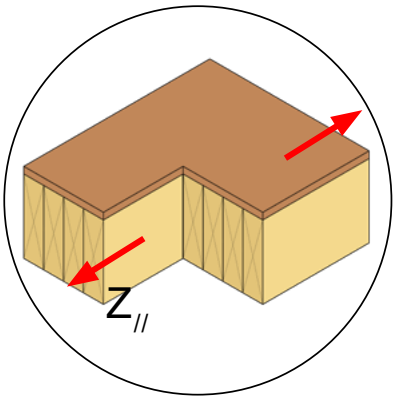
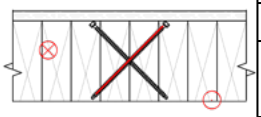


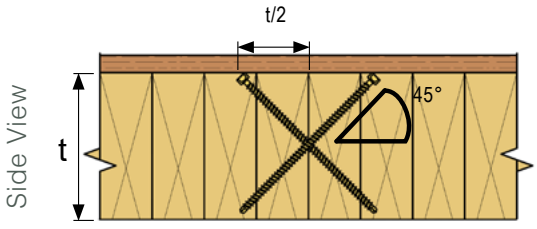
Table PP.6.1, Reference Lateral Design Values for NLT Butt Joints Loaded in Shear

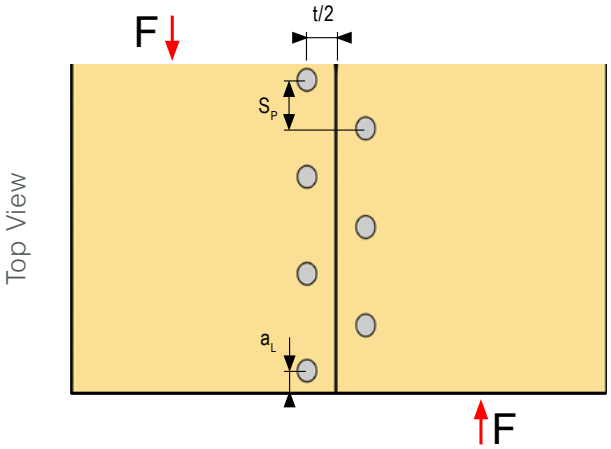
NLT Panel & Joint Configuration					Reference Design Values [lbs]		
Loading			Panel Thickness (t)	Fastener Options	Standard Loading C_D =1.0	Short Term Loading C_D =1.6	Minimum Spacing in a Row (S_P)
NLT	$Z_{//}$		3-1/2"	VG Cyl 1/4" x 4-3/4"	123	197	1-3/4"
			5-1/2"	VG Cyl 1/4" x 5-1/2"			
			7-1/4"	VG Cyl 1/4" x 7-1/8"			
			9-1/4"	VG CSK 5/16" x 9-1/2"	190	305	2-3/16"

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners are installed at a 45° angle, intersecting the shear plane in the NLT panel at a depth equal to the spline thickness.
6. The angle between force and fastener axis is 90°.
7. $Z_{||}$ Angle between loading direction and wood grain in the shear plane $\Theta = 0°$.

Geometry Requirements





Kiln

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First Tech Credit Union

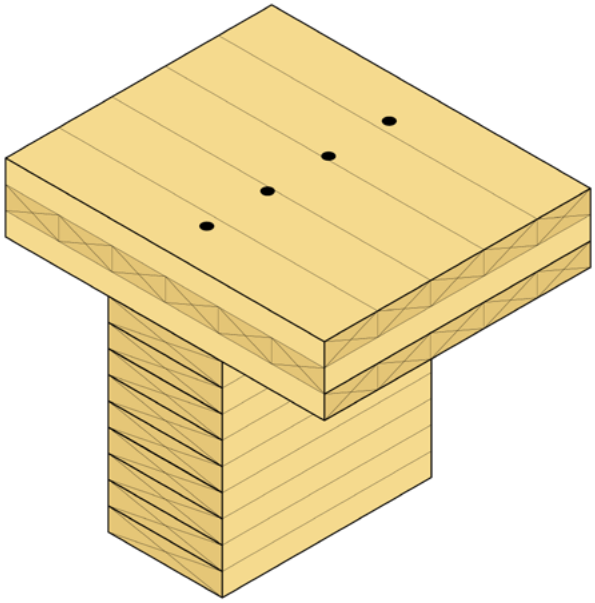
Hillsboro, Oregon

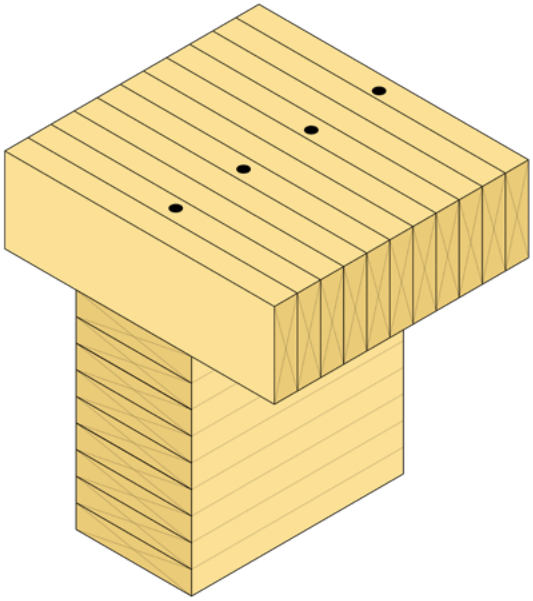
Courtesy of Oregon Forest Resources Institute

Panel to Beam Connections

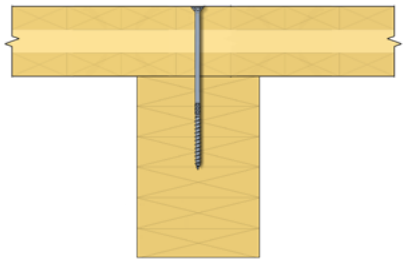
For post and beam structures, diaphragm forces are often transferred to collector elements such as beams, which then transfer the forces to the lateral load resisting system on the way down to the foundation. Floor to beam connections often benefit from the high strength and stiffness of fully threaded inclined screws or screw crosses to transfer these high magnitude forces.

Floor to beam connections can also maximize the effective bending stiffness of the two elements through composite action. Inclined fully threaded screws or screw crosses minimize slip at the interface, thereby maximizing connection efficiency with regards to composite effects.

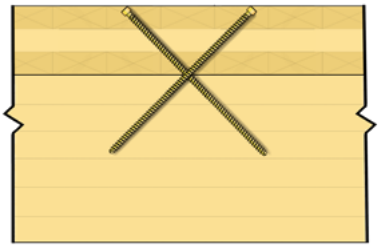




Typical Panel to Glulam Beam Connections

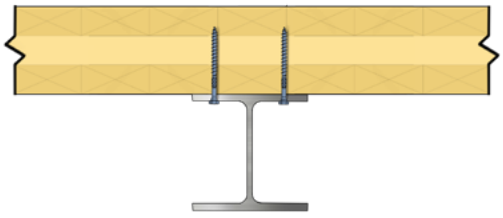


CLT panel to Glulam beam connection with a fastener in shear, see page 38 for details.

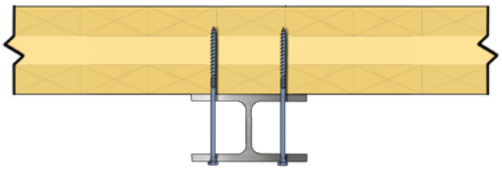


Connection with inclined fasteners arranged in a screw cross, see page 44 for details.

Typical Panel to Steel Beam Connections



CLT deep H-beam connection using shear screws, see Steel to Wood Connections Section.



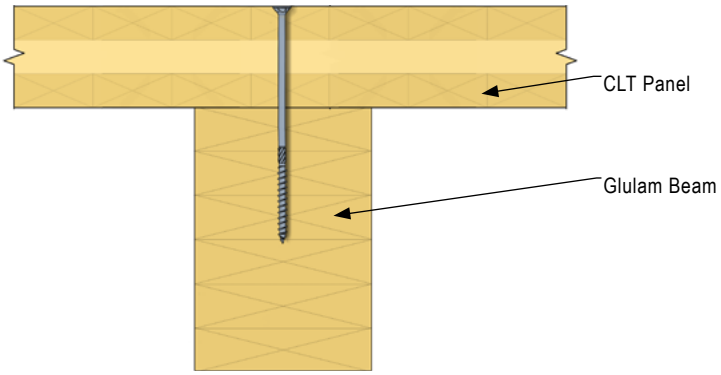
CLT shallow H-beam connection using shear screws, see Steel to Wood Connections Section.

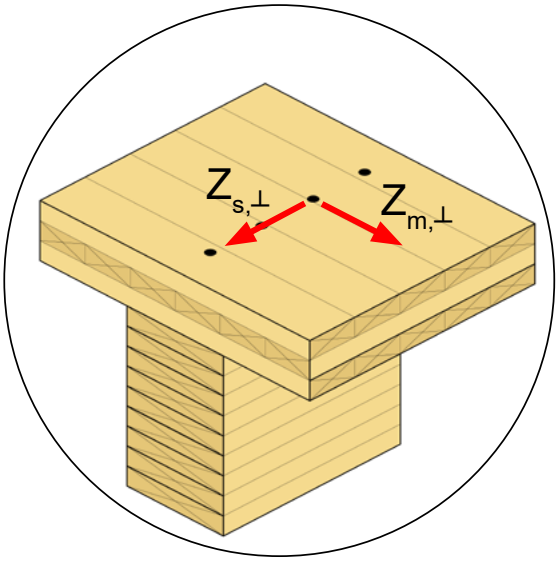
CLT Panel to Beam Connection in Shear

Partially threaded screws can be used to transfer shear forces and close the gap between two elements when connecting CLT diaphragms.

Four possible connection configurations, based on the angle to grain relationship, are tabulated on the following pages.

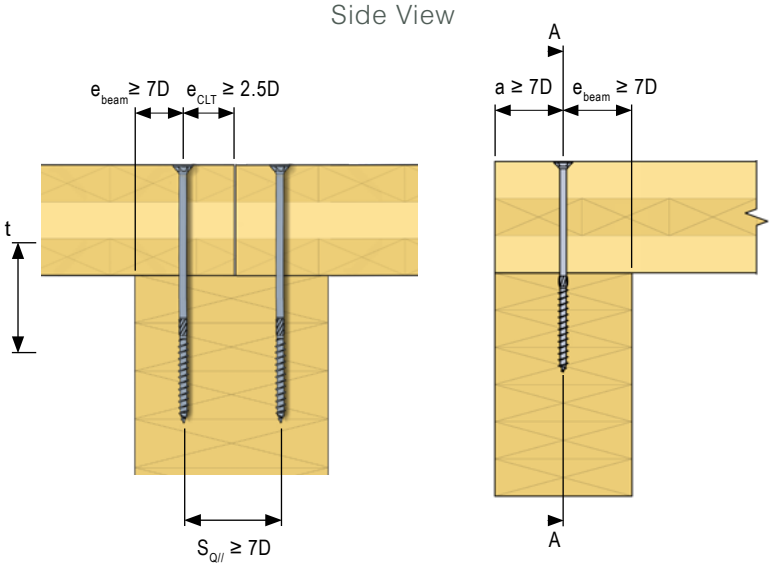
If the CLT panel or the beam is expected to shrink, screws should be countersunk enough so that they do not push into the concrete slap on top of the CLT panel.



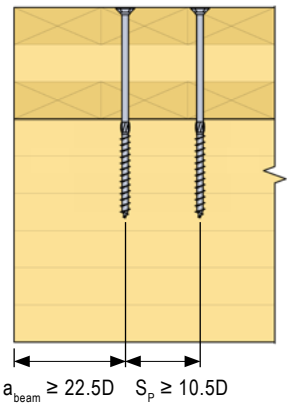


Geometry Requirements*

Side View

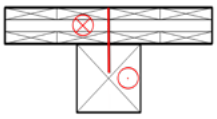
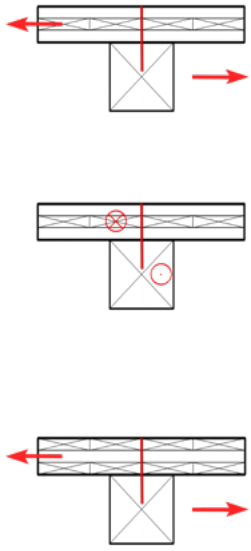


A-A Section



Notes:
1. *Minimum geometry requirements for S.P.F. panels and D.Fir glulam beams.

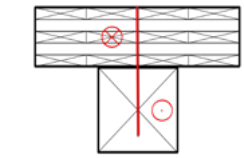
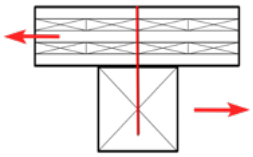
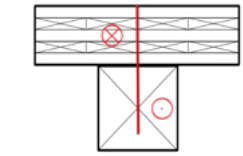
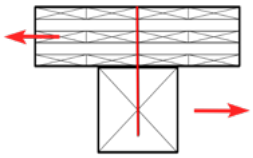
Table PB.1.1, Reference Lateral Design Values for CLT Panel to Beam Connections in Shear

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	
3 PLY	$Z_{//}$		D-Fir (0.49)	3-1/8"	Eco 1/4" x 6-1/4"	198	317	2-5/8"
				3-3/8"				
				4-1/8"	Eco 1/4" x 7-7/8"	198	317	2-5/8"
					Eco 5/16" x 7-7/8"	259	414	3-3/8"
	$Z_{\perp}$ or $Z_{m,\perp}$ or $Z_{s,\perp}$			3-1/8"	Eco 1/4" x 6-1/4"	198	317	2-5/8"
				3-3/8"				
				4-1/8"	Eco 1/4" x 7-7/8"	198	317	2-5/8"
					Eco 5/16" x 7-7/8"	207	331	3-3/8"

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Reference lateral design values presented in the table above provide failure mode IIIs or IV except if otherwise identified with an asterisk (*) in which case the failure mode is not IIIs or IV.
3. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
4. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
5. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
6. Fasteners are installed at a 90° angle intersecting the shear plane at the interface of the CLT panel and supporting beam.
7. The angle between force and fastener axis is 90°.
8. The main member is assumed as a glulam member with G = 0.49.
9. Reference lateral design values may be applied to parallel and perpendicular loading towards the panel joint considering grain directions and minimum spacing requirements.
10. $Z_{||}$ Main member and side member loaded parallel to grain $\Theta = 0°$.
    $Z_{m,\perp}$ Main member loaded perpendicular to grain ($\Theta = 90°$); side member loaded parallel to grain ($\Theta = 0°$); $\Theta = 90°$ with regards to K_{Θ}.
    $Z_{s,\perp}$ Main member loaded parallel to grain ($\Theta = 0°$); side member loaded perpendicular to grain ($\Theta = 90°$); $\Theta = 90°$ with regards to K_{Θ}.
    $Z_{\perp}$ Main member and side member loaded perpendicular to grain $\Theta = 90°$.

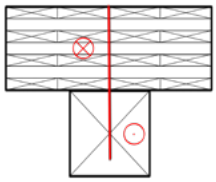
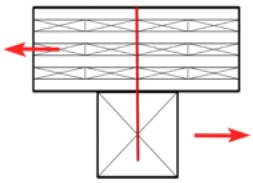
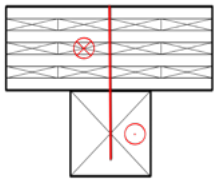
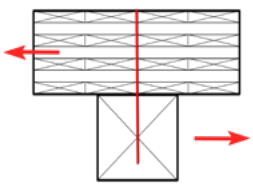
Table PB.1.2, Reference Lateral Design Values for CLT Panel to Beam Connections in Shear

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"	Eco 5/16" x 9-1/2"	259	414	3-3/8"
				5-1/2"				
				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"	Eco 5/16" x 9-1/2"	207	331	3-3/8"
				5-1/2"				
				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"	Eco 5/16" x 9-1/2"	207	331	3-3/8"
				5-1/2"				
				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"	Eco 5/16" x 9-1/2"	207	331	3-3/8"
				5-1/2"				
				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"

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Reference lateral design values presented in the table above provide failure mode IIIs or IV except if otherwise identified with an asterisk (*) in which case the failure mode is not IIIs or IV.
3. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
4. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
5. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
6. Fasteners are installed at a 90° angle intersecting the shear plane at the interface of the CLT panel and supporting beam.
7. The angle between force and fastener axis is 90°.
8. The main member is assumed as a glulam member with G = 0.49.
9. Reference lateral design values may be applied to parallel and perpendicular loading towards the panel joint considering grain directions and minimum spacing requirements.
10. $Z_{||}$ Main member and side member loaded parallel to grain $\Theta = 0°$.
    $Z_{m,\perp}$ Main member loaded perpendicular to grain ($\Theta = 90°$); side member loaded parallel to grain ($\Theta = 0°$); $\Theta = 90°$ with regards to K_Θ.
    $Z_{s,\perp}$ Main member loaded parallel to grain ($\Theta = 0°$); side member loaded perpendicular to grain ($\Theta = 90°$); $\Theta = 90°$ with regards to K_Θ.
    $Z_{\perp}$ Main member and side member loaded perpendicular to grain $\Theta = 90°$.

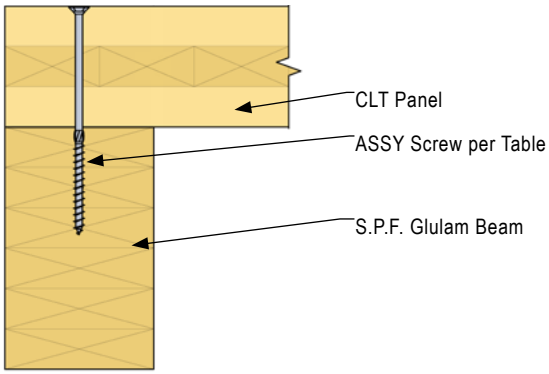
Table PB.1.3, Reference Lateral Design Values for CLT Panel to Beam Connections in Shear

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	
7 PLY	$Z_{//}$		D-Fir (0.49)	7-1/2”	Eco 5/16” x 11-7/8”	259	414	3-3/8”
					Eco 3/8” x 11-7/8”	380	608	4”
				8-5/8”	Eco 5/16” x 13-3/8”	259	414	3-3/8”
					Eco 3/8” x 14-1/4”	380	608	4”
				9-5/8”	Eco 3/8” x 15”	380	608	4”
					SK 1/2” x 15-3/4”	546	874	5-1/4”
	$Z_{m,\perp}$			7-1/2”	Eco 5/16” x 11-7/8”	207	331	3-3/8”
					Eco 3/8” x 11-7/8”	282	411	4”
				8-5/8”	Eco 5/16” x 13-3/8”	207	331	3-3/8”
					Eco 3/8” x 14-1/4”	282	411	4”
				9-5/8”	Eco 3/8” x 15”	282	411	4”
					SK 1/2” x 15-3/4”	399	573	5-1/4”
	$Z_{s,\perp}$			7-1/2”	Eco 5/16” x 11-7/8”	207	331	3-3/8”
					Eco 3/8” x 11-7/8”	273	451	4”
				8-5/8”	Eco 5/16” x 13-3/8”	207	331	3-3/8”
					Eco 3/8” x 14-1/4”	273	451	4”
				9-5/8”	Eco 3/8” x 15”	273	451	4”
					SK 1/2” x 15-3/4”	384	638	5-1/4”
	$Z_{\perp}$			7-1/2”	Eco 5/16” x 11-7/8”	207	331	3-3/8”
					Eco 3/8” x 11-7/8”	257	437	4”
				8-5/8”	Eco 5/16” x 13-3/8”	207	331	3-3/8”
					Eco 3/8” x 14-1/4”	257	437	4”
				9-5/8”	Eco 3/8” x 15”	257	437	4”
					SK 1/2” x 15-3/4”	358	573	5-1/4”

See notes under Table PB.1.2, page 40.

CLT Floor to Beam Connection

CLT floor panels can also be fastened to supporting timber beams below with partially threaded self-tapping screws installed from the top surface of the panel in order to transfer shear and uplift forces.



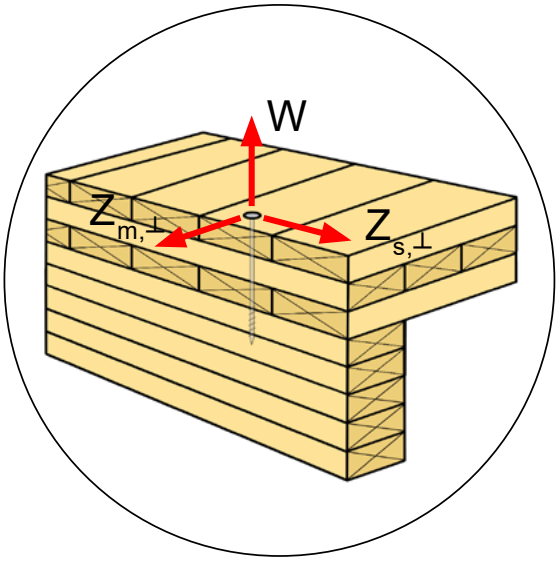


Table PB.3.1, Reference Design Values for CLT Floor to Beam Connection

CLT Panel & Beam Configuration			Fastener Options	Reference Design Values [lbs]			
	Beam Type	Panel Thickness (t)		$Z_{m,\perp}$	$Z_{s,\perp}$	W_{ECO}	W_{SK}
3 PLY	SPF (0.42)	3-1/8"	Eco / SK 1/4" x 6-1/4"	185	185	141	274
		3-3/8"					
		4-1/8"	Eco / SK 1/4" x 7-1/8"				
5 PLY	SPF (0.42)	5-1/8"	Eco / SK 1/4" x 7-1/8"	157	157	141	274
		5-1/2"	Eco / SK 1/4" x 8-5/8"	185	185		
		6-7/8"	Eco / SK 1/4" x 10-1/4"				

Notes:

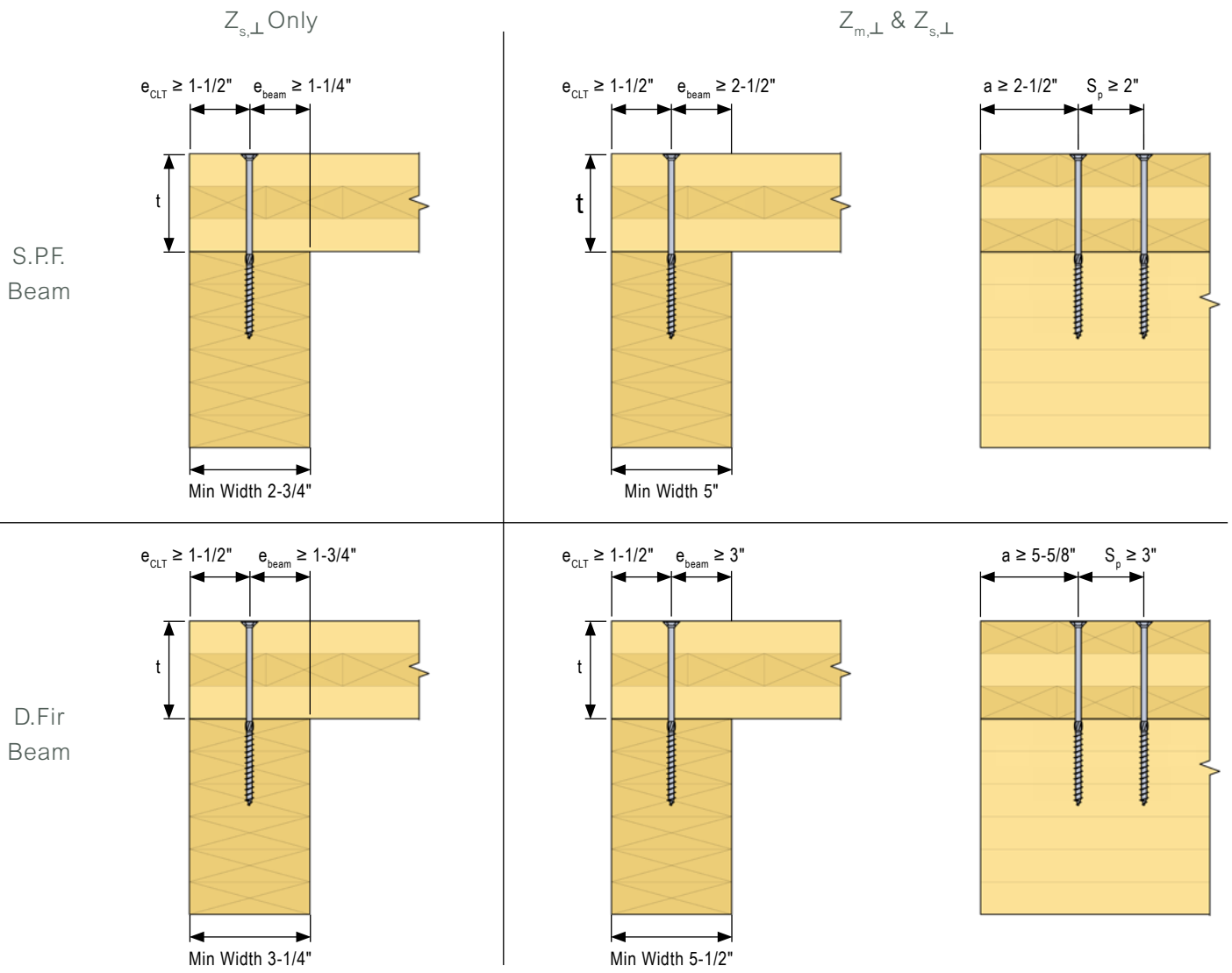
1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the geometry requirements presented in the adjacent figures (page 43) and the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners to be installed at a 90° angle intersecting the shear plane at the interface of the CLT panel and supporting beam.
6. Short term loading (C_P = 1.6) can be applied to $Z_{m,\perp}$ and $Z_{s,\perp}$.
7. $Z_{m,\perp}$ Main member loaded perpendicular to grain (Θ = 90°); side member loaded parallel to grain (Θ = 0°); Θ = 90° with regards to K_Θ.
   $Z_{s,\perp}$ Main member loaded parallel to grain (Θ = 0°); side member loaded perpendicular to grain (Θ = 90°); Θ = 90° with regards to K_Θ.

Table PB.3.2, Reference Design Values for CLT Floor to Beam Connection

CLT Panel & Beam Configuration			Fastener Options	Reference Design Values [lbs]			
	Beam Type	Panel Thickness (t)		$Z_{m,\perp}$	$Z_{s,\perp}$	W_{ECO}	W_{SK}
3 PLY	D-Fir (0.49)	3-1/8"	Eco / SK 1/4" x 6-1/4"	198	198	141	274
		3-3/8"					
		4-1/8"	Eco / SK 1/4" x 7-1/8"				
5 PLY	D-Fir (0.49)	5-1/8"	Eco / SK 1/4" x 7-1/8"	195	195	141	274
		5-1/2"	Eco / SK 1/4" x 8-5/8"	198	198		
		6-7/8"	Eco / SK 1/4" x 10-1/4"				

See notes under table PB.3.1, page 42.

Geometry Requirements



CLT Panel to Beam Connection with Inclined Screws

Inclined, fully threaded screws can be used in place of screws loaded perpendicular to the screw axis for shear connections wherever greater stiffness and higher capacity is required. The use of screw crosses ensures equal capacity in alternating loading directions. Partially threaded screws can be installed in advance of the inclined screws for assembly purposes. The partially threaded screws serve to close the gap between the elements and hold them together tightly until the load transmitting inclined screws are installed.

Reference design values refer to one screw cross (two fully threaded screws). The shear capacity of assembly screws must not be accounted for.

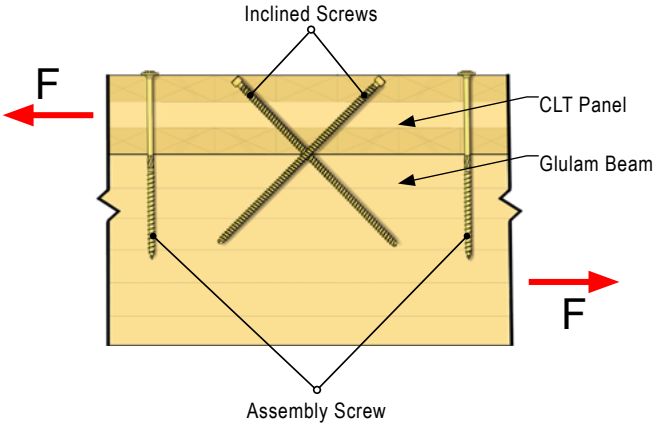
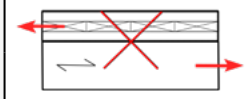
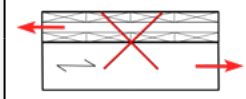


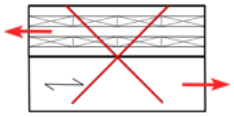
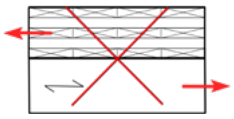
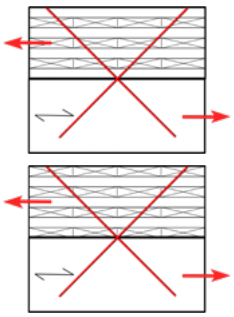
Table PB.2.1, Reference Design Values for CLT Panel to Beam Connection Inclined Screws

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	$Z_{//}$		D-Fir (0.49)	3-1/8"		VG CSK 5/16" x 8-5/8"	1,171	1,873	4-3/4"
				3-3/8"		VG CSK 5/16" x 9-1/2"	1,283	2,031	4-3/4"
				4-1/8"		VG CSK 5/16" x 11-7/8"	1,582	2,259*	4-3/4"
						VG CSK 3/8" x 11-7/8"	1,769	2,830	5-5/8"
	$Z_{\perp}$		D-Fir (0.49)	3-1/8"		VG CSK 5/16" x 8-5/8"	1,171	1,873	4-3/4"
				3-3/8"		VG CSK 5/16" x 9-1/2"	1,308	2,050	4-3/4"
				4-1/8"		VG CSK 5/16" x 11-7/8"	1,666	2,259*	4-3/4"
						VG CSK 3/8" x 11-7/8"	1,862	2,932	5-5/8"

Notes:

1. Reference design values apply to two fasteners in a screw cross configuration, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the geometry requirements presented in the adjacent figures (page 45) and the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners are installed at a 45° angle intersecting the shear plane at the interface of the CLT panel and supporting beam.
6. The angle between force and fastener axis is 45°.
7. The main member is assumed as a glulam member with G = 0.49.
8. Reference lateral design values only apply to parallel loading along the span direction of the glulam.
9. * The upper limit of the adjusted withdrawal resistance is set by the allowable fastener tensile strength, no further increase allowed.
10. $Z_{//}$ Reference lateral design value per screw cross with CLT main member loaded along the major span direction.
    $Z_{\perp}$ Reference lateral design value per screw cross with CLT main member loaded along the minor span direction.

Table PB.2.2, Reference Design Values for CLT Panel to Beam Connection Inclined Screws

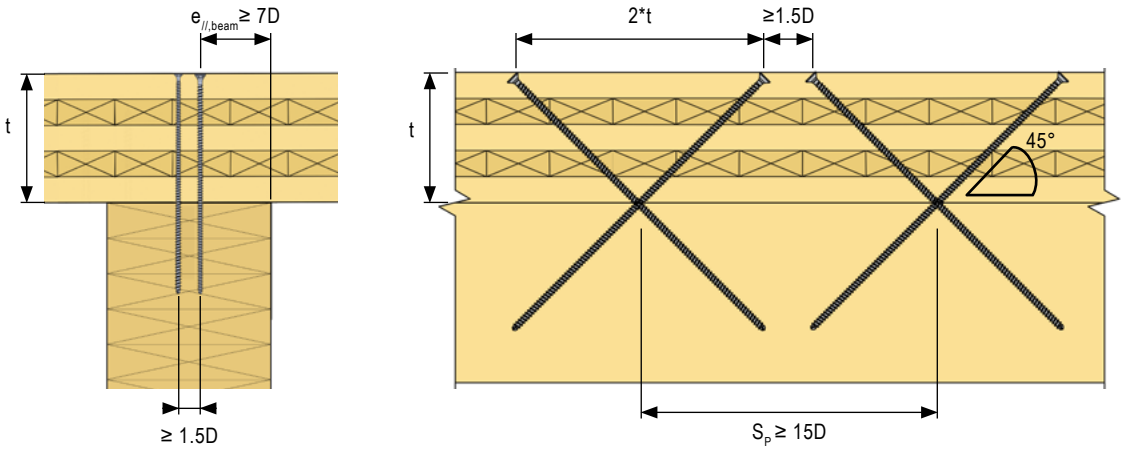
CLT Panel & Joint Configuration					Fastener Options		Reference Design Values per Screw Cross [lbs]		Minimum Spacing in a Row (S_P)
Loading			Beam Type	Panel Thickness (t)			Standard Loading C_D =1.0	Short Term Loading C_D =1.6	
5 PLY	$Z_{//}$		D-Fir (0.49)	5-1/8”		VG Cyl 5/16” x 15”	2,016	2,259*	4-3/4”
				5-1/2”		VG Cyl 5/16” x 15”	2,038	2,259*	4-3/4”
				6-7/8”		VG Cyl 5/16” x 19”	2,259*	2,259*	4-3/4”
						VG CSK 3/8” x 19”	2,932	3,246*	5-5/8”
	$Z_{\perp}$		D-Fir (0.49)	5-1/8”		VG Cyl 5/16” x 15”	2,046	2,259*	4-3/4”
				5-1/2”		VG Cyl 5/16” x 15”	2,050	2,259*	4-3/4”
				6-7/8”		VG Cyl 5/16” x 19”	2,259*	2,259*	4-3/4”
						VG CSK 3/8” x 19”	2,953	3,246*	5-5/8”
7 PLY	$Z_{//}$ or $Z_{\perp}$		D-Fir (0.49)	7-1/2”		VG Cyl 5/16” x 20-7/8”	2,259*	2,259*	4-3/4”
						VG CSK 3/8” x 20-7/8”	3,036	3,246*	5-5/8”
				8-5/8”		VG Cyl 5/16” x 22-7/8”	2,259*	2,259*	4-3/4”
						VG CSK 3/8” x 22-7/8”	3,246*	3,246*	5-5/8”
				9-5/8”		VG CSK 3/8” x 25-5/8”			

See notes under Table PB.2.1, page 44.

Geometry Requirements

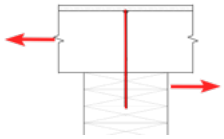
CLT - SPF

Beam - D.Fir



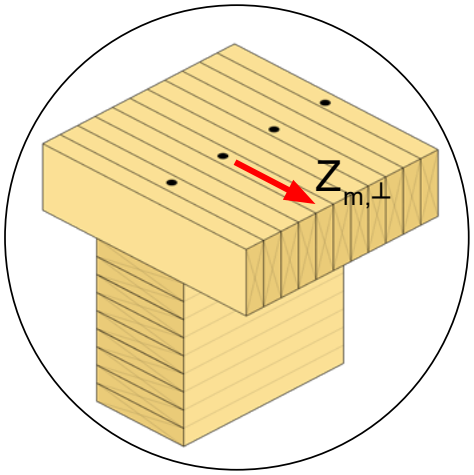
NLT Panel to Beam Connection in Shear

Table PB.4, Reference Lateral Design Values for NLT Panel to Beam Connections in Shear

NLT 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	
NLT	$Z_{m,\perp}$		D-Fir (0.49)	3-1/2"	Eco 1/4" x 7-7/8"	198	316	3"
				5-1/2"	Eco 1/4" x 10-1/4"			
				7-1/4"	Eco 1/4" x 11-7/8"			
				9-1/4"	Eco 5/16" x 14-1/4"	207	332	3-3/8"
				11-1/4"	Eco 5/16" x 15-3/4"			

Notes:

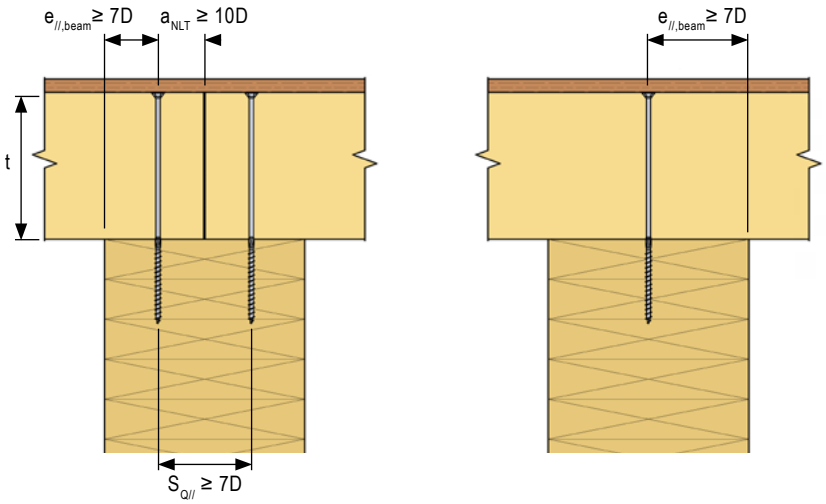
1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners are installed at a 90° angle intersecting the shear plane at the interface of the NLT panel and supporting beam.
6. The angle between force and fastener axis is 90°.
7. The main member is assumed as a glulam member with G = 0.49.
8. $Z_{m,\perp}$ Main member loaded perpendicular to grain (ϴ = 90°); side member loaded parallel to grain (ϴ = 0°); ϴ = 90° with regards to K_θ.
   $Z_{s,\perp}$ Main member loaded parallel to grain (ϴ = 0°); side member loaded perpendicular to grain (ϴ = 90°); ϴ = 90° with regards to K_θ.



Geometry Requirements

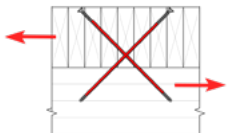
NLT - SPF

Beam - D.Fir



NLT Panel to Beam Connection with Inclined Screws

Table PB.5, Reference Lateral Design Values for NLT Panel to Beam Connections with Inclined Screws

NLT Panel & Beam 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	
NLT	Z //		D-Fir (0.49)	3-1/2"	VG CSK 5/16" x 9-1/2"	1,274	2,023	4-3/4"
				5-1/2"	VG Cyl 5/16" x 14-1/4"	1,851	2,259*	
				7-1/4"	VG Cyl 5/16" x 17"	1,934		
				9-1/4"	VG Cyl 5/16" x 20-7/8"	2,128		

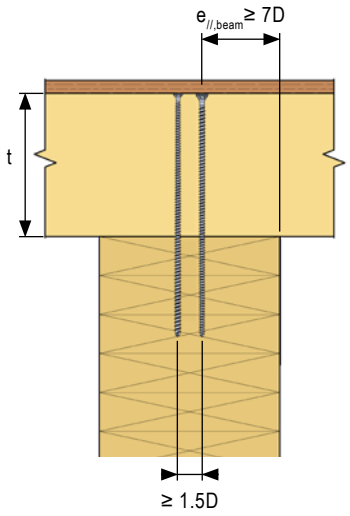
Notes:

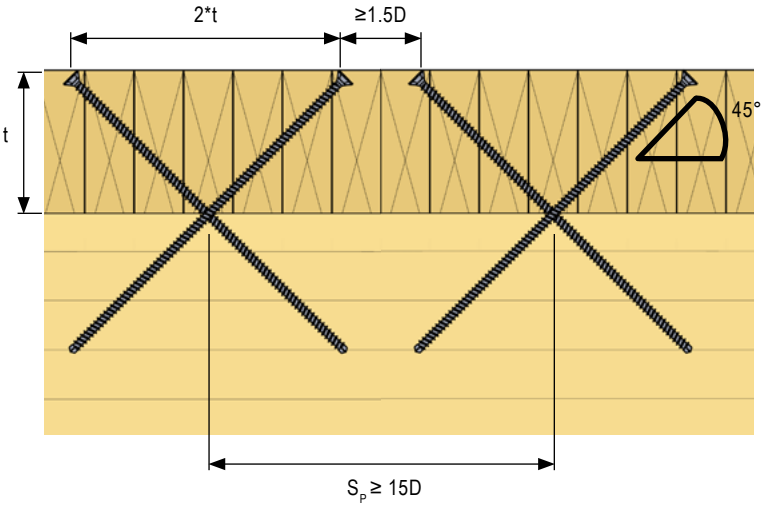
1. Reference design values apply to two fasteners in a screw cross configuration, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners are installed at a 45° angle intersecting the shear plane at the interface of the NLT panel and supporting beam.
6. The angle between force and fastener axis is 45°.
7. The main member is assumed as a glulam member with G = 0.49.
8. Reference lateral design values only apply to parallel loading along the span direction of the glulam and with the screws installed perpendicular-to-grain in the NLT.
9. * The upper limit of the adjusted withdrawal resistance is set by the allowable fastener tensile strength, no further increase allowed.

Geometry Requirements

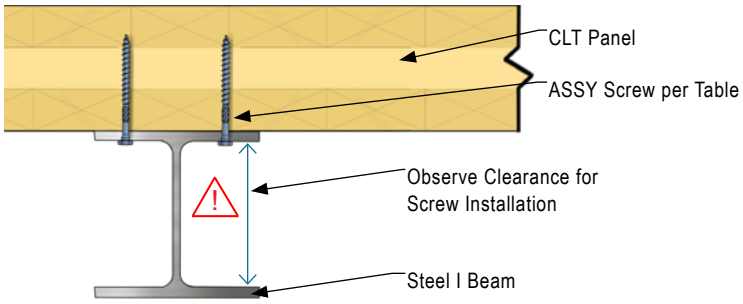
NLT - SPF

Beam - D.Fir





CLT Panel to Steel Beam Connection



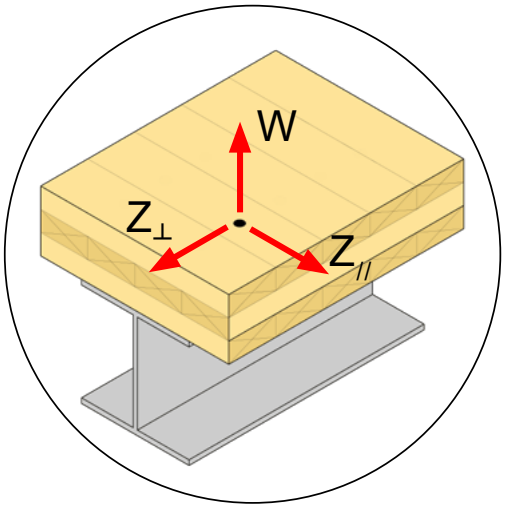
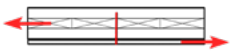
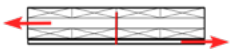


Table PB.6.1, Reference Lateral Design Values for CLT Steel Beam Connections

CLT Panel & Steel Beam Configuration					Fastener Options	Reference Design Values [lbs]	
Loading			Panel Thickness (t)	Steel Thickness		Z	W
3 PLY	$Z_{//}$		3-1/8" to 4-1/8"	3/16"	Kombi 5/16" x 3-1/8"	279	358
				1/4"		312	
				1/2"		323*	
	$Z_\perp$		3-1/8" to 4-1/8"	3/16"	Kombi 5/16" x 3-1/8"	223	
				1/4"		249	
				1/2"		258*	

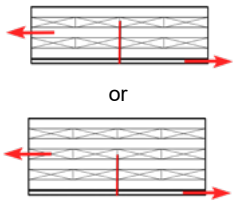
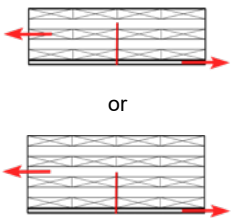
Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Reference lateral design values presented in the table above provide failure mode IIIs or IV except if otherwise identified with an asterisk (*) in which case the failure mode is not IIIs or IV.
3. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
4. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
5. Connector placement must respect the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
6. Fasteners are installed at a 90° angle intersecting the shear plane at the interface of the CLT panel and supporting steel beam.
7. The angle between force and fastener axis is 90°.
8. The side member is assumed as ASTM A36 grade steel or higher. In accordance with the NDS, a dowel bearing strength of F_e = 87,000 psi for steel is used in the yield limit equations.
9. Steel members must be pre-drilled prior to the installation of the fasteners. The designer must assure that all possible stress limits in the steel and wood are not exceeded.
10. $Z_{||}$ Main member loaded parallel to grain. ($\theta = 0°$)
    $Z_\perp$ Main member loaded perpendicular to grain. ($\theta = 90°$)
    W Screws loaded in withdrawal.

Table W.5.2, Steel Plate Pre-Drilling Diameter

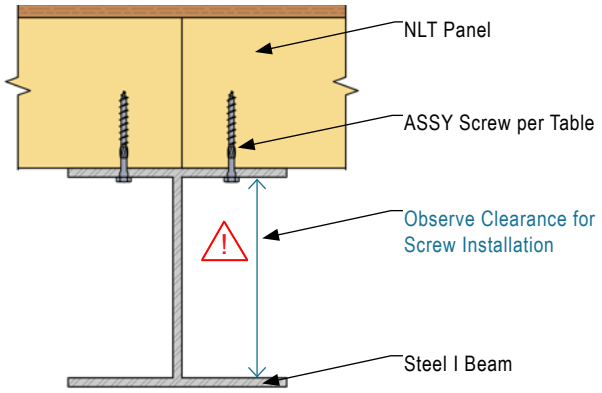
Screw Nominal Diameter	Steel Plate Hole Diameter
in.	in.
1/4"	**9/32"**
5/16"	**3/8"**
3/8"	**7/16"**
1/2"	**17/32"**

Table PB.6.2, Reference Lateral Design Values for CLT Steel Side Plate Connections

CLT Panel & Steel Beam Configuration					Fastener Options	Reference Design Values [lbs]	
Loading			Panel Thickness (t)	Steel Thickness		Z	W
5 PLY or More	$Z_{//}$		5-1/2" to 9-5/8"	3/16"	Kombi 5/16" x 3-1/8"	279	358
					Kombi 3/8" x 4-3/4"	394	652
					Kombi 1/2" x 4-3/4"	542	667
					Kombi 1/2" x 5-1/2"		
				1/4"	Kombi 5/16" x 3-1/8"	312	358
					Kombi 3/8" x 4-3/4"	430	652
					Kombi 1/2" x 4-3/4"	575	667
					Kombi 1/2" x 5-1/2"		
				1/2"	Kombi 3/8" x 4-3/4"	505	652
					Kombi 1/2" x 4-3/4"	713*	667
					Kombi 1/2" x 5-1/2"	725	
5 PLY or More	$Z_{\perp}$		5-1/2" to 9-5/8"	3/16"	Kombi 5/16" x 3-1/8"	223	358
					Kombi 3/8" x 4-3/4"	267	652
					Kombi 1/2" x 4-3/4"	356	667
					Kombi 1/2" x 5-1/2"		
				1/4"	Kombi 5/16" x 3-1/8"	249	358
					Kombi 3/8" x 4-3/4"	292	652
					Kombi 1/2" x 4-3/4"	378*	667
					Kombi 1/2" x 5-1/2"	379	
				1/2"	Kombi 3/8" x 4-3/4"	339	652
					Kombi 1/2" x 4-3/4"	439*	667
					Kombi 1/2" x 5-1/2"	472	

See notes under Table PB.6.1, page 48.

NLT Panel to Steel Beam Connection



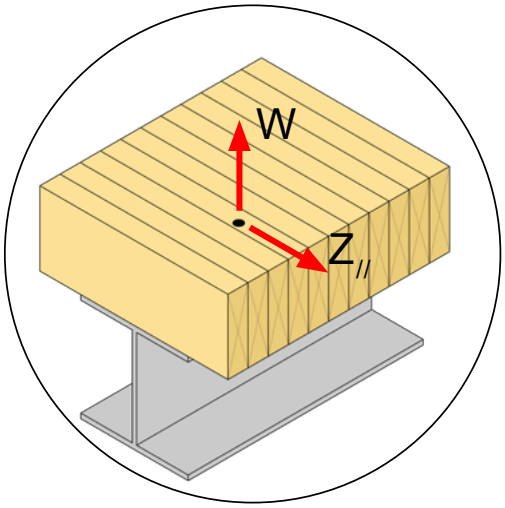


Table PB.7.1, Reference Lateral Design Values for NLT to Steel Beam Connections

NLT Panel & Steel Beam Configuration				Fastener Options	Reference Design Values [lbs]	
Loading		Panel Thickness (t)	Steel Thickness		Z	W
NLT	$Z_{//}$	3-1/2" to 5-1/2"	3/16"	Kombi 5/16" x 3-1/8"	279	358
			1/4"		312	
			1/2"		323	

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners are installed at a 90° angle intersecting the shear plane at the interface of the NLT panel and supporting steel beam.
6. The angle between force and fastener axis is 90°.
7. The side member is assumed as ASTM A36 grade steel or higher. In accordance with the NDS, a dowel bearing strength of F_e = 87,000 psi for steel is used in the yield limit equations.
8. Steel members must be pre-drilled prior to the installation of the fasteners. The designer must assure that all possible stress limits in the steel and wood are not exceeded.
9. $Z_{||}$ Main member loaded parallel to grain. ($\Theta = 0°$)
   $Z_{\perp}$ Main member loaded perpendicular to grain. ($\Theta = 90°$)
   W Screws loaded in withdrawal.

Table PB.7.3,Steel Plate Pre-Drilling Hole Size Diameter

Screw Nominal Diameter	Steel Plate Hole Diameter
in.	in.
1/4"	**9/32"**
5/16"	**3/8"**
3/8"	**7/16"**
1/2"	**17/32"**

Table PB.7.2, Reference Lateral Design Values for NLT to Steel Beam Connections

NLT Panel & Steel Beam Configuration						Reference Design Values [lbs]	
Loading		Panel Thickness (t)	Steel Thickness		Fastener Options	Z	W
NLT	$Z_{//}$	5-1/2" to 11-1/4"	3/16"		Kombi 5/16" x 3-1/8"	279	358

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners are installed at a 90° angle intersecting the shear plane at the interface of the NLT panel and supporting steel beam.
6. The angle between force and fastener axis is 90°.
7. The side member is assumed as ASTM A36 grade steel or higher. In accordance with the NDS, a dowel bearing strength of F_e = 87,000 psi for steel is used in the yield limit equations.
8. Steel members must be pre-drilled prior to the installation of the fasteners. The designer must assure that all possible stress limits in the steel and wood are not exceeded.
9. $Z_{||}$ Main member loaded parallel to grain. ($\Theta = 0°$)
   $Z_{\perp}$ Main member loaded perpendicular to grain. ($\Theta = 90°$)
   W Screws loaded in withdrawal.

Post to Beam Connections

Beam Hanger Systems

The beam hanger systems are pre-engineered solutions for easily connecting post to beam or girder to beam members in mass timber structures. High loads are supported with simple and fast installation, making the beam hanger systems one of the most cost-effective mass-timber connecting solutions on the market.

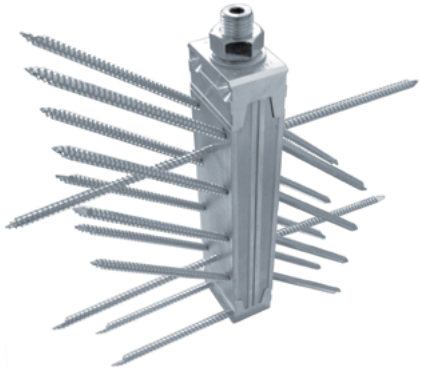
AVAILABLE IN MULTIPLE SIZES

TESTED IN NORTH AMERICA

GIGANT System

RICON S VS System

MEGANT System



Engineered for Mass Timber

Optimizing post and beam framing systems

Easy to Install

Simple drop-in assembly accelerates the construction process

Versatile

Can be installed on steel, concrete and wood

Certified Fire Rated

Full scale fully loaded fire tested in America

Inter-Story Drift Performance Tested

Used in seismic zones

Moisture Content Variation Tested

Dry-Wet-Dry & Wet-Wet-dry configurations tested

CERTIFICATIONS

ISO 50001
for the Fasteners

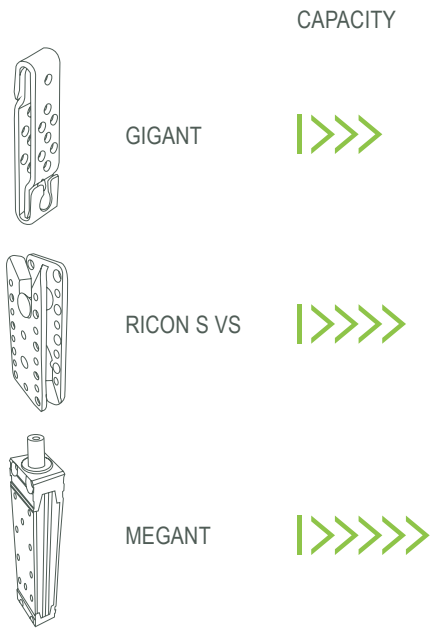
ETA

Certified Fire Rated

Full-scale fully-loaded fire resistance testing performed at the Southwest Research Institute in San Antonio, Texas, following the ASTM E119-16a, certified the RICON S VS and MEGANT systems with a 1.5 hour fire rating.

Pre-designed

Our detailed Beam Hanger Design Guide provides tabulated design values and precise installation instructions for each of our Beam Hanger Systems, reducing the engineering & detailing time needed to successfully complete a project.



Easy to Install

Beam Hanger Systems can be pre-installed in a controlled shop environment, offering the following benefits:

- Accelerated construction time
- Fewer power tools
- Reduced on-site labor
- Reduces risk of injury and error

High Architectural Value

The standardized and complete beam hanger system, includes detailed routing procedures, allowing for a repetitive and precise installation while offering an architecturally appealing clean wood appearance.

Notes:
For more information please consult our **Beam Hanger Design Guide.**

MTC **Beam Hanger Design Guide** contains tabulated design values, detailed explanations for fire rating and skewed connections, installation instruction and the full range of our products.

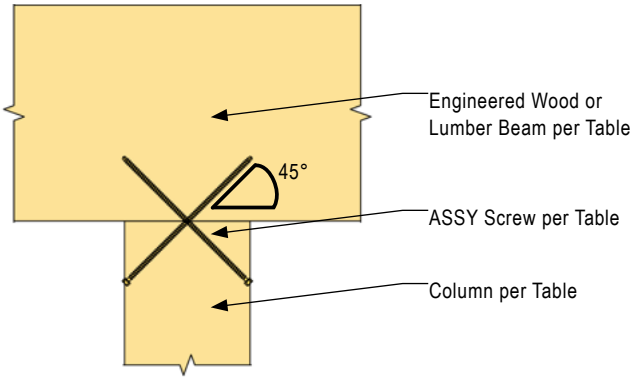
Carbon 12

Portland, Oregon

Courtesy of Andrew Poque

Post to Beam Connection - Bearing

As an alternative to pre-engineered steel connectors, both fully threaded and partially threaded self-tapping screws can connect beams to posts in bearing connections. Post to beam connections are capable of resisting longitudinal and transverse lateral loads, as well as uplift forces. Either for temporary or permanent work, self-tapping screws are an efficient alternative for post to beam connections and can easily be concealed if required.



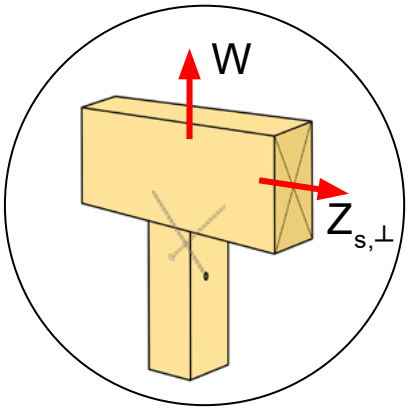


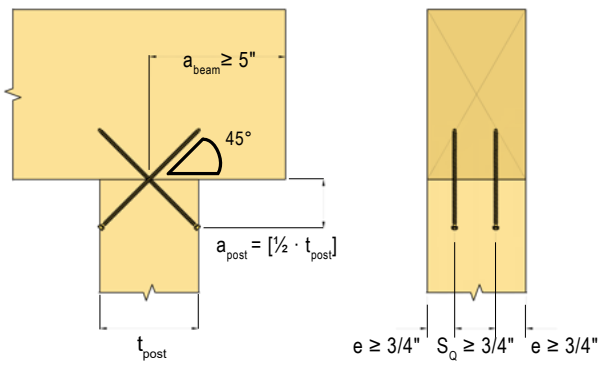
Table PT.1, Reference Design Values for Beam to Post Connection (Bearing)

Beam to Post Configuration			Fastener Options	Reference Design Values per Screw Cross [lbs]
Loading	**Beam Type**	**Colum Size**		
W or $Z_{s,\perp}$	SPF Sawn Lumber & Glulam (0.42)	6 x 6”	VG Cyl 1/4” x 6-1/4”	390
			VG Cyl 1/4” x 7-1/8”	551
			VG Cyl 1/4” x 7-7/8”	689
		8 x 8”	VG Cyl 1/4” x 7-1/8”	220
			VG Cyl 1/4” x 7-7/8”	428
	D-Fir (0.49)	6 x 6”	VG Cyl 1/4” x 6-1/4”	465
			VG Cyl 1/4” x 7-1/8”	593
			VG Cyl 1/4” x 7-7/8”	718
		8 x 8”	VG Cyl 1/4” x 7-1/8”	283
			VG Cyl 1/4” x 7-7/8”	511
	EWP (0.50)	6 x 6”	VG Cyl 1/4” x 6-1/4”	419
			VG Cyl 1/4” x 7-1/8”	593
			VG Cyl 1/4” x 7-7/8”	718
		8 x 8”	VG Cyl 1/4” x 7-1/8”	238
			VG Cyl 1/4” x 7-7/8”	461

Notes:

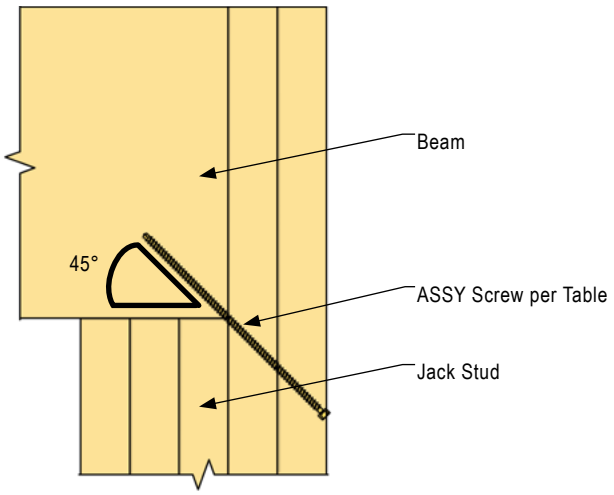
1. Reference design values apply to two fasteners in a screw cross configuration, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners are installed in a screw cross configuration, intersecting the shear plane at the interface of the post and the beam.
6. The angle between force and fastener axis is 45°.
7. Engineered Wood Products must have an Equivalent Specific Gravity (ESG) of 0.50 as per their respective ICC-ES Evaluation Report for the loading condition.

Geometry Requirements



Beam to Jack Stud Connection

Fully threaded self-tapping screws installed at a 45° angle are an efficient and simple way to connect headers to jack and king studs. Single or double screws can be installed to resist uplift forces as well as lateral loads along the length of the header. A comparable nailed or premanufactured connection would require a considerable additional amount of work in order to obtain the same capacities.



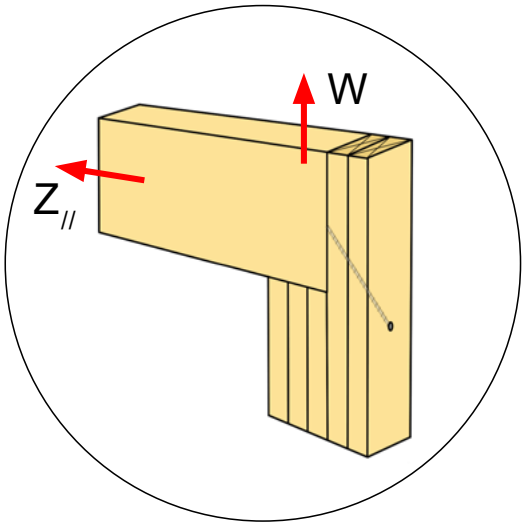


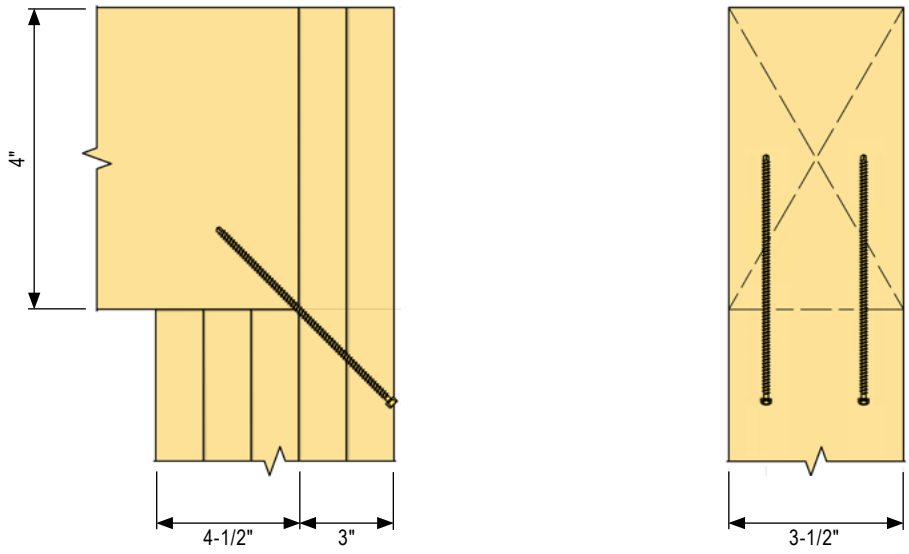
Table PT.2, Reference Design Values for Beam to Jack Stud Connection

Beam to Jack Stud Configuration			Fastener Options	Reference Design Values [lbs]
Loading	**Jack Stud**	**Beam Type**		
W or $Z_{//}$	Double 2" Lumber	SPF	VG Cyl 1/4" x 6-1/4"	180
		Sawn Lumber & Glulam (0.42)	VG Cyl 1/4" x 7-1/8"	270
			VG Cyl 1/4" x 7-7/8"	347
		D-Fir (0.49)	VG Cyl 1/4" x 6-1/4"	215
			VG Cyl 1/4" x 7-1/8"	322
			VG Cyl 1/4" x 7-7/8"	387
		EWP (0.50)	VG Cyl 1/4" x 6-1/4"	194
			VG Cyl 1/4" x 7-1/8"	290
			VG Cyl 1/4" x 7-7/8"	373

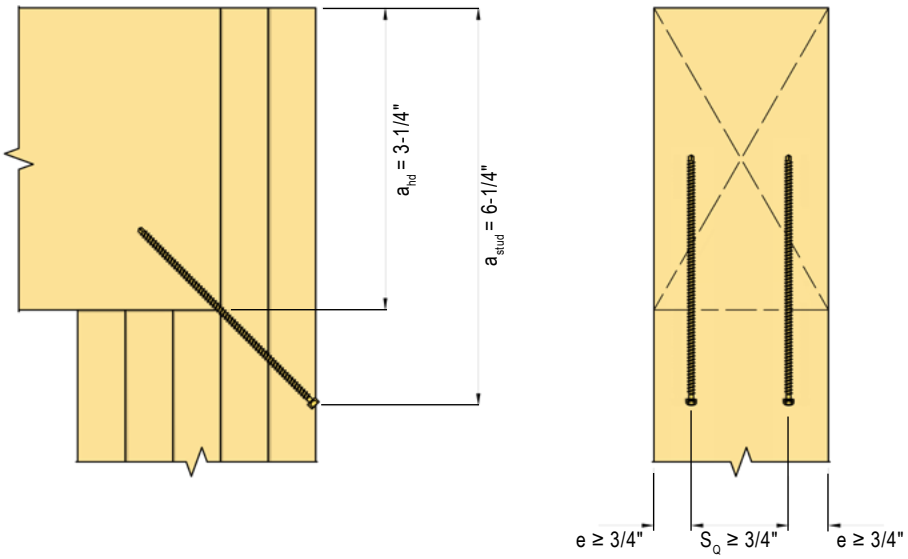
Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners to be installed at a 45° angle intersecting the shear plane at the interface of the post and the beam.
6. Sawn Lumber studs with multiple plies must be independently fasten to each other as per the applicable design codes or standards.
7. Engineered Wood Products must have an Equivalent Specific Gravity (ESG) of 0.50 as per their respective ICC-ES Evaluation Report for the loading condition.

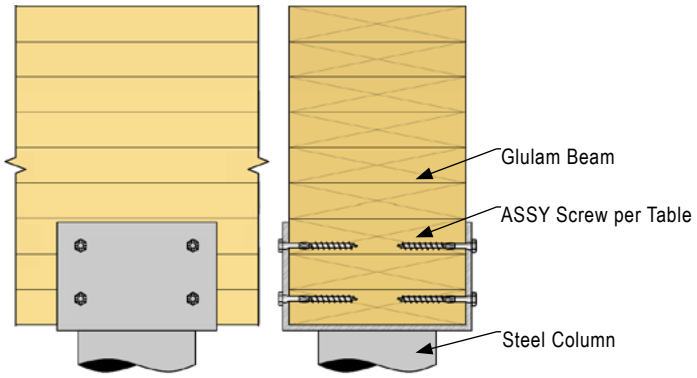
Minimum Timber Requirements



Geometry Requirements



Wood Beam to Steel Column - Shear Screws



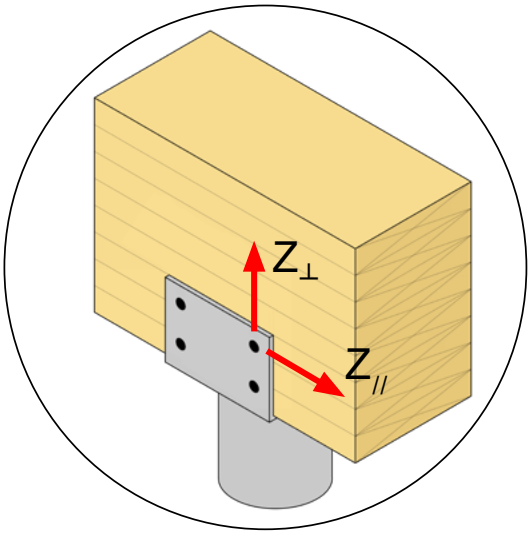


Table PT.3, Reference Design Values for Steel Column

Wood & Steel Beam Configuration		Fastener Options		Reference Design Values [lbs]	
Beam Type	Steel Thickness			$Z_{//}$	$Z_{\perp}$
SPF (0.42)	1/4”		Kombi 5/16” x 2-3/8”	264	211
			Kombi 5/16” x 3-1/8”	312	249
			Kombi 5/16” x 4”		
	1/2”		Kombi 5/16” x 2-3/8”	265	212
			Kombi 5/16” x 3-1/8”	323	259
			Kombi 5/16” x 4”	337	269
	3/4”		Kombi 5/16” x 2-3/8”	250	200
			Kombi 5/16” x 3-1/8”	302	241
			Kombi 5/16” x 4”	337	269
EWP (0.50)	1/4”		Kombi 5/16” x 2-3/8”	326	261
			Kombi 5/16” x 3-1/8”	353	282
			Kombi 5/16” x 4”		
	1/2”		Kombi 5/16” x 2-3/8”	323	258
			Kombi 5/16” x 3-1/8”	386	309
			Kombi 5/16” x 4”		
	3/4”		Kombi 5/16” x 2-3/8”	300	240
			Kombi 5/16” x 3-1/8”	377	302
			Kombi 5/16” x 4”	386	309

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners are installed at a 90° angle intersecting the shear plane at the interface of the glulam beam and steel plate.
6. Steel members must be pre-drilled prior to the installation of the fasteners. The designer must assure that all possible stress limits in the steel and wood are not exceeded.
7. The side member must be ASTM A36 grade steel or higher. In accordance with the NDS, a dowel bearing strength of F_e = 87,000 psi for steel is used in the yield limit equations.
8. $Z_{||}$ Main member loaded parallel to grain ($\Theta = 0°$).
   $Z_{\perp}$ Main member loaded perpendicular to grain ($\Theta = 90°$).

Wood Beam to Steel Column - Inclined Screws

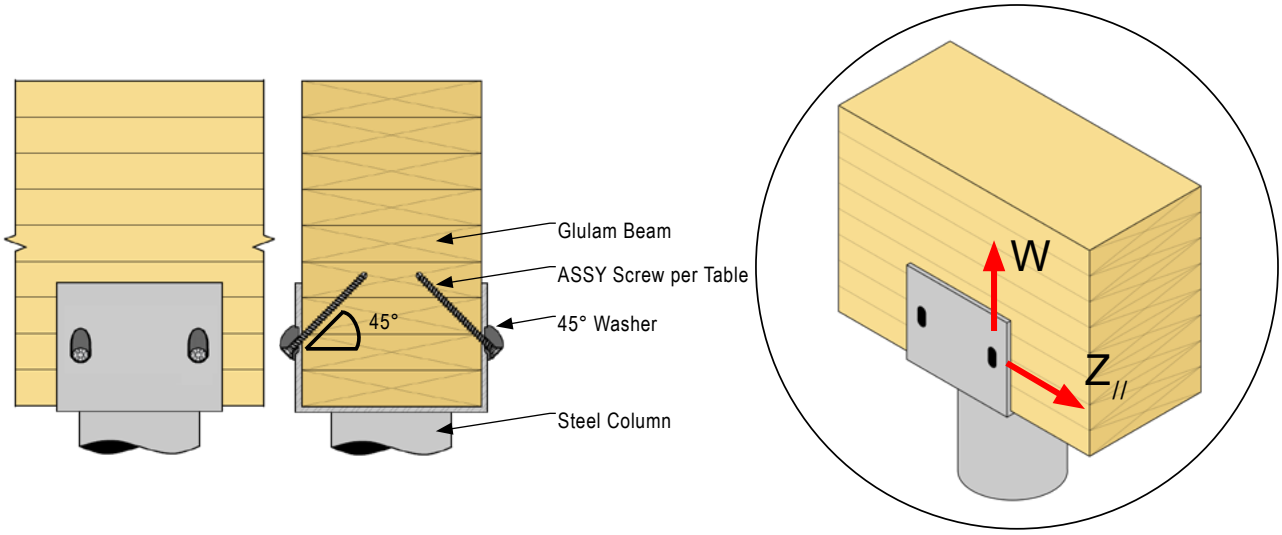


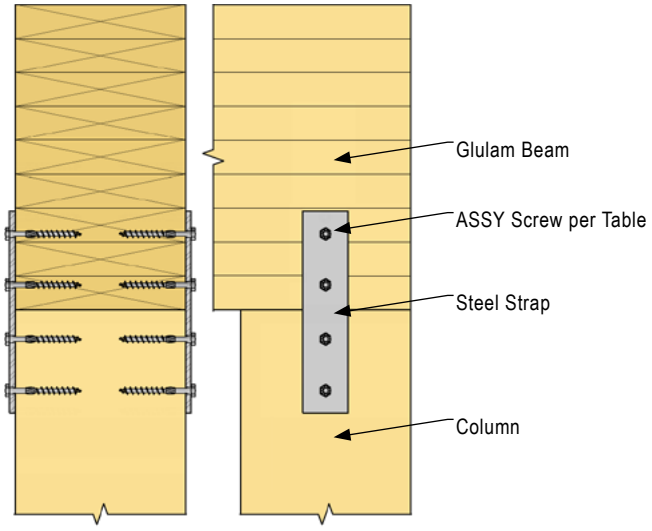
Table PT.4.1, Reference Design Values for Steel Column with Inclined Screws

Wood & Steel Beam Configuration		Fastener Options	Reference Design Values [lbs]	
Beam Type	Steel Thickness		W	$Z_{//}$
SPF (0.42)	1/4"	VG CSK 5/16" x 4-3/4"	553	264
		VG CSK 5/16" x 5-1/2"	665	
		VG CSK 5/16" x 6-1/4"	778	
	3/8"	VG CSK 5/16" x 4-3/4"	534	
		VG CSK 5/16" x 5-1/2"	646	
		VG CSK 5/16" x 6-1/4"	759	
	9/16"	VG CSK 5/16" x 4-3/4"	506	
		VG CSK 5/16" x 5-1/2"	618	
		VG CSK 5/16" x 6-1/4"	731	
EWP (0.50)	1/4"	VG CSK 5/16" x 4-3/4"	467	308
		VG CSK 5/16" x 5-1/2"	562	
		VG CSK 5/16" x 6-1/4"	657	
	3/8"	VG CSK 5/16" x 4-3/4"	451	
		VG CSK 5/16" x 5-1/2"	546	
		VG CSK 5/16" x 6-1/4"	641	
	9/16"	VG CSK 5/16" x 4-3/4"	427	
		VG CSK 5/16" x 5-1/2"	522	
		VG CSK 5/16" x 6-1/4"	617	

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners are installed at a 45° angle intersecting the shear plane at the interface of the glulam beam and steel plate.
6. Steel members must be pre-drilled prior to the installation of the fasteners. The designer must assure that all possible stress limits in the steel and wood are not exceeded.
7. The side member must be ASTM A36 grade steel or higher. In accordance with the NDS, a dowel bearing strength of F_e = 87,000 psi for steel is used in the yield limit equations.
8. For more information on how to predrill a steel plate with MTC Solutions 45° washer, please refer to the detailing section of this guide, page 104.
9. $Z_{||}$ Main member loaded parallel to grain ($\Theta = 0°$).

Beam Bearing Straps - Shear Screws



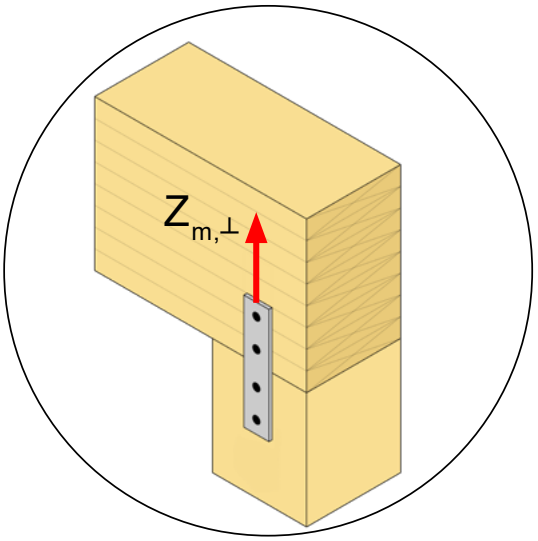


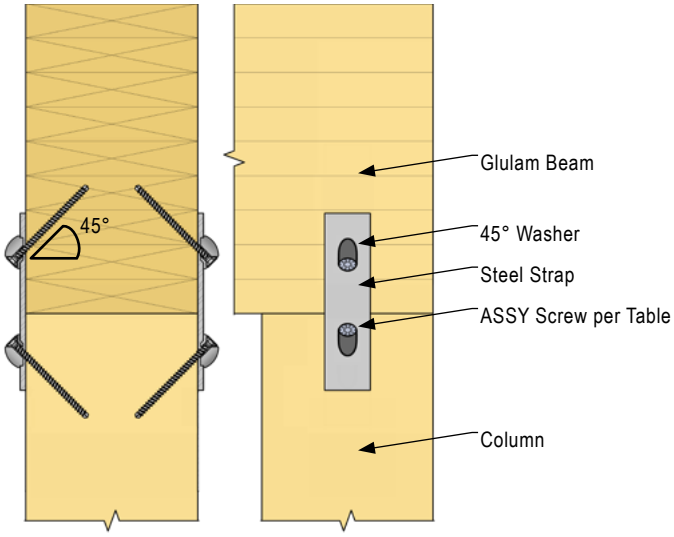
Table PT.5, Reference Design Values for Beam Bearing Straps

Wood & Steel Beam Configuration		Fastener Options	Reference Design Values [lbs]
Beam Type	Steel Thickness		$Z_{m,\perp}$
SPF (0.42)	1/4”	Kombi 5/16” x 2-3/8”	211
		Kombi 5/16” x 3-1/8”	249
		Kombi 5/16” x 4”	
	1/2”	Kombi 5/16” x 2-3/8”	212
		Kombi 5/16” x 3-1/8”	259
		Kombi 5/16” x 4”	269
	3/4”	Kombi 5/16” x 2-3/8”	200
		Kombi 5/16” x 3-1/8”	241
		Kombi 5/16” x 4”	269
EWP (0.50)	1/4”	Kombi 5/16” x 2-3/8”	261
		Kombi 5/16” x 3-1/8”	282
		Kombi 5/16” x 4”	
	1/2”	Kombi 5/16” x 2-3/8”	258
		Kombi 5/16” x 3-1/8”	309
		Kombi 5/16” x 4”	
	3/4”	Kombi 5/16” x 2-3/8”	240
		Kombi 5/16” x 3-1/8”	302
		Kombi 5/16” x 4”	309

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners are installed at a 90° angle intersecting the shear plane at the interface of the glulam beam and steel plate.
6. Steel members must be pre-drilled prior to the installation of the fasteners. The designer must assure that all possible stress limits in the steel and wood are not exceeded.
7. The side member must be ASTM A36 grade steel or higher. In accordance with the NDS, a dowel bearing strength of F_e = 87,000 psi for steel is used in the yield limit equations.
8. $Z_{m,\perp}$ Main member loaded perpendicular to grain (Θ = 90°); side member loaded parallel to grain (Θ = 0°); Θ = 90° with regards to K_Θ.

Beam Bearing Straps - Inclined Screws



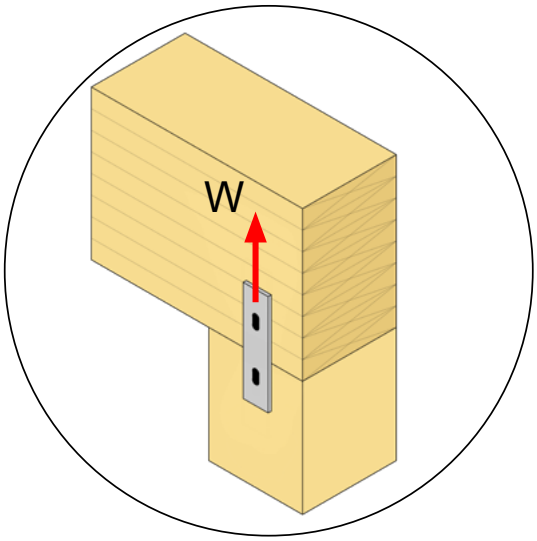


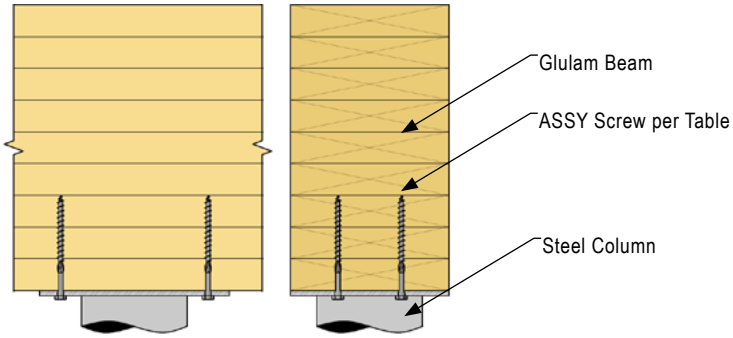
Table PT.6.1, Reference Design Values for Beam Bearing Straps with Inclined Screws

Wood & Steel Beam Configuration		Fastener Options with 45° Washers	Reference Design Values [lbs]
Beam Type	Steel Thickness		W
SPF (0.42)	1/4”	VG CSK 5/16” x 4-3/4”	553
		VG CSK 5/16” x 5-1/2”	665
		VG CSK 5/16” x 6-1/4”	778
	3/8”	VG CSK 5/16” x 4-3/4”	534
		VG CSK 5/16” x 5-1/2”	646
		VG CSK 5/16” x 6-1/4”	759
	9/16”	VG CSK 5/16” x 4-3/4”	506
		VG CSK 5/16” x 5-1/2”	618
		VG CSK 5/16” x 6-1/4”	731
EWP (0.50)	1/4”	VG CSK 5/16” x 4-3/4”	467
		VG CSK 5/16” x 5-1/2”	562
		VG CSK 5/16” x 6-1/4”	657
	3/8”	VG CSK 5/16” x 4-3/4”	451
		VG CSK 5/16” x 5-1/2”	546
		VG CSK 5/16” x 6-1/4”	641
	9/16”	VG CSK 5/16” x 4-3/4”	427
		VG CSK 5/16” x 5-1/2”	522
		VG CSK 5/16” x 6-1/4”	617

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners are installed at a 45° angle intersecting the shear plane at the interface of the glulam beam and steel plate.
6. Steel members must be pre-drilled prior to the installation of the fasteners. The designer must assure that all possible stress limits in the steel and wood are not exceeded.
7. The side member must be ASTM A36 grade steel or higher. In accordance with the NDS, a dowel bearing strength of F_e = 87,000 psi for steel is used in the yield limit equations.
8. For more information on how to predrill a steel plate with MTC Solutions 45° washer, please refer to the detailing section of this guide, page 104.

Wood Beam to Steel Column - Bottom Plate



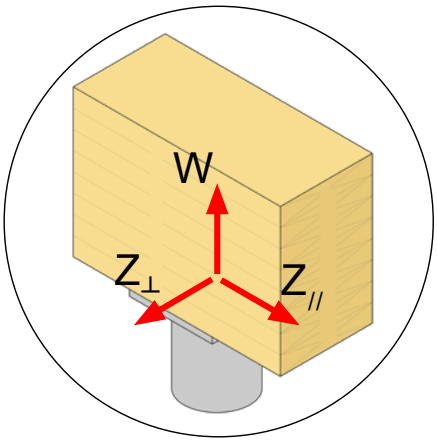


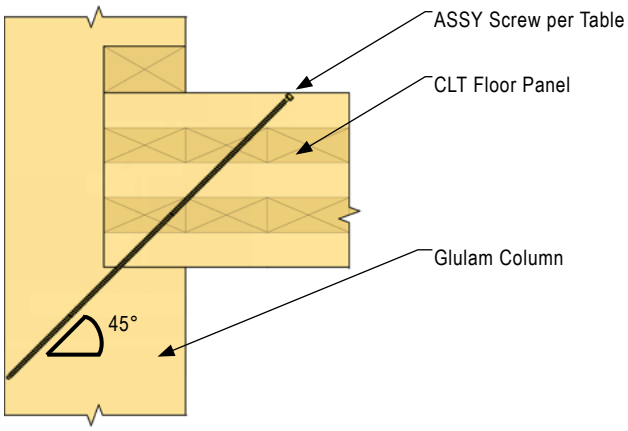
Table PT.7, Reference Design Values for Steel Column - Bottom Plate

Wood & Steel Beam Configuration		Fastener Options	Reference Design Values [lbs]		
Beam Type	Steel Thickness		$Z_{//}$	$Z_{\perp}$	W
SPF (0.42)	1/4”	Kombi 5/16” x 2-3/8”	264	211	252
		Kombi 5/16” x 3-1/8”	312	249	358
		Kombi 5/16” x 4”			437
	1/2”	Kombi 5/16” x 2-3/8”	265	212	252
		Kombi 5/16” x 3-1/8”	323	259	358
		Kombi 5/16” x 4”	337	269	437
	3/4”	Kombi 5/16” x 2-3/8”	250	200	252
		Kombi 5/16” x 3-1/8”	302	241	358
		Kombi 5/16” x 4”	337	269	437
EWP (0.50)	1/4”	Kombi 5/16” x 2-3/8”	326	261	213
		Kombi 5/16” x 3-1/8”	353	282	302
		Kombi 5/16” x 4”			369
	1/2”	Kombi 5/16” x 2-3/8”	323	258	213
		Kombi 5/16” x 3-1/8”	386	309	302
		Kombi 5/16” x 4”			369
	3/4”	Kombi 5/16” x 2-3/8”	300	240	213
		Kombi 5/16” x 3-1/8”	377	302	302
		Kombi 5/16” x 4”	386	309	369

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners are installed at a 90° angle intersecting the shear plane at the interface of the glulam beam and steel plate.
6. Steel members must be pre-drilled prior to the installation of the fasteners. The designer must assure that all possible stress limits in the steel and wood are not exceeded.
7. The side member must be ASTM A36 grade steel or higher. In accordance with the NDS, a dowel bearing strength of F_e = 87,000 psi for steel is used in the yield limit equations.
8. $Z_{||}$ Main member loaded parallel to grain (θ = 0°).
   $Z_{\perp}$ Main member loaded perpendicular to grain (θ = 90°).

Housed CLT Floor Uplift Connections



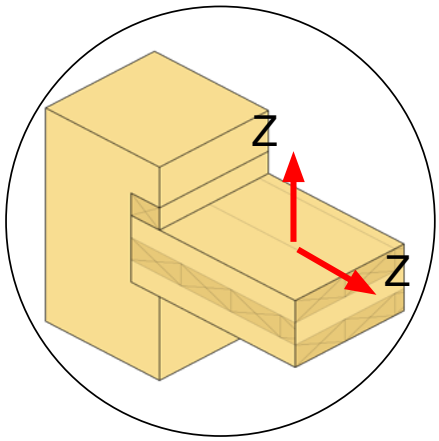


Table PT.8, Reference Lateral Design Values for Housed CLT Floor Uplift Connections; 45° Inclined Screws

Panel Configuration			Fastener Options	Reference Design Values [lbs]	
Loading		Panel Thickness (t)		Standard Loading C_D =1.0	Short Term Loading C_D =1.6
3 PLY	$Z_{//}$	3-1/8”	VG CSK 5/16” x 7-7/8”	436	698
		3-3/8”	VG CSK 5/16” x 8-5/8”	467	747
		4-1/8”	VG CSK 5/16” x 11”	665	1,064
	$Z_{\perp}$	3-1/8”	VG CSK 5/16” x 7-7/8”	439	702
		3-3/8”	VG CSK 5/16” x 8-5/8”	501	802
		4-1/8”	VG CSK 5/16” x 11”	686	1,098
5 PLY	$Z_{//}$	5-1/2”	VG Cyl 5/16” x 14-1/4”	838	1,255*
		6-7/8”	VG CSK 3/8” x 17”	1,064	1,702
	$Z_{\perp}$	5-1/2”	VG Cyl 5/16” x 14-1/4”	890	1,255*
		6-7/8”	VG CSK 3/8” x 17”	1,085	1,736
7 PLY	$Z_{//}$	7-1/2”	VG CSK 3/8” x 19”	1,202	1,803*
		8-5/8”	VG CSK 3/8” x 22-7/8”	1,572	
		9-5/8”	VG CSK 3/8” x 25-5/8”	1,803*	
	$Z_{\perp}$	7-1/2”	VG CSK 3/8” x 19”	1,289	1,803*
		8-5/8”	VG CSK 3/8” x 22-7/8”	1,607	
		9-5/8”	VG CSK 3/8” x 25-5/8”	1,803*	

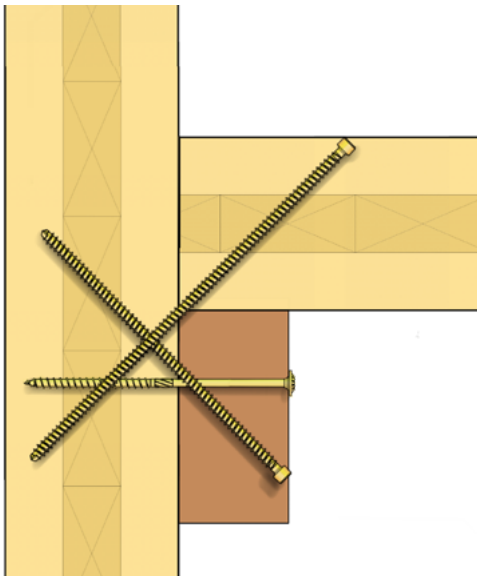
Notes:

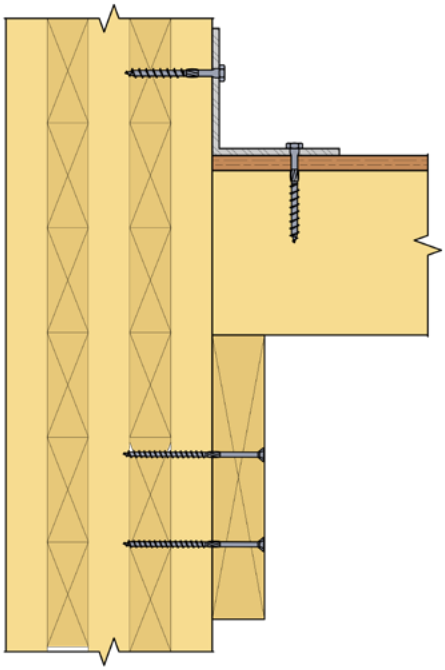
1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners are installed at a 45° angle intersecting the shear plane at the interface of CLT floor, wall and ledger. Fasteners must penetrate the whole thickness of the CLT floor panel (t).
6. The angle between force and fastener axis is 45°.
7. Reference lateral design values may be applied to uplift and horizontal tension loading towards the panel joint.
8. Adjustment for narrow edge loading of CLT (C_{eg}) may be neglected as corresponding withdrawal resistances are already multiplied by the angle to grain reduction factor R_{α}. (12.2.1.5; NDS-2018)
9. $Z_{//}$ Main member loaded along the major CLT span direction; side member loaded along the major CLT span direction.
   $Z_{\perp}$ Main member loaded along the major CLT span direction; side member loaded along the minor CLT span direction.

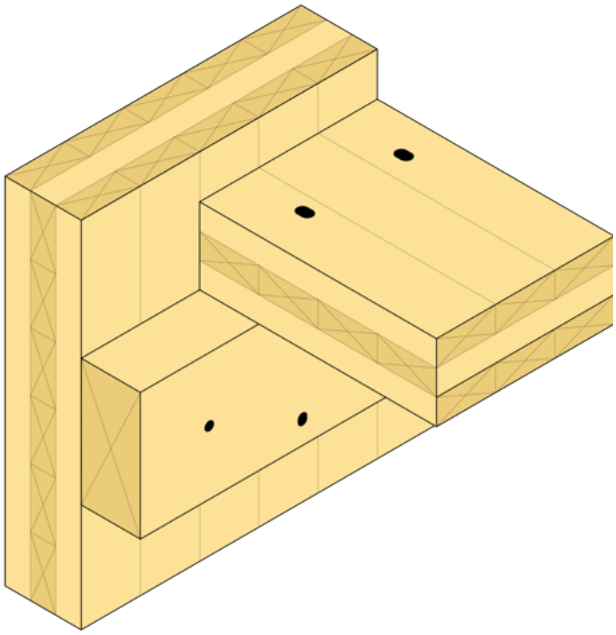
Ledger Connections

A typical detail used for balloon framing is the structural ledger. Most ledgers for construction with CLT are made from engineered wood products such as LVL, PSL, OSL and LSL. Steel ledgers are also an option. For most applications, connections will exhibit perpendicular-to-grain loading in the side member while parallel-to-grain loading in the CLT wall or main member. Materials typically show different specific gravities, which has to be considered in design. Connections with fasteners acting in shear are typically ductile and show lower capacities than fasteners installed at an angle.

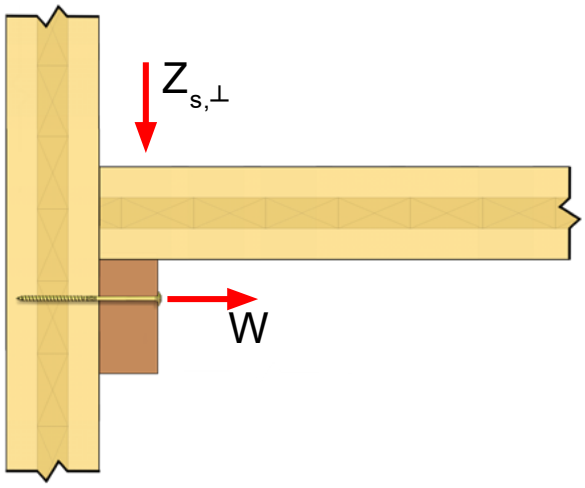
For steel angle connections, see the Steel to Wood Connections Section.





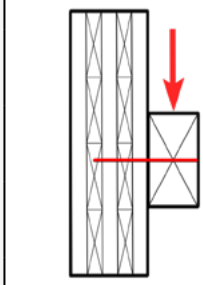


CLT Ledger Connection - 90° Shear Screws Only



90° Shear Screws Only

Table LG.1.1, Reference Lateral Design Values for Wall to Ledger Connections; 90° Shear Screws Only

CLT Panel & Ledger Configuration						Fastener Options	Reference Design Values [lbs]	
Loading			Ledger Thickness	Panel Thickness (t)			Z	W
3 PLY to 7 PLY	$Z_{s,\perp}$		1-3/4”	≥ 3-1/8”		Eco 1/4” x 4-3/4”	199	262
			3-1/2”	≥ 5-1/8”		Eco 5/16” x 8-5/8”	209	327
						Eco 3/8” x 8-5/8”	285	509
						Eco 3/8” x 10-1/4”		
			5-1/4”	≥ 5-1/8”		SK 1/2” x 10-1/4”	402	939

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners are installed at a 90° angle intersecting the shear plane at the interface of EWP and CLT.
6. The angle between force and fastener axis is 90°.
7. The side member, assumed as Engineered Wood Products, must have an Equivalent Specific Gravity (ESG) of 0.50 as per their respective ICC-ES Evaluation Report for the loading condition.
8. $Z_{s,\perp}$ Main member loaded parallel to grain ($\Theta = 0°$); side member loaded perpendicular to grain ($\Theta = 90°$); $\Theta = 90°$ with regards to K_Θ.

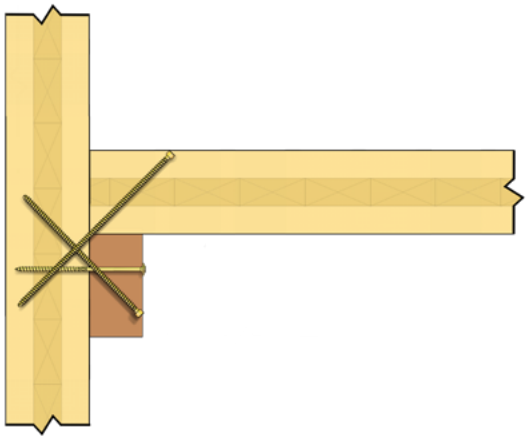
Complete CLT Ledger Connection

An option for connecting the ledger to the CLT wall element is through the use of inclined fully threaded screws. Connection strength and stiffness is assumed to come entirely from the inclined screws.

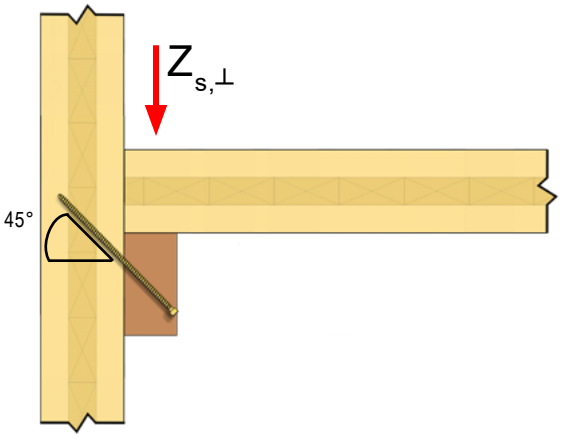
Shear screws installed at 90° angle are used during installation to ensure proper placement and tight connection between side and main member, and to provide ductility to this critical connection. The shear screws can also reduce the eccentricity created by the inclined screws.

For design purposes, capacities of shear and inclined fasteners may not be combined, as both systems have different inherent stiffnesses.

Part.a - Downward Capacity of Complete Ledger Connection



Complete Ledger Connection



45° Inclined Screws

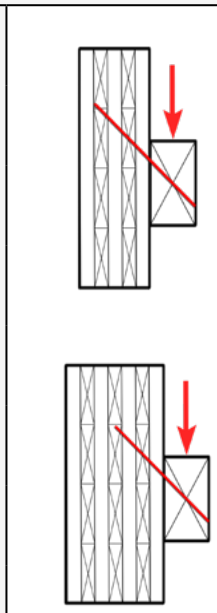
Table LG.2.1, Reference Design Values for CLT Wall to Ledger Connections; 45° Inclined Screws

CLT Panel & Ledger Configuration					Fastener Options	Reference Design Values [lbs]
Loading			Ledger Thickness	Panel Thickness (t)		
3 PLY	$Z_{s,\perp}$		1-3/4"	≥ 3-1/8"	VG CSK 5/16" x 6-1/4"	313
			1-3/4"	≥ 4-1/8"	VG CSK 3/8" x 7-1/8"	369

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners are installed at a 45° angle intersecting the shear plane at the interface of EWP and CLT.
6. The angle between force and fastener axis is 45°.
7. The side member, assumed as Engineered Wood Products, must have an Equivalent Specific Gravity (ESG) of 0.50 as per their respective ICC-ES Evaluation Report for the loading condition.
8. Reference lateral design values only apply to parallel (gravity shear) loading.
9. $Z_{s\perp}$ Reference lateral design value per screw loaded primarily in tension.

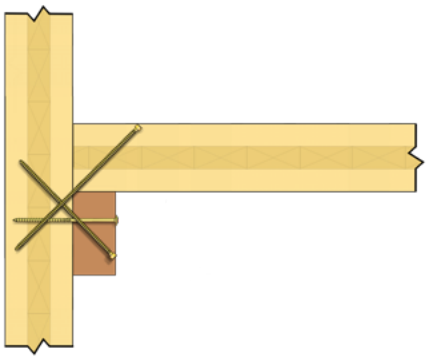
Table LG.2.2, Reference Design Values for CLT Wall to Ledger Connections; 45° Inclined Screws Only

CLT Panel & Ledger Configuration						Fastener Options	Reference Design Values [lbs]
Loading			Ledger Thickness	Panel Thickness (t)			
7 PLY & 5 PLY	$Z_{s,\perp}$		1-3/4"	≥ 5-1/8"		VG CSK 5/16" x 6-1/4"	313
				≥ 6-7/8"		VG CSK 3/8" x 7-1/8"	369
			3-1/2"	≥ 5-1/8"		VG CSK 5/16" x 11"	627
				≥ 5-1/8"		VG CSK 3/8" x 11"	739
			5-1/4"	≥ 5-1/8"		VG CSK 5/16" x 14-1/4"	877
				≥ 5-1/8"		VG CSK 3/8" x 14-1/4"	972
				≥ 6-7/8"		VG CSK 5/16" x 15"	940
				≥ 6-7/8"		VG CSK 3/8" x 15"	1108

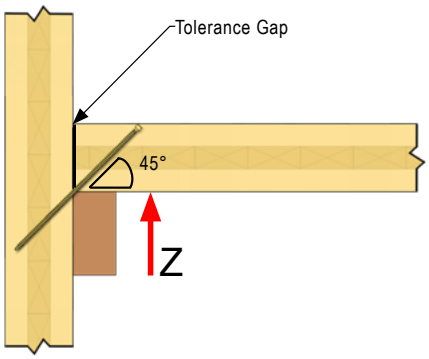
See notes under Table LG.2, page 66.

Part.b - Uplift Capacity of Complete Ledger Connection

In order to secure floor panels resting on a ledger, toe screws are usually used to prevent uplift or lateral movement during construction or throughout the lifetime of a building. When using fully threaded self-tapping fasteners, capacities in both horizontal and vertical directions can be determined with the axial resistance of the fastener. Toe screws are typically installed at a 45°angle. If any tolerance gaps between the CLT wall and floor panel are present, reference lateral design values shall be reduced accordingly.

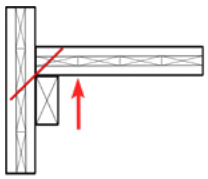
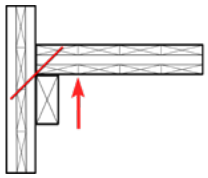


Example of Finished Install



45° Inclined Toe Screws

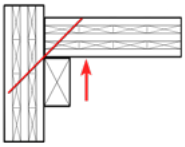
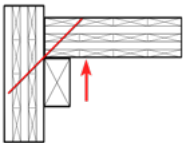
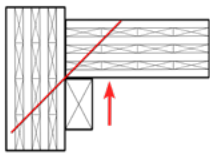
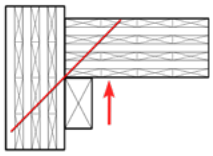
Table LG.3.1, Reference Design Values for CLT Wall to Ledger Connections; 45° Inclined Toe Screws

CLT Panel & Ledger Configuration				Fastener Options	Reference Design Values [lbs]	
Loading			Panel Thickness (t)		Standard Loading [C_D =1.0]	Short Term Loading [C_D =1.6]
3 PLY	$Z_{\parallel}$		3-1/8"	VG CSK 5/16" x 7-7/8"	436	698
			3-3/8"	VG CSK 5/16" x 8-5/8"	467	747
			4-1/8"	VG CSK 5/16" x 11"	665	1,064
	$Z_{\perp}$		3-1/8"	VG CSK 5/16" x 7-7/8"	439	702
			3-3/8"	VG CSK 5/16" x 8-5/8"	501	802
			4-1/8"	VG CSK 5/16" x 11"	686	1,098

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners are installed at a 45° angle intersecting the shear plane at the interface of CLT floor and wall.
6. The angle between force and fastener axis is 45°.
7. Reference lateral design values may be applied to uplift and horizontal tension loading towards the panel joint.
8. Adjustment for narrow edge loading of CLT (C_{eg}) may be neglected as corresponding withdrawal resistances are already multiplied by the angle to grain reduction factor R_{α}. (12.2.1.5; NDS-2018)
9. * The upper limit of the adjusted withdrawal resistance is set by the allowable fastener tensile strength, no further increase allowed.
10. $Z_{\parallel}$ Main member loaded along the major CLT span direction; side member loaded along the major CLT span direction..
    $Z_{\perp}$ Main member loaded along the major CLT span direction; side member loaded along the minor CLT span direction..

Table LG.3.2, Reference Design Values for CLT Wall to Ledger Connections; Uplift 45° Inclined Screws Only

CLT Panel & Ledger Configuration				Fastener Options	Reference Design Values [lbs]	
Loading			Panel Thickness (t)		Standard Loading [C_D =1.0]	Short Term Loading [C_D =1.6]
5 PLY	$Z_{//}$		5-1/2”	VG Cyl 5/16” x 14-1/4”	838	1,255*
			6-7/8”	VG CSK 3/8” x 17”	1,064	1,702
	$Z_{\perp}$		5-1/2”	VG Cyl 5/16” x 14-1/4”	838	1,255*
			6-7/8”	VG CSK 3/8” x 17”	1,064	1,702
7 PLY	$Z_{//}$		7-1/2”	VG CSK 3/8” x 19”	1,202	1,803*
			8-5/8”	VG CSK 3/8” x 22-7/8”	1,572	
			9-5/8”	VG CSK 3/8” x 25-5/8”	1,803*	
	$Z_{\perp}$		7-1/2”	VG CSK 3/8” x 19”	1,289	1,803*
			8-5/8”	VG CSK 3/8” x 22-7/8”	1,607	
			9-5/8”	VG CSK 3/8” x 25-5/8”	1,803*	

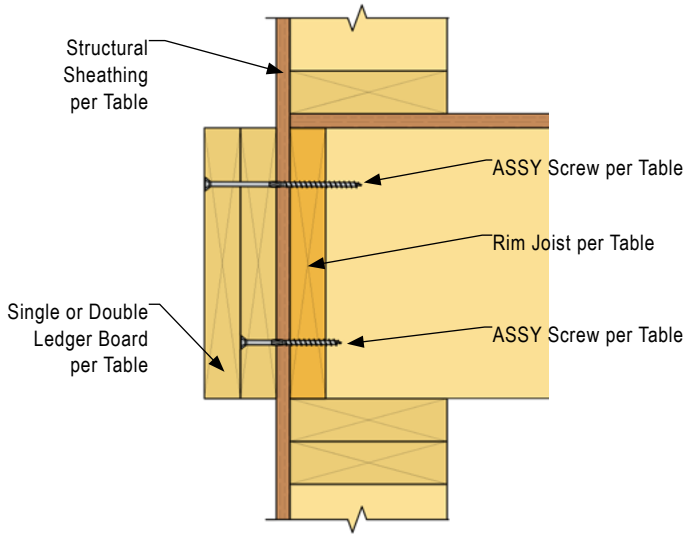
1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners are installed at a 45° angle intersecting the shear plane at the interface of CLT floor and wall.
6. The angle between force and fastener axis is 45°.
7. Reference lateral design values may be applied to uplift and horizontal tension loading towards the panel joint.
8. Adjustment for narrow edge loading of CLT (C_{eg}) may be neglected as corresponding withdrawal resistances are already multiplied by the angle to grain reduction factor R_{α}. (12.2.1.5; NDS-2018)
9. * The upper limit of the adjusted withdrawal resistance is set by the allowable fastener tensile strength, no further increase allowed.
10. $Z_{||}$ Main member loaded along the major CLT span direction; side member loaded along the major CLT span direction..

    $Z_{\perp}$ Main member loaded along the major CLT span direction; side member loaded along the minor CLT span direction..

Ledger Board to Rim Joist Connection

Single and double ledger boards can be fastened to floor rim joists through structural sheathing with partially threaded self-tapping screws.

The connection presented below can be easily implement for both new construction and additions to existing structures.



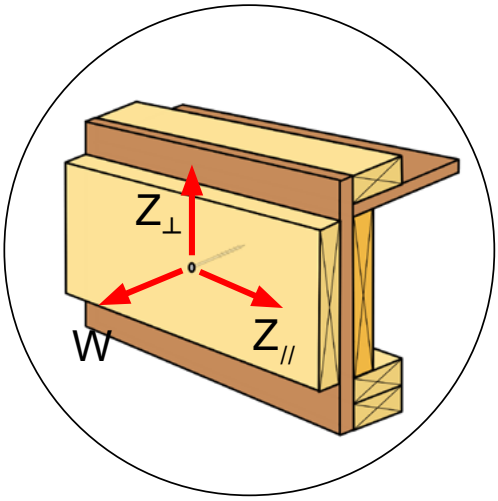


Table LG.6.1, Reference Design Values for Ledger Board to Rim Joist Connection

Ledger Configuration					Fastener Options	Reference Design Values [lbs]			
Type		Thickness	Ledger Board	Rim Joist		$Z_{//}$	$Z_{\perp}$	W_{ECO}	W_{SK}
SPF	G = 0.42	1/2"	1-1/4" EWP	1-1/4" EWP	Eco / SK 1/4" x 3-1/2"	186		187	
				2" Lumber	Eco / SK 1/4" x 3-1/2"	186		237	
			2" Lumber	1-1/4" EWP	Eco / SK 1/4" x 3-1/2"	171		163	218
				2" Lumber	Eco / SK 1/4" x 3-1/2"	171		163	237
			1-3/4" EWP	1-1/4" EWP	Eco / SK 1/4" x 4-3/4"	198		187	
				2" Lumber	Eco / SK 1/4" x 4-3/4"	199		237	
			2-1/2" EWP	1-1/4" EWP	Eco / SK 1/4" x 5-1/2"	198		187	
				2" Lumber	Eco / SK 1/4" x 5-1/2"	199		237	
			Double 2" Lumber	1-1/4" EWP	Eco / SK 1/4" x 5-1/2"	185		156	
				2" Lumber	Eco / SK 1/4" x 5-1/2"	185		163	203
			3-1/2" EWP	1-1/4" EWP	Eco / SK 1/4" x 6-1/4"	198		218	
				2" Lumber	Eco / SK 1/4" x 6-1/4"	199		262	338

Notes:

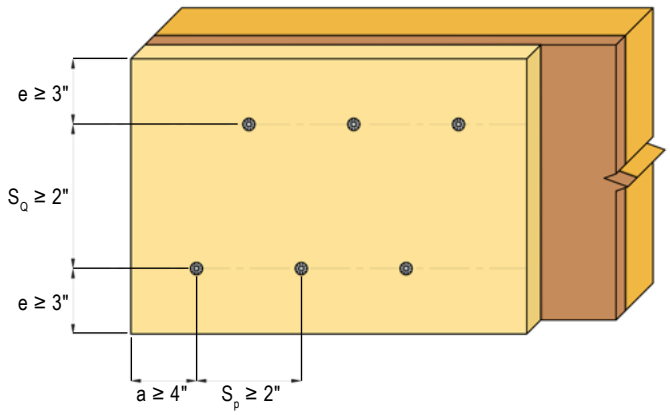
1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners to be installed at a 90° angle intersecting the shear plane at the interface of members.
6. Engineered Wood Products must have an Equivalent Specific Gravity (ESG) of 0.50 as per their respective ICC-ES Evaluation Report for the loading condition.
7. Wall sheathing must be independently fastened to the rim joist backing as per the applicable design codes or standards.
8. Double ledger boards must be independently fastened to each other as per the applicable design codes or standards.
9. It is recommended that additional backing be provided whenever the screw protrudes behind the rim joist.

Table LG.6.2, Reference Design Values for Ledger Board to Rim Joist Connection

Ledger Configuration					Fastener Options	Reference Design Values [lbs]			
Type		Thickness	Ledger Board	Rim Joist		$Z_{//}$	$Z_{\perp}$	W_{ECO}	W_{SK}
OSB / Plywood	Structural 1, Marine Grade G = 0.50	1/2"	1-1/4" EWP	1-1/4" EWP	Eco / SK 1/4" x 3-1/2"	198		187	
				2" Lumber	Eco / SK 1/4" x 3-1/2"	186		237	
			2" Lumber	1-1/4" EWP	Eco / SK 1/4" x 3-1/2"	181		163	218
				2" Lumber	Eco / SK 1/4" x 3-1/2"	171		163	237
			1-3/4" EWP	1-1/4" EWP	Eco / SK 1/4" x 4-3/4"	217		187	
				2" Lumber	Eco / SK 1/4" x 4-3/4"	199		237	
			2-1/2" EWP	1-1/4" EWP	Eco / SK 1/4" x 5-1/2"	217		187	
				2" Lumber	Eco / SK 1/4" x 5-1/2"	199		237	
			Double 2" Lumber	1-1/4" EWP	Eco / SK 1/4" x 5-1/2"	199		156	
				2" Lumber	Eco / SK 1/4" x 5-1/2"	185		163	203
			3-1/2" EWP	1-1/4" EWP	Eco / SK 1/4" x 6-1/4"	217		218	
				2" Lumber	Eco / SK 1/4" x 6-1/4"	199		262	338

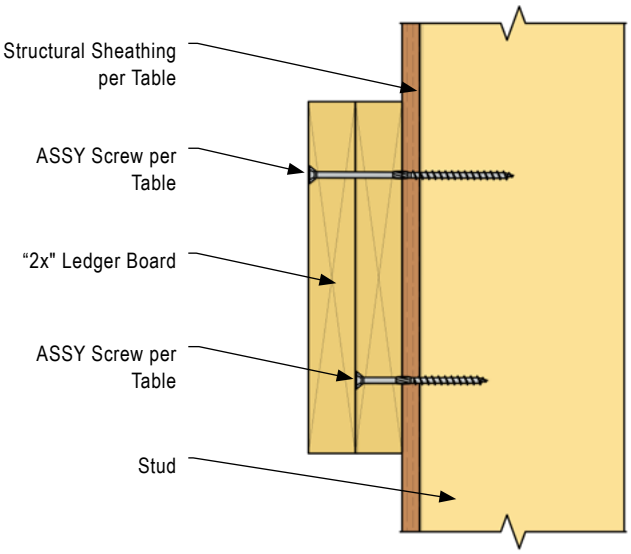
See notes under table LG.6.1, page 70.

Geometry Requirements



Ledger Board to Stud Wall Connection

Similar to rim joist connections, single and double ledger boards can be fastened to stud wall backing through structural sheathing with partially threaded self-tapping screws.



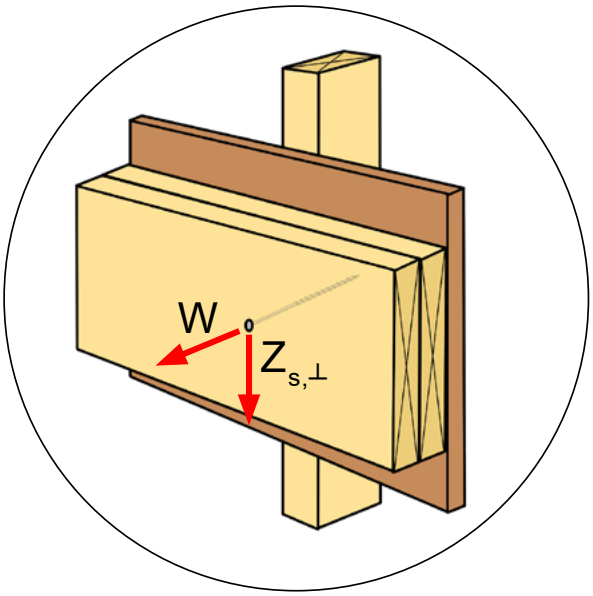


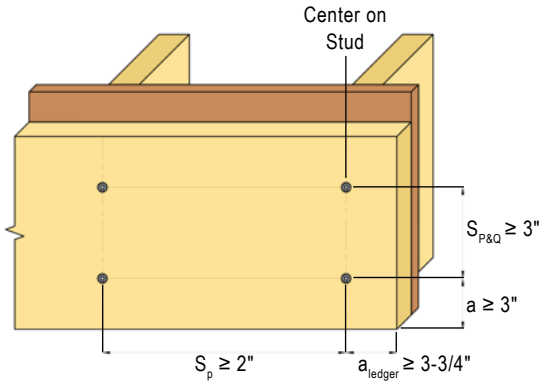
Table LG.7.1, Reference Design Values for Ledger Board to Stud Wall Connection

Ledger Configuration				Fastener Options	Reference Design Values [lbs]		
	Thickness	Stud Type	Ledger Board		$Z_{s,\perp}$	W_{ECO}	W_{SK}
OSB / Plywood	1/2”	2” Stud	1-1/4” EWP	Eco / SK 1/4” x 3-1/2”	186	262	296
			2” Lumber		171	163	274
			1-3/4” EWP	Eco / SK 1/4” x 4-3/4”	199	262	423
			2-1/2” EWP	Eco / SK 1/4” x 5-1/2”	185	262	423
			Double 2” Lumber	Eco / SK 1/4” x 6-1/4”	185	163	299
			3-1/2” EWP	Eco / SK 1/4” x 6-1/4”	199	262	423

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners to be installed at a 90° angle intersecting the shear plane at the interface of members.
6. Engineered Wood Products must have an Equivalent Specific Gravity (ESG) of 0.50 as per their respective ICC-ES Evaluation Report for the loading condition.
7. Wall sheathing must be independently fastened to the rim joist backing as per the applicable design codes or standards.
8. Double ledger boards must be independently fastened to each other as per the applicable design codes or standards.

Geometry Requirements



Specific Ledger to Stud Connection Design

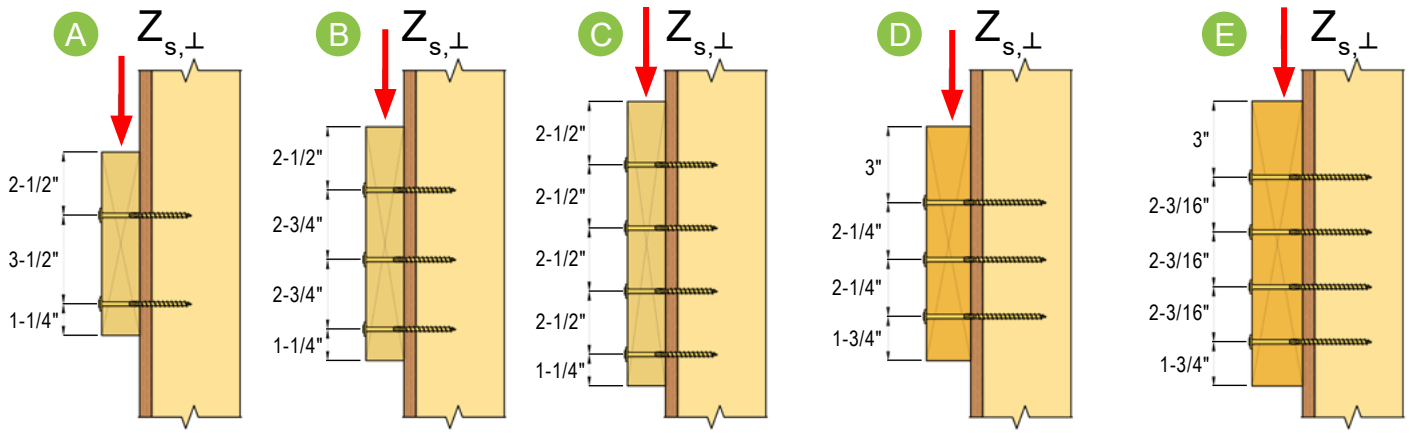
Table LG.7.2, Adjusted Design Values for Ledger Board to Stud Wall Connection

Ledger Configuration						Fastener Options	Number of Effective Fastener in a Row (n_F)	Adjusted Design Values [lbs]		
Thickness		Stud Type	Ledger Board	Assembly				$Z_{s,\perp}$	W_{ECO}	W_{SK}
OSB / Plywood	1/2"	2" Lumber	2 x 8" Lumber	A		Eco / SK 1/4" x 3-1/2"	2	319	304	552
			Double 2 x 8" Lumber			Eco / SK 1/4" x 6-1/4"	2	345		
			2 x 10" Lumber	B		Eco / SK 1/4" x 3-1/2"	3	460	440	799
			Double 2 x 10" Lumber			Eco / SK 1/4" x 6-1/4"	3	497		
			2 x 12" Lumber	C		Eco / SK 1/4" x 3-1/2"	4	596	587	1,065
			Double 2 x 12" Lumber			Eco / SK 1/4" x 6-1/4"	4	644		
			1.75 x 9.25" EWP	D		Eco / SK 1/4" x 4-3/4"	3	535	707	1,107
			3.5 x 9.25" EWP			Eco / SK 1/4" x 6-1/4"	3			
			1.75 x 11.31" EWP	E		Eco / SK 1/4" x 4-3/4"	4	694	943	1,521
			3.5 x 11.31" EWP			Eco / SK 1/4" x 6-1/4"	4			

Notes:

1. Adjusted design values apply to effective number fastener in a row (n_F), conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners to be installed at a 90° angle intersecting the shear plane at the interface of members.
6. Engineered Wood Products must have an Equivalent Specific Gravity (ESG) of 0.50 as per their respective ICC-ES Evaluation Report for the loading condition.
7. Wall sheathing must be independently fastened to the rim joist backing as per the applicable design codes or standards.
8. Double ledger boards must be independently fastened to each other as per the applicable design codes or standards.
9. Adjusted design values include the factored resistance (Z or W) and effective number fastener in a row (n_F).

Geometry Requirements



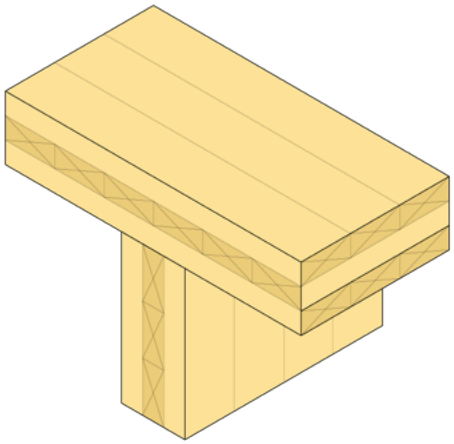
Note:

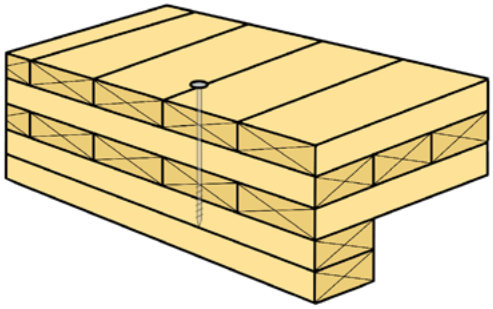
1. Minimum spacing requirements

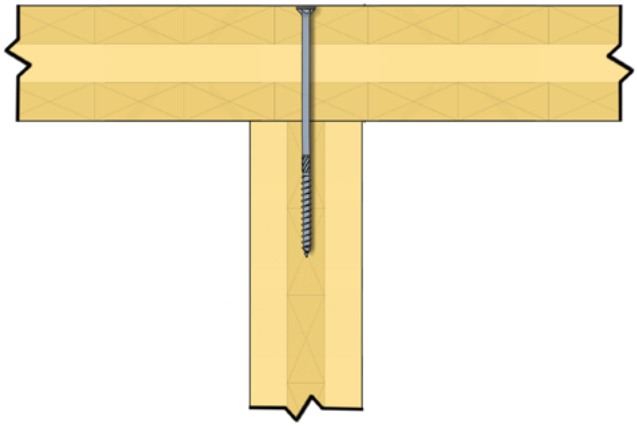
Floor to Wall Connections

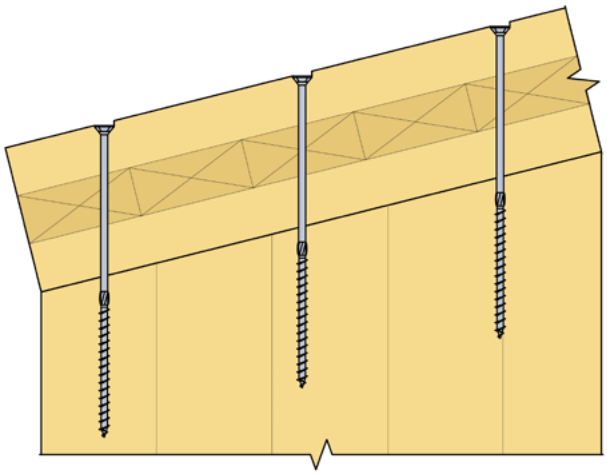
For CLT wall to floor connections, the designer should allocate special attention to ensure that minimum end and edge distance requirements for the narrow edge of CLT are satisfied.

Designers should also be aware that a three-ply or seven-ply CLT wall panel with its major span direction oriented vertically may accept the screw into the side grain of the middle ply, whereas a five-ply panel in the same orientation may accept the screw into the end grain of the middle ply. As lateral loading in the narrow panel face of CLT is generally considered as loading perpendicular to the grain for fasteners with D>1/4" (12.3.3.6; NDS-2018), only two loading scenarios are presented in that section.



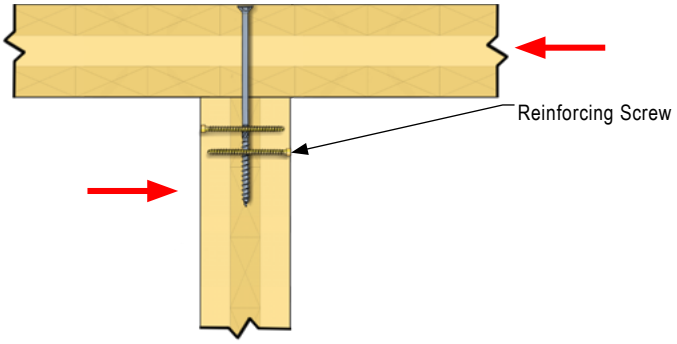






Reinforcement Possibilities

Out of plane shear loading in the narrow edge of CLT can result in reduced capacity due to splitting. Splitting risks may be reduced by installing fully threaded reinforcing screws.



CLT Floor to Wall Connections in Shear

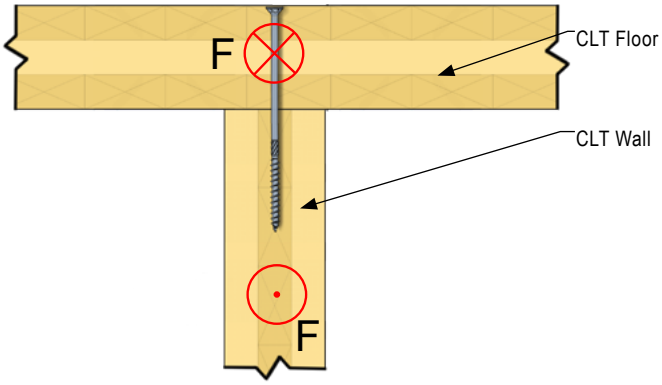
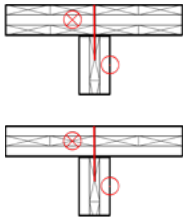
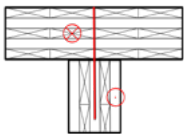
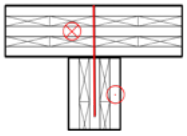


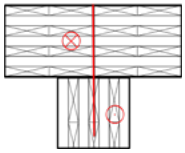
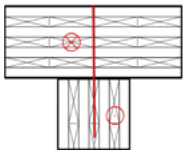
Table FW.1.1, Reference Lateral Design Values for CLT Floor to Wall Panel Connections Loaded in Shear

Panel Configuration				Fastener Options	Reference Design Values [lbs]		Minimum Spacing in a Row (S_P)
Loading			Panel Thickness (t)		Standard Loading C_D =1.0	Short Term Loading C_D =1.6	
3 PLY	$Z_{//}$		3-1/8"	Eco 1/4" x 6-1/4"	185	296	2-1/2"
			3-3/8"				
	$Z_{\perp}$		4-1/8"	Eco 1/4" x 7-7/8"			
				Eco 5/16" x 7-7/8"	194	310	3-1/8"
5 PLY	$Z_{//}$		5-1/8"	Eco 5/16" x 9-1/2"	194	310	3-1/8"
			5-1/2"				
			6-7/8"	Eco 5/16" x 11-7/8"			
				Eco 3/8" x 11-7/8"	265	424	3-7/8"
	$Z_{\perp}$		5-1/8"	Eco 5/16" x 9-1/2"	194	310	3-1/8"
			5-1/2"				
			6-7/8"	Eco 5/16" x 11-7/8"			
				Eco 3/8" x 11-7/8"	244	390	3-7/8"

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners are installed at a 90° angle intersecting the shear plane at the interface of both CLT members.
6. Adjustment for narrow edge loading of CLT (C_{eg}=0.67) shall be applied for values listed for 3/8" and 1/2" diameter fasteners.
7. For loading perpendicular to the wall surface, effects of splitting shall be considered.
8. $Z_{//}$ Main member loaded perpendicular to grain (ϴ = 90°; narrow edge); side member loaded parallel to grain (ϴ = 0°); ϴ = 90° with regards to $K_ϴ$.
   $Z_{\perp}$ Main member loaded perpendicular to grain (ϴ = 90°; narrow edge); side member loaded perpendicular to grain (ϴ = 90°); ϴ = 90° with regards to $K_ϴ$.

Table FW.1.2, Reference Lateral Design Values for CLT Panel to Wall Connections Loaded in Shear

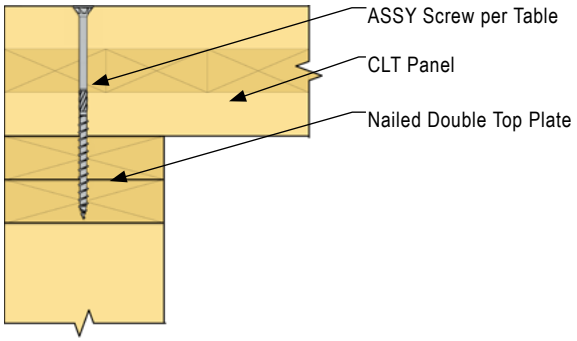
Panel Configuration				Fastener Options	Reference Design Values [lbs]		Minimum Spacing in a Row (S_P)
Loading			Panel Thickness (t)		Standard Loading C_D =1.0	Short Term Loading C_D =1.6	
7 PLY	$Z_{//}$		7-1/2"	Eco 5/16" x 11-7/8"	194	310	3-1/8"
				Eco 3/8" x 11-7/8"	265	424	3-7/8"
			8-5/8"	Eco 5/16" x 13-3/8"	194	310	3-1/8"
				Eco 3/8" x 14-1/4"	265	424	3-7/8"
			9-5/8"	Eco 3/8" x 15"			
				SK 1/2" x 15-3/4"	374	598	5"
	$Z_{\perp}$		7-1/2"	Eco 5/16" x 11-7/8"	194	310	3-1/8"
				Eco 3/8" x 11-7/8"	244	390	3-7/8"
			8-5/8"	Eco 5/16" x 13-3/8"	194	310	3-1/8"
				Eco 3/8" x 14-1/4"	244	390	3-7/8"
			9-5/8"	Eco 3/8" x 15"			
				SK 1/2" x 15-3/4"	339	542	5"

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners are installed at a 90° angle intersecting the shear plane at the interface of both CLT members.
6. The angle between force and fastener axis is 90°.
7. Adjustment for narrow edge loading of CLT (C_{eg}=0.67) shall be applied for values listed for 3/8" and 1/2" diameter fasteners.
8. For loading perpendicular to the wall surface, effects of splitting shall be considered.
9. $Z_{||}$ Main member loaded perpendicular to grain (Θ = 90°; narrow edge); side member loaded parallel to grain (Θ = 0°); Θ = 90° with regards to K_Θ.
   $Z_{\perp}$ Main member loaded perpendicular to grain (Θ = 90°; narrow edge); side member loaded perpendicular to grain (Θ = 90°); Θ = 90° with regards to K_Θ.

CLT Floor to Top Plate Connection - Top Screwed

In hybrid structures made of light-frame walls and mass timber floor, an efficient option to connect CLT floor panels to load-bearing walls uses self-tapping screws installed from the top of the panel.



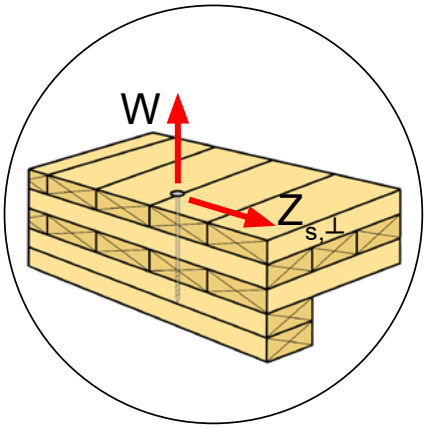


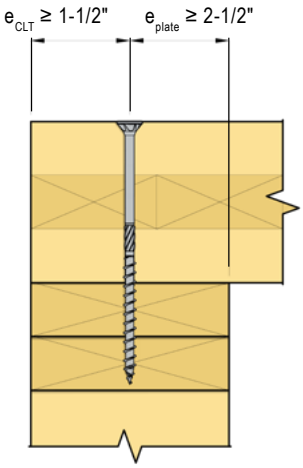
Table FW.2, Reference Design Values for CLT Floor to Top Plate Connection (Top)

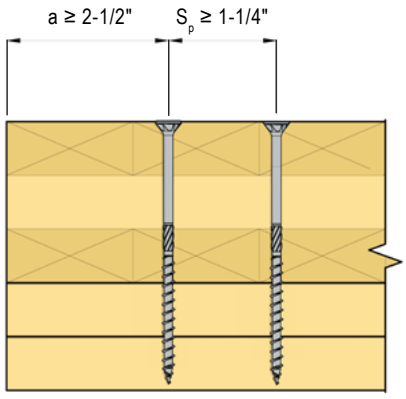
Panel & Top Wall Configuration			Fastener Options	Reference Design Values [lbs]		
	Wall Top Plate	Panel Thickness (t)		$Z_{s,\perp}$	W_{ECO}	W_{SK}
3 PLY	Double 2" Lumber	3-1/8"	Eco / SK 1/4" x 6-1/4"	185	163	299
		3-3/8"	Eco / SK 1/4" x 6-1/4"			
		4-1/8"	Eco / SK 1/4" x 7-1/8"			
5 PLY	Double 2" Lumber	5-1/8"	Eco / SK 1/4" x 7-7/8"	185	163	299
		5-1/2"	Eco / SK 1/4" x 8-5/8"			
		6-7/8"	Eco / SK 1/4" x 10-1/4"			

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners to be installed at a 90° angle intersecting the shear plane at the interface of the wall and floor members.
6. Double top plates and built-up studs must be independently fasten to each other as per the applicable design codes or standards.

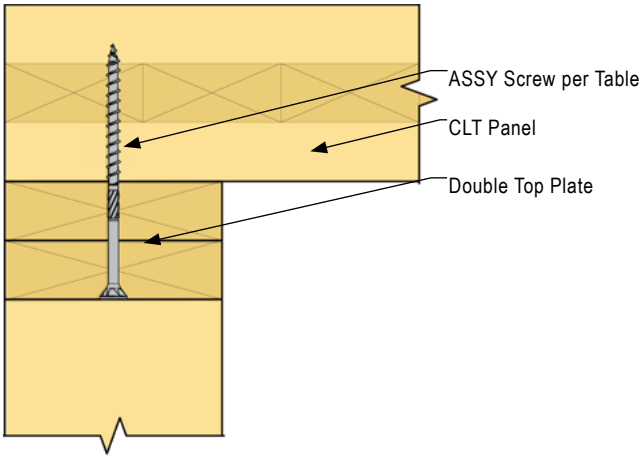
Geometry Requirements





CLT Floor to Top Plate Connection - Bottom Screwed

Self-tapping screws offer a quick to install, ductile connection between CLT floor panels and supporting light-frame walls below. Installing self-tapping screws through the double top plate is the most economic option due to shorter screw lengths compared to other alternatives.



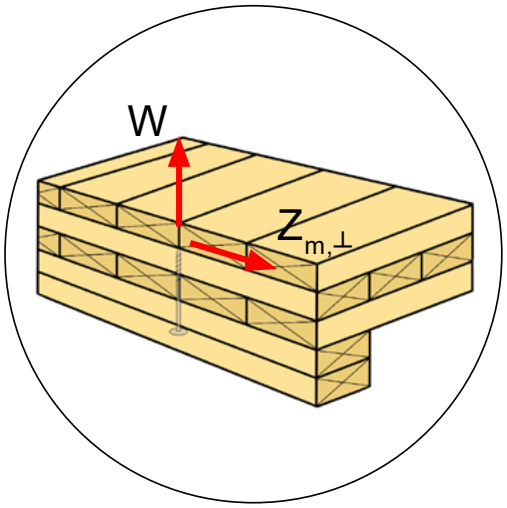


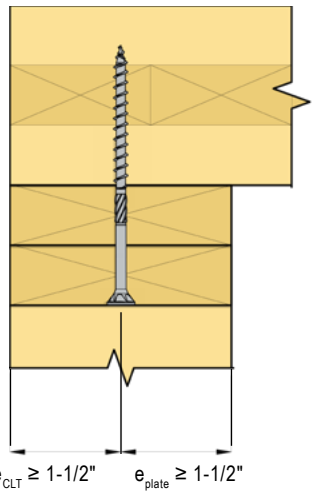
Table FW 3. Reference Design Values for CLT Floor to Top Plate Connection (Bottom)

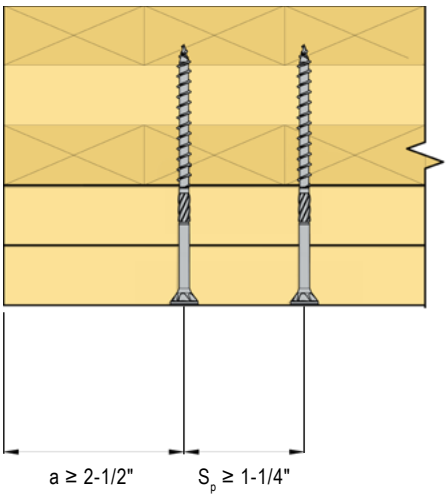
Panel & Top Wall Configuration			Fastener Options	Reference Design Values [lbs]		
Wall Top Plate		Panel Thickness (t)		$Z_{m,\perp}$	W_{ECO}	W_{SK}
3 PLY	Double 2" Lumber	3-1/8"	Eco / SK 1/4" x 5-1/2"	185	163	299
		3-3/8"				
		4-1/8"				

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners to be installed at a 90° angle intersecting the shear plane at the interface of the wall and floor members.
6. Double top plates and built-up studs must be independently fasten to each other as per the applicable design codes or standards.

Geometry Requirements





NLT Floor to Top Plate Connection - Inclined Screws

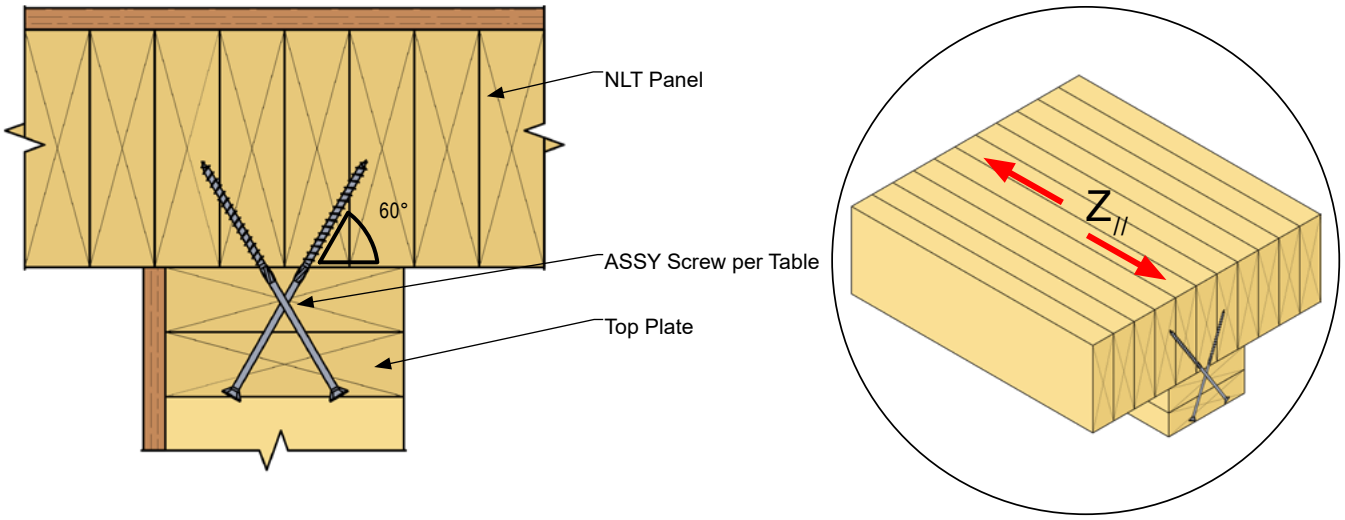


Table FW.9, Reference Design Values for Built-Up Stud to Top Plate Connections

Panel & Top Wall Configuration		Fastener Options	Reference Design Values per Screw Cross [lbs]
Loading	**Buil-Up Top Plate**		
$Z_{//}$	Double 2" Lumber	Eco 1/4" x 4-3/4"	290
		Eco 1/4" x 5-1/2"	370
		Eco 1/4" x 6-1/4"	
	Triple 2" Lumber	Eco 1/4" x 7-1/8"	366
		Eco 1/4" x 7-7/8"	370
		Eco 1/4" x 8-5/8"	

Notes:

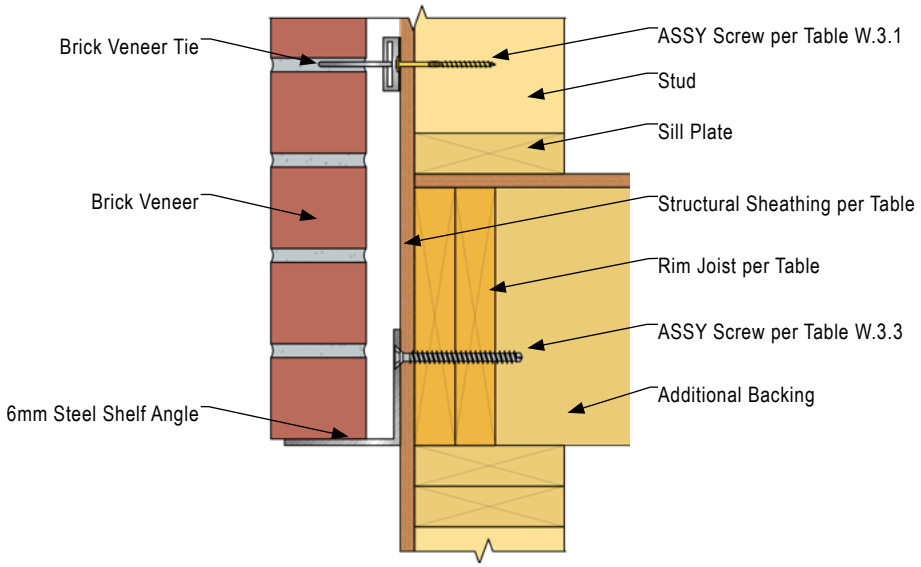
1. Reference design values apply to two fasteners in a screw cross configuration, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners to be installed at a 60° angle intersecting the shear plane at the interface wall and floor members.
6. The angle between force and fastener axis is 90°.
7. Sawn Lumber studs and plates with multiple plies must be independently fasten to each other as per the applicable design codes or standards.

Wall Connections

Brick Veneer to Wall Connection

Non-structural brick veneers are commonly supported laterally by proprietary steel connectors. These steel connectors can easily be installed with partially threaded self-tapping screws since they will tightly fasten the steel connector to the main structural framing.

By eliminating pre-drilling requirements fully-threaded self-tapping screws are a more efficient alternative to typical lag-bolt or through-bolt shelf-angle connections.



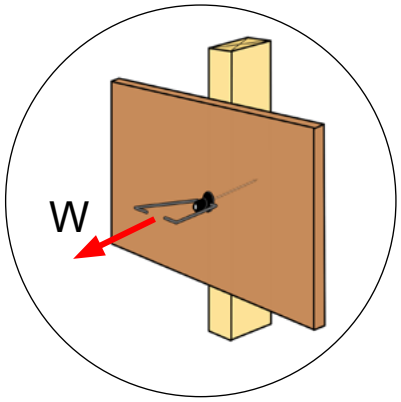


Table W.3.1, Reference Design Values for Brick Veneer Tie Connection

Sheating Configuration		Stud Backing	Tie Plate Thickness	Fastener Options	Reference Design Values [lbs]
Type	Thickness				W
Plywood (G = 0.42)	3/8" - 1"	2" Lumber	16 ga	Eco 1/4" x 2-3/8"	169
				Eco 1/4" x 2-3/4"	186

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. The adjusted withdrawal design value shall not exceed the allowable tensile strength of the screw.
6. Refer to the brick veneer tie manufacturer for specific installation and design requirements.
7. Wall sheathing must be independently fastened to the stud wall backing as per the applicable design codes or standards.
8. Steel members must be pre-drilled prior to the installation of the fasteners. The designer must assure that all possible stress limits in the steel and wood are not exceeded.

Table W.3.2, Steel Plate Pre-Drilling Hole Diameter

Screw Nominal Diameter	Steel Plate Hole Diameter
in.	in.
1/4"	**9/32"**
3/8"	**7/16"**
1/2"	**17/32"**

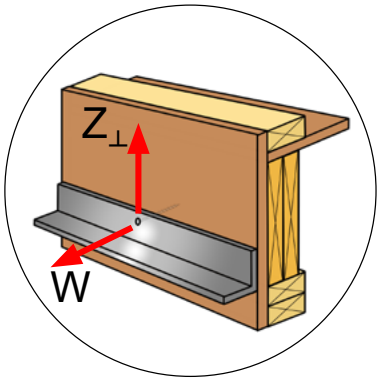


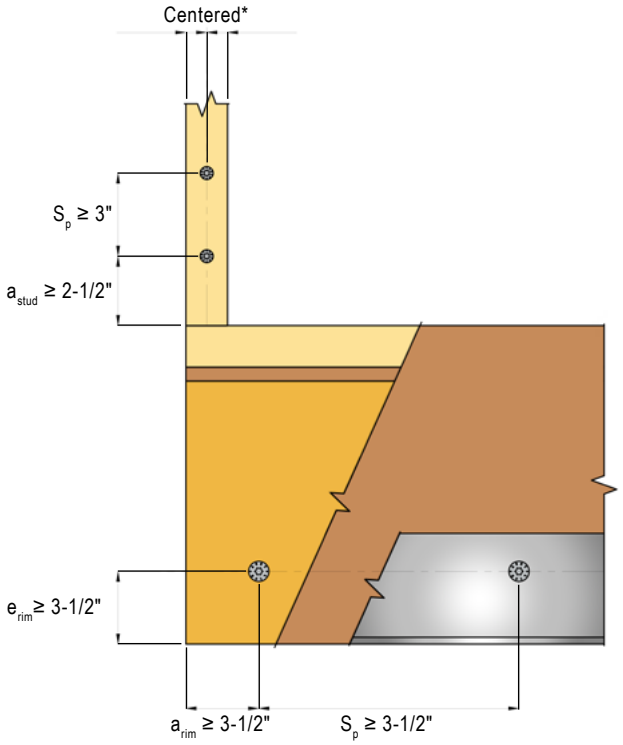
Table W.3.3, Refence Design Values for Brick Veneer Shelf Angle Connection

Sheating Configuration			Steel Thickness	Rim Joist	Additional Backing	Fastener Options		Reference Design Values [lbs]	
Type		Thickness						$Z_\perp$	W
Plywood	G = (0.49)	1/2"	1/4"	1-1/4" EWP	1-1/4" EWP		VG CSK 3/8" x 4"	319	554
							VG CSK 1/2" x 4-3/4"	275	596
					1-3/4" EWP		VG CSK 3/8" x 4"	319	554
							VG CSK 1/2" x 4-3/4"	307	708
				2" Lumber	2" Lumber		VG CSK 3/8" x 4"	319	622
							VG CSK 1/2" x 4-3/4"	307	796
Plywood (Structural 1)	G = (0.50)	1/2"	1/4"	1-1/4" EWP	1-1/4" EWP		VG CSK 3/8" x 4"	367	554
							VG CSK 1/2" x 4-3/4"	388	596
					1-3/4" EWP		VG CSK 3/8" x 4"	367	554
							VG CSK 1/2" x 4-3/4"	388	708
				2" Lumber	2" Lumber		VG CSK 3/8" x 4"	367	622
							VG CSK 1/2" x 4-3/4"	388	796

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners to be installed at a 90° angle intersecting the shear plane at the interface of the wall and the steel angle.
6. Reference design values apply to screws installed perpendicular to the grain of the main wood member.
7. The adjusted withdrawal design value shall not exceed the allowable tensile strength of the screw.
8. Shelf angle steel must conform to ASTM A36/A36M-14: Standard Specification for Carbon Structural Steel (or better).
9. Steel members must be pre-drilled prior to the installation of the fasteners. The designer must assure that all possible stress limits in the steel and wood are not exceeded.
10. Engineered Wood Products must have an Equivalent Specific Gravity (ESG) of 0.50 as per their respective ICC-ES Evaluation Report for the loading condition shown above.
11. Wall sheathing must be independently fastened to the rim joist as per the applicable design codes or standards.
12. Rim joist backing must be independently fastened to the rim joist as per the applicable design codes or standards.
13. It is recommended that additional backing be provided whenever the screw protrudes behind the rim joist.

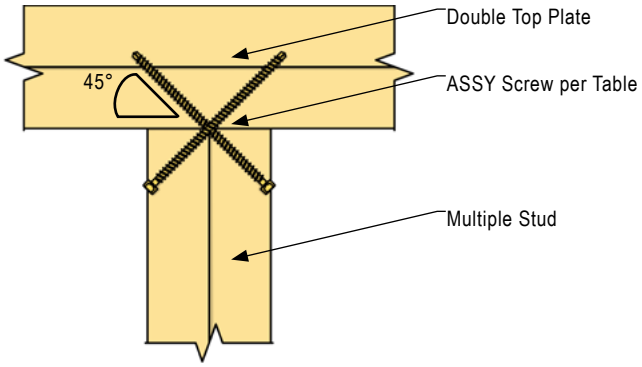
Geometry Requirements



Notes:
1. * Fastener shall be installed centered on stud.

Top Plate to Stud Lateral Connection

In cases where double top plates need to be connected to built-up studs to transfer large shear or uplift loads, inclined fully threaded self-tapping screws can be used for a stiff and strong connection.



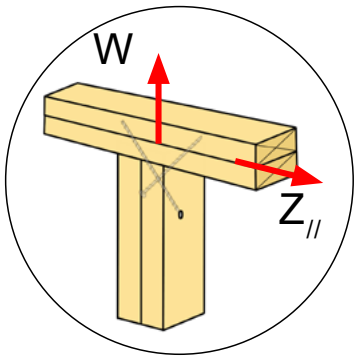


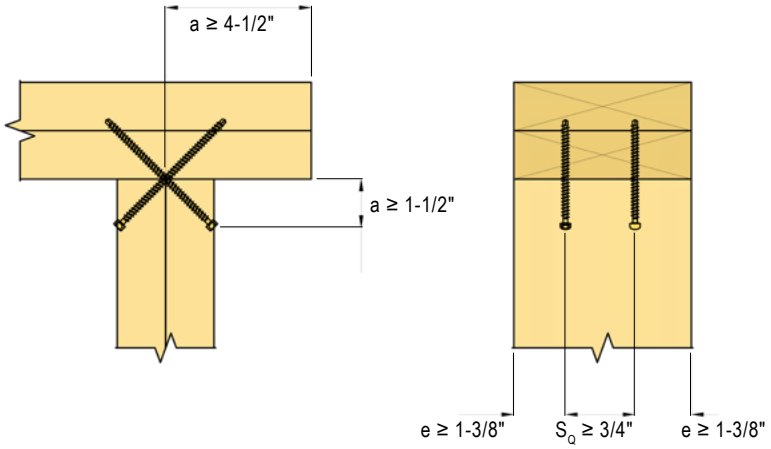
Table W.4.1, Reference Design Values for Built-Up Stud to Top Plate Connections

Top Plate & Stud Configuration			Fastener Options	Reference Design Values [lbs]
Top Plate	Loading	Buil-Up Stud		
Double 2" Lumber	$Z_{//}$ or W	Dbl. 2" Lumber	VG Cyl 1/4" x 4-3/4"	417
			VG Cyl 1/4" x 5-1/2"	422
			VG Cyl 1/4" x 6-1/4"	
		Trip. 2" Lumber	VG Cyl 1/4" x 4-3/4"	259
			VG Cyl 1/4" x 5-1/2"	424
			VG Cyl 1/4" x 6-1/4"	578

Notes:

1. Reference design values apply to two fasteners in a screw cross configuration, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners to be installed at a 45° angle intersecting the shear plane at the interface of the studs and the top plate.
6. The angle between force and fastener axis is 45°.
7. Sawn Lumber studs and plates with multiple plies must be independently fasten to each other as per the applicable design codes or standards.

Geometry Requirements



UMass Design Building

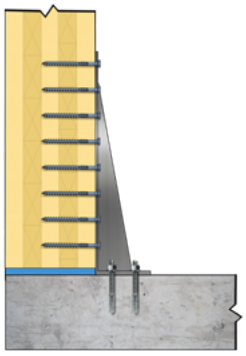
Amherst, Massachusetts

Courtesy of Alex Schreyer/Mass U Mass

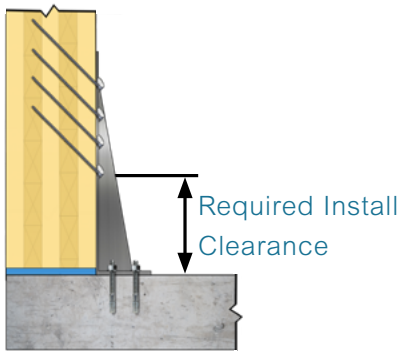
Steel to Wood Connections

Steel to CLT connections are a very common detail seen in modern mass timber construction, ranging from long collector straps fastened to the lateral load resisting core to high capacity hold down systems. Due to the high dowel bearing strength of steel, shear connections are typically stiffer than wood-to-wood installations but are limited by the bending yield strength of the fastener and wood embedment strength.

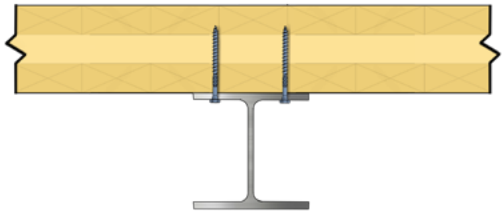
The possibility of using inclined screws, either with angled washers or reamed housing to accept the screw head offers high capacity options. The high connection strength of inclined screws thereby opens new doors toward innovative and economical design in modern mass timber structures. Due to the high axial stiffness of self-tapping fasteners, applications in moment resisting timber joints and collector plates for high overturning forces can be achieved with smaller numbers of screws, while providing high stiffness to the system.



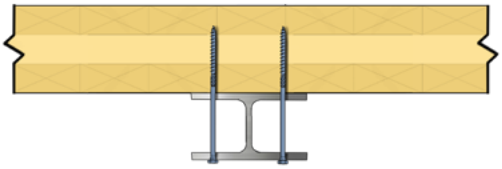
CLT wall hold down connection using shear screws, see page 86 for details.



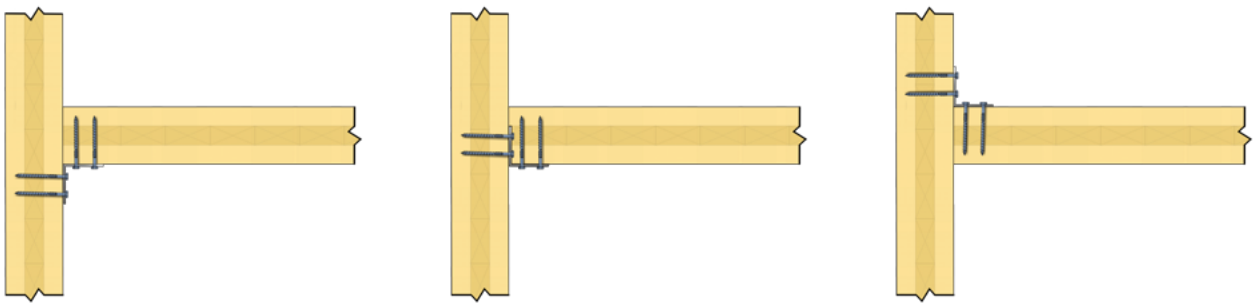
CLT wall hold down connection using inclined screws, see page 88 for details.



CLT deep H-beam connection using shear screws, see page 86 for details.



CLT wide H-beam connection using shear screws, see page 86 for details.

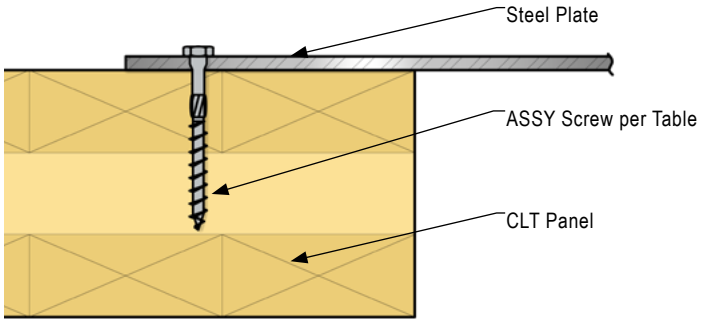


CLT floor to wall connections using angle brackets in different configurations, see page 86 for details on steel to wood connection.

CLT Panel with Steel Side Plate in Shear

The ASSY Kombi screw is engineered for steel to wood connections where the screw is loaded perpendicular to the screw axis.

The tapered shoulder of the Kombi head reduces slip and also provides a suitable bearing surface for the steel side plate.



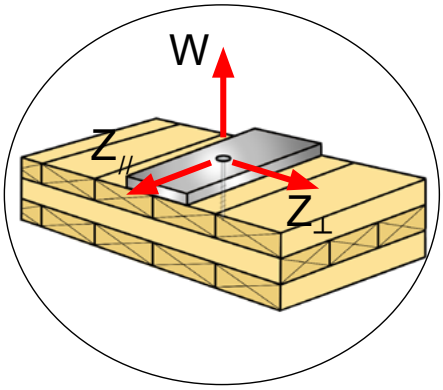
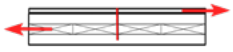
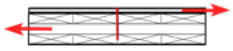


Table SC.1.1, Reference Lateral Design Values for CLT Steel Side Plate Connections

CLT Panel & Steel Plate Configuration					Fastener Options	Reference Design Values [lbs]	
Loading			Panel Thickness [t]	Steel Plate Thickness		Z	W
3 PLY	$Z_{//}$		3-1/8" to 4-1/8"	3/16"	Kombi 5/16" x 3-1/8"	279	358
				1/4"	Kombi 5/16" x 3-1/8"	312	
				1/2"	Kombi 5/16" x 3-1/8"	323*	
	$Z_{\perp}$		3-1/8" to 4-1/8"	3/16"	Kombi 5/16" x 3-1/8"	223	
				1/4"	Kombi 5/16" x 3-1/8"	249	
				1/2"	Kombi 5/16" x 3-1/8"	259*	

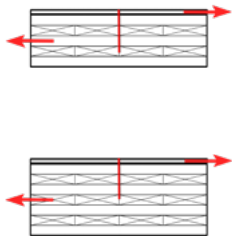
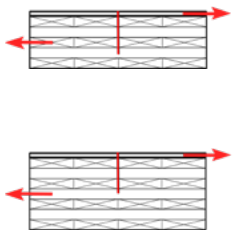
Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Reference lateral design values presented in the table above provide failure mode IIIs or IV except if otherwise identified with an asterisk (*) in which case the failure mode is not IIIs or IV.
3. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
4. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
5. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
6. Fasteners are installed at a 90° angle intersecting the shear plane at the interface of steel side member and CLT.
7. The angle between force and fastener axis is 90°.
8. Steel members must be pre-drilled prior to the installation of the fasteners. The designer must assure that all possible stress limits in the steel and wood are not exceeded.
9. The side member must be ASTM A36 grade steel or higher. In accordance with the NDS, a dowel bearing strength of F_e = 87,000 psi for steel is used in the yield limit equations.
10. $Z_{||}$ Main member loaded parallel to grain (ϴ = 0°).
    $Z_{\perp}$ Main member loaded perpendicular to grain (ϴ = 90°).
    W Steel plate loaded in withdrawal.

Table SC.1.3, Steel Plate Pre-Drilling Hole Diameter

Screw Nominal Diameter	Steel Plate Hole Diameter
in.	in.
1/4"	**9/32"**
5/16"	**3/8"**
3/8"	**7/16"**
1/2"	**17/32"**

Table SC.1.2, Reference Lateral Design Values for CLT Steel Side Plate Connections

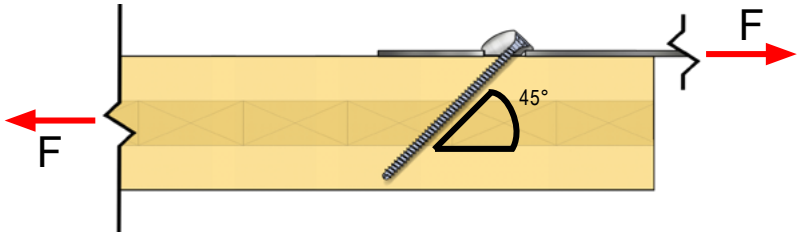
CLT Panel & Steel Plate Configuration						Reference Design Values [lbs]	
Loading		Panel Thickness [t]	Steel Plate Thickness	Fastener Options		Z	W
5 PLY & 7 PLY	$Z_{//}$		5-1/2" to 9-5/8"	3/16"	Kombi 5/16" x 3-1/8"	279	358
					Kombi 3/8" x 4-3/4"	394	652
					Kombi 1/2" x 4-3/4"	542	667
					Kombi 1/2" x 5-1/2"		
				1/4"	Kombi 5/16" x 3-1/8"	312	358
					Kombi 3/8" x 4-3/4"	430	652
					Kombi 1/2" x 4-3/4"	575	667
					Kombi 1/2" x 5-1/2"		
				1/2"	Kombi 3/8" x 4-3/4"	505	652
					Kombi 1/2" x 4-3/4"	713*	667
					Kombi 1/2" x 5-1/2"	725	
	$Z_{\perp}$		5-1/2" to 9-5/8"	3/16"	Kombi 5/16" x 3-1/8"	223	358
					Kombi 3/8" x 4-3/4"	267	652
					Kombi 1/2" x 4-3/4"	356	667
					Kombi 1/2" x 5-1/2"		
				1/4"	Kombi 5/16" x 3-1/8"	249	358
					Kombi 3/8" x 4-3/4"	292	652
					Kombi 1/2" x 4-3/4"	378*	667
					Kombi 1/2" x 5-1/2"	379	
				1/2"	Kombi 3/8" x 4-3/4"	339	652
					Kombi 1/2" x 4-3/4"	439*	667
					Kombi 1/2" x 5-1/2"	472	

See notes under Table Table SC.1.1, page 86.

CLT and Steel Plate with Inclined Screws

Steel to wood connections with inclined fasteners installed at a 45° angle usually offer higher connection strength and stiffness versus 90° shear screws. Tabulated values in this section incorporate the use of ASSY 45° wedge washers to provide bearing support in thin steel plates (although the use of thicker plates with reamed out holes is possible). When using wedge washers, ASSY 45° pre-drill jigs are used to establish 45° pilot holes at the correct location in the panels.

To reduce group tear-out failure modes and to activate the reinforcing effect of the crossing layers, screws should penetrate as many plies as possible. Inclined screws can transmit large tensile forces and connections must be accordingly detailed. Detailing must consider offsetting cross screws by 1.5D and overlapping of 4D when installing from opposite sides.



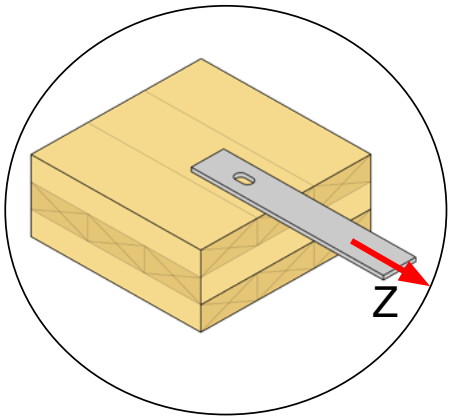
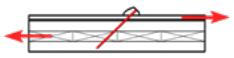
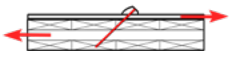


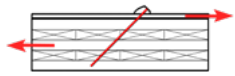
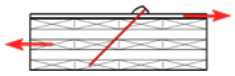
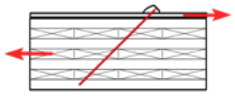
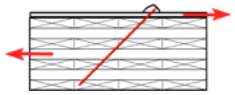
Table SC.2.1, Reference Lateral Design Values for CLT Steel Side Plate Connections

CLT Panel & Steel Plate Configuration					Fastener Options	Reference Design Values [lbs]
	Loading		Steel Plate Thickness	Panel Thickness (t)		
3 PLY	$Z_{\parallel}$		5/32" - 1/2"	≥ 3-3/8"	VG CSK 5/16" x 5-1/2"	532
				≥ 4-1/8"	VG CSK 5/16" x 6-1/4"	649
			1/4" - 3/4"	≥ 4-1/8"	VG CSK 3/8" x 6-1/4"	634
	$Z_{\perp}$		5/32" - 1/2"	≥ 3-3/8"	VG CSK 5/16" x 5-1/2"	576
				≥ 4-1/8"	VG CSK 5/16" x 6-1/4"	667
			1/4" - 3/4"	≥ 4-1/8"	VG CSK 3/8" x 6-1/4"	639

Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners are installed with MTC Solutions 45° washer, intersecting the shear plane at the interface of steel side member and CLT.
6. The angle between force and fastener axis is 45°.
7. For ranges in steel plate thicknesses a design value is provided while assuring no through penetration of the fastener in the CLT panel with minimum steel plate thickness.
8. The side member must be ASTM A36 grade steel or higher. In accordance with the NDS, a dowel bearing strength of F_e = 87,000 psi for steel is used in the yield limit equations.
9. Steel members must be pre-drilled prior to the installation of the fasteners. The designer must assure that all possible stress limits in the steel and wood are not exceeded.
10. For more information on how to predrill a steel plate with MTC Solutions 45° washer, please refer to the detailing section of this guide, page 104.
11. $Z_{\parallel}$ Reference lateral design value per screw in tension with loading direction along major span direction of CLT panel.
    $Z_{\perp}$ Reference lateral design value per screw in tension with loading direction along minor span direction of CLT panel.

Table SC.2.2, Reference Lateral Design Values for CLT Steel Side Plate Connections

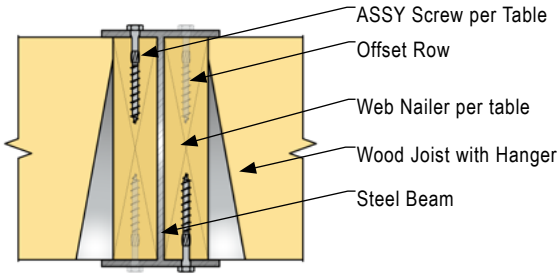
CLT Panel & Steel Plate Configuration					Fastener Options	Reference Design Values [lbs]
Loading			Steel Plate Thickness	Panel Thickness (t)		
5 PLY	$Z_{//}$		5/32" - 1/2"	≥ 5-1/8"	VG CSK 5/16" x 7-1/8"	777
				≥ 5-1/2"	VG CSK 5/16" x 7-7/8"	857
				≥ 6-7/8"	VG CSK 5/16" x 9-1/2"	1,109
			1/4" - 3/4"	≥ 5-1/8"	VG CSK 3/8" x 7-1/8"	762
				≥ 5-1/2"	VG CSK 3/8" x 7-7/8"	865
				≥ 6-7/8"	VG CSK 3/8" x 9 -1/2"	1,137
	$Z_{\perp}$		5/32" - 1/2"	≥ 5-1/8"	VG CSK 5/16" x 7-1/8"	784
				≥ 5-1/2"	VG CSK 5/16" x 7-7/8"	912
				≥ 6-7/8"	VG CSK 5/16" x 9-1/2"	1,113
			1/4" - 3/4"	≥ 5-1/8"	VG CSK 3/8" x 7-1/8"	783
				≥ 5-1/2"	VG CSK 3/8" x 7-7/8"	914
				≥ 6-7/8"	VG CSK 3/8" x 9-1/2"	1,147
7 PLY	$Z_{//}$		1/4" - 3/4"	≥ 7-1/2"	VG CSK 3/8" x 10-1/4"	1,216
				≥ 8-5/8"	VG CSK 3/8" x 12-5/8"	1,611
				≥ 9-5/8"	VG CSK 3/8" x 13-3/8"	1,730
			1/4" - 1"	≥ 7-1/2"	VG CSK 1/2" x 11"	1,326
				≥ 8-5/8"	VG CSK 1/2" x 11-7/8"	1,481
	$Z_{//}$		1/4" - 3/4"	≥ 7-1/2"	VG CSK 3/8" x 10-1/4"	1,302
				≥ 8-5/8"	VG CSK 3/8" x 12-5/8"	1,646
				≥ 9-5/8"	VG CSK 3/8" x 13-3/8"	1,743
			1/4" - 1"	≥ 7-1/2"	VG CSK 1/2" x 11"	1,411
				≥ 8-5/8"	VG CSK 1/2" x 11-7/8"	1,544

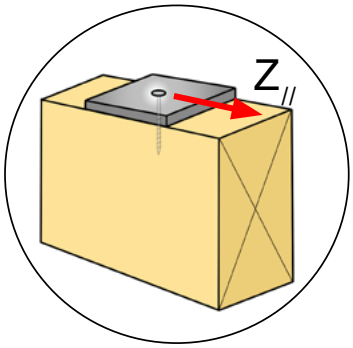
See notes under Table Table SC.2.1, page 88.

Steel Beam to Wood Connection

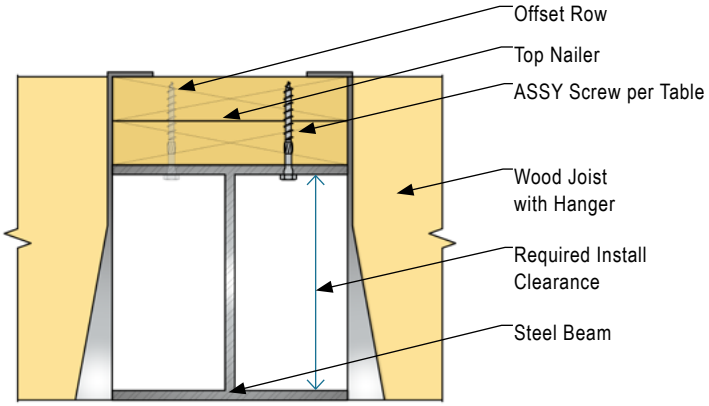
Timber joist members can be connected to structural steel I-beams by providing either web or top flange nailers that the joists can be attached to. Self-tapping screws can be installed to structurally connect nailers to the steel beam and be able to transfer in-plane lateral diaphragm forces.

Steel Beam to Web Nailer Connection





Steel Beam to Top Nailer Connection



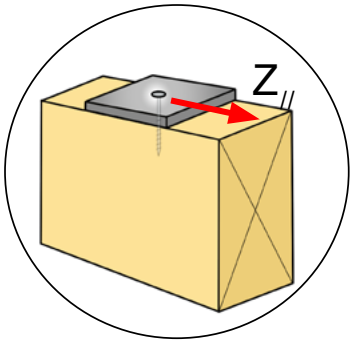


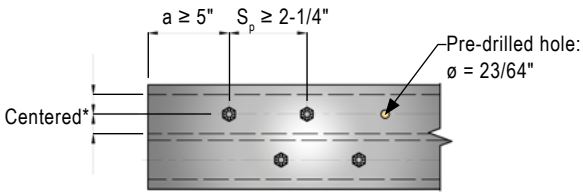
Table SC.3.1, Reference Design Values for Steel Beam to Web Nailer Connection

Steel Beam & Wood Configuration				Fastener Options	Reference Design Values [lbs]
Loading	Nailer S.G. Or E.S.G.	Nailer Thickness	Flange Thickness		
$Z_{//}$	0.42	1-1/2”	0.1”	Kombi 5/16” x 3-1/8”	228
			0.2”	Kombi 5/16” x 3-1/8”	246
			0.3”	Kombi 5/16” x 3-1/8”	278
			0.4”	Kombi 5/16” x 3-1/8”	271
			0.5”	Kombi 5/16” x 3-1/8”	265
	0.5	1-3/4”	0.1”	Kombi 5/16” x 3-1/8”	286
			0.2”	Kombi 5/16” x 3-1/8”	320
			0.3”	Kombi 5/16” x 3-1/8”	353
			0.4”	Kombi 5/16” x 3-1/8”	342
			0.5”	Kombi 5/16” x 3-1/8”	331

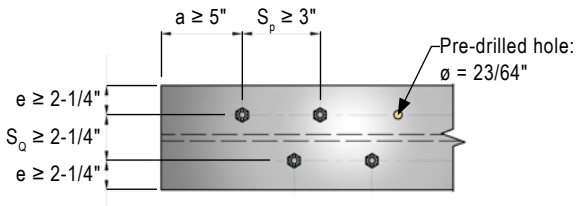
Notes:

1. Reference design values apply to a single fastener, conforming to the connection geometry and the loading configuration described for that design value.
2. Allowable loads listed are only valid for Allowable Stress Design in the USA and for listed ASSY screws.
3. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
4. Connector placement must respect the geometry requirements presented in the minimum spacing, edge, & end distance requirements for ASSY screws, as specified in the Detailing Section of this guide, pages 92 to 104.
5. Fasteners to be installed at a 90° angle intersecting the shear plane at the interface of the steel and wood members.
6. Reference design values apply to screws installed perpendicular to the grain direction of the main wood member.
7. Steel members must be pre-drilled prior to the installation of the fasteners. The designer must assure that all possible stress limits in the steel and wood are not exceeded.
8. Steel beams must conform to ASTM A36/A36M-14: Standard Specification for Carbon Structural Steel (or better).
9. Engineered Wood Products must have an Equivalent Specific Gravity (ESG) of 0.50 as per their respective ICC-ES Evaluation Report for the loading condition shown above.

Geometry Requirements



Web Connection



Top Connection

Notes:
* Fastener shall be installed centered on nailer.

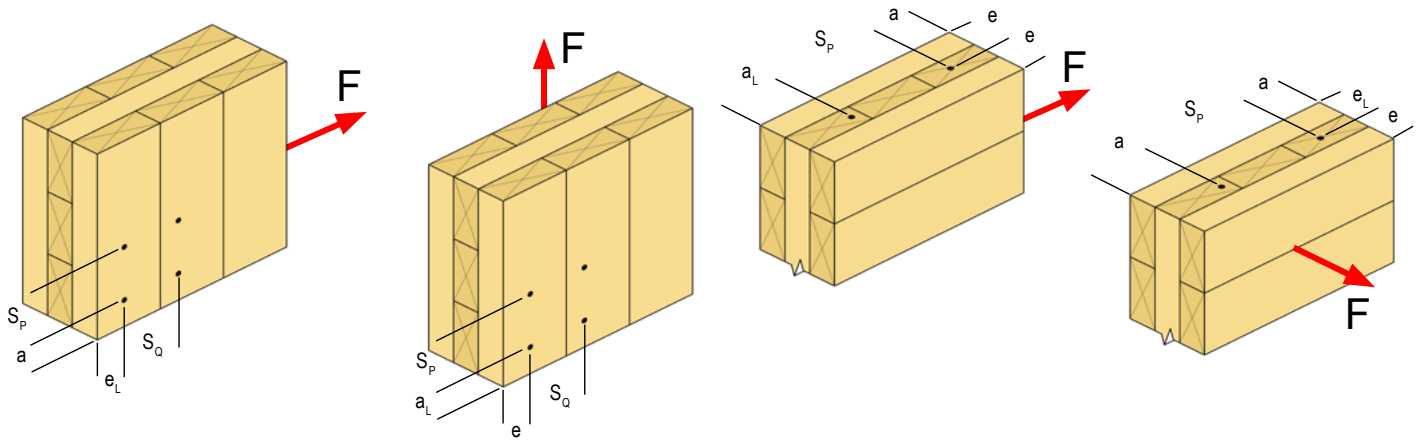
Geometry Requirements

Spacing and Edge Distance Requirements

Spacing and distance requirements ensure full fastener resistance can be developed. Self-tapping screws displace wood fiber as the screw is driven into the member, while pre-drilling removes wood fiber.

The spacing and edge distance requirements for self-tapping screws, vary when compared to other fasteners. If pre-drilling is implemented, the spacing and edge distance requirements as per NDS 2018 may apply.

Geometry Requirements in CLT for ASSY Screws Without Pre-Drilled Holes



Fasteners in Plane Surface

Fasteners in Narrow Edge

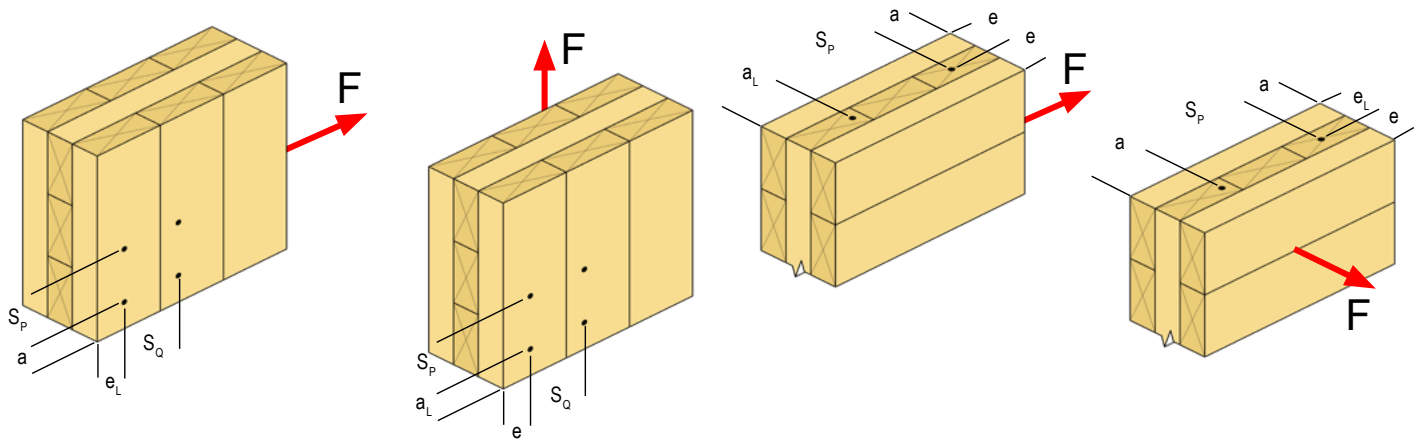
Table S.1.1, CLT Connection Geometry Requirements without Pre-drilling

CLT Plane	End Distance		Edge Distance		Spacing Between Fasteners in a Row	Spacing Between Rows
	a_L	a	e_L	e	S_P	S_Q
Fastener In Plane Surface	6 D	6 D	6 D	2.5 D	4 D	2.5 D
Fastener in Narrow Edge	12 D	7 D	6 D	3 D	10 D	4 D

Notes:

1. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
2. Spacing, end and edge distance requirements are calculated with the nominal diameter of the fastener D.
3. Spacing, end and edge distance requirements in the above tables were veified in testing.
4. The listed values are applicable when the CLT panel tickness is at least 10·D.
5. The minimum penetration depth of the screw into the narrow face of the panel should be equal to the maximum of the thread length and 10D.

Geometry Requirements in CLT for ASSY Scews With Pre-Drilled Holes



Fasteners in Plane Surface

Fasteners in Narrow Edge

Table S.1.2, CLT Connection Geometry Requirements with Pre-drilled Holes, C_Δ=1.0

CLT Plane	End Distance		Edge Distance		Spacing Between Fasteners in a Row	Spacing Between Rows
	a_L	a	e_L	e	S_P	S_Q
Fastener In Plane Surface	7 D	4 D	4 D	3 D	4 D	4 D
Fastener in Narrow Edge	7 D	4 D	3 D	3 D	4 D	4 D

Notes:

1. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
2. Spacing, end and edge distance requirements are calculated with the nominal diameter of the fastener D.
3. Geometry requirements in CLT for ASSY scews with pre-drilled holes are taken from NDS 2018, clause 12.5.
4. Full penatration length must be pre-drilled with a hole diameter according to the pre-drilling recommendations, presented in Table S.5.

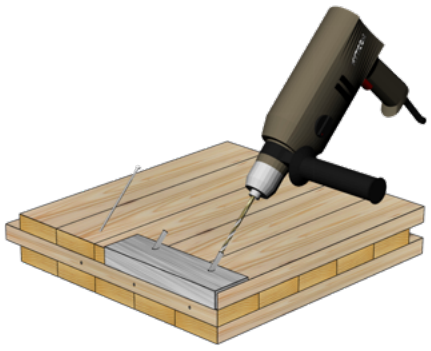
Pre-Drilling Recommendations

Table S.5, Pre-drilling hole diameter

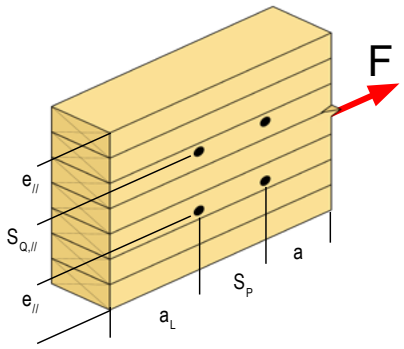
Major Diameter	Softwood	Hardwood	Steel Plate
[D]	*[in.]*	*[in.]*	*[in.]*
1 / 4"	5 / 32"	5 / 32"	9 / 32"
5 / 16"	3 / 16"	15 / 64"	23 / 64"
3 / 8"	15 / 64"	17 / 64"	7 / 16"
1 / 2"	17 / 64"	5 / 16"	33 / 64"

Notes:

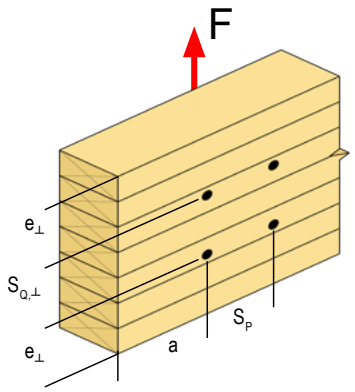
1. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
2. Consult a qualified design professional before pre-drilling.
3. Pre-drilled holes that exceed the diameters listed above may reduce the capacity of the screws.
4. Recommendations only applicable to ASSY screws.



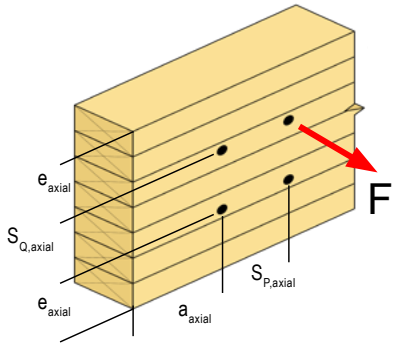
Geometry Requirements for ASSY Screws



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_L	a_{axial}	$e_{//}$	$e_{\perp}$	e_{axial}	S_p	$S_{p,axial}$	$S_{Q\perp} / S_{Q//}$	$S_{Q,axial}$
Partial Thread	G ≤ 0.42	10 D	10 D	5 D	10 D	5 D	5 D	5 D	5 D	5 D
	0.42 < G ≤ 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 ≤ 0.42	7 D	5 D	3 D	7 D	3 D	7 D	5 D	5 D	2.5 D
	0.42 < G ≤ 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

Notes:
1. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
2. Spacing, end and edge distance requirements are calculated with the nominal diameter of the fastener D.
3. According to ICC-ESR-3178 and ICC-EDR-3179
4. Tabulated values listed above must prevent splitting in wood. Shall splitting be observed a design professional must be consulted immediately.
5. Within a row, fasteners may be staggered up to 2·D to further reduce the potential for splitting.

Table S.2.2, Timber Connection Geometry Requirements with Pre-drilled Holes, C_{Δ}=1.0

End Distance			Edge Distance				Spacing Between Fasteners in a Row		Spacing Between Rows		
a	a_L	a_{axial}	$e_{//}$	$e_{\perp}$	$e_{\perp,L}$	e_{axial}	S_p	$S_{p,axial}$	$S_{Q//}$	$S_{Q\perp}$	$S_{Q,axial}$
4 D	7 D *	4 D	3 D	4 D	4 D	3 D	4 D	4 D	3 D	5 D	4 D

Notes:
1. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.
2. Spacing, end and edge distance requirements are calculated with the nominal diameter of the fastener D.
3. Full penatration length must be pre-drilled with a hole diameter according to the pre-drilling recommendations, presented in Table S.5.
4. According to NDS 2018, section 12.5
5. Minimum fastener penetration 6·D.
6. * for softwood only

ASSY Allowable Fastener Tensile Strength

Table S.3, ASSY Allowable Tensile Strength

Major Diameter	ASSY Eco / Kombi / SK	ASSY VG CSK / VG CYL
[D]	*[lbs.]*	*[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

Notes:
1. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.

ASSY Adjusted Fastener Torsional Strength

Table S.4, ASSY Adjusted Torsional Strength

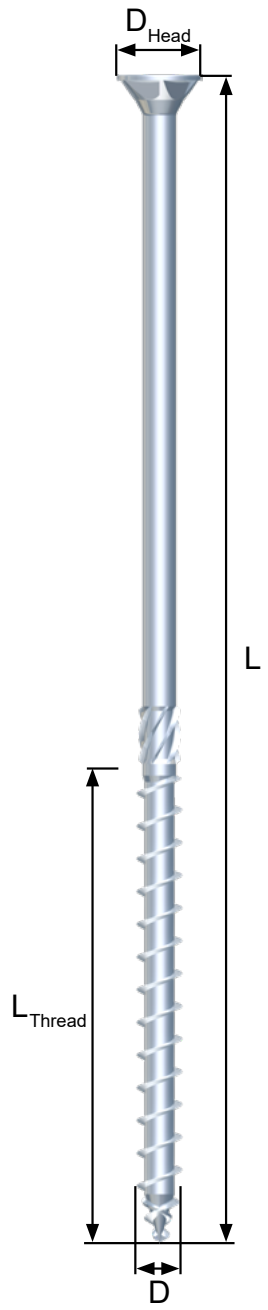
Fastener Type	Adjusted Torsional Strength *[lbs. * ft.]*				
	[D]				
	1 / 4”	5 / 16”	3 / 8”	1 / 2”	9 / 16”
ASSY Eco / Kombi / SK	5.90	13.57	26.55	38.50	N / A
ASSY VG CSK / VG CYL	5.90	13.57	26.55	44.25	67.85

Notes:
1. All connection design must meet all relevant requirements of the General Notes to the Designer section, page 16.

Hardware

ASSY Ecofast

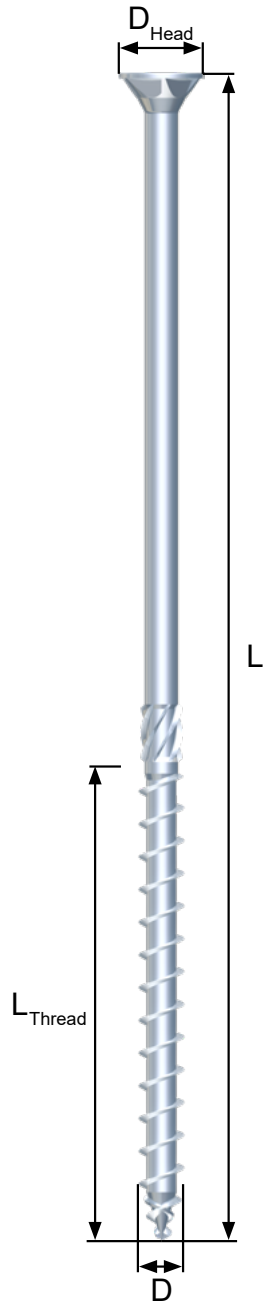
Item#	Box size	D		L		L_{Thread}		D_{Head}	Bit
#	pieces	in. [mm]		in.	[mm]	in.	[mm]	in. [mm]	
110060060000100	200	1/4 [6]		2-1/8	[60]	1-1/2	[37]	0.472 [12]	AW 30
110060070000100	200			2-3/4	[70]	1-5/8	[42]		
110060080000100	100			3-1/8	[80]	2	[50]		
110060090000100	100			3-1/2	[90]	2	[50]		
110060100000100	100			4	[100]	2 3/8	[60]		
110060120000100	100			4-3/4	[120]	2-3/4	[70]		
110060140000100	100			5-1/2	[140]	2-3/4	[70]		
110060160000100	100			6-1/4	[160]	2-3/4	[70]		
110060180000100	100			7-1/8	[180]	2-3/4	[70]		
110060200000100	100			7-7/8	[200]	2-3/4	[70]		
110060220000100	100			8-5/8	[220]	2-3/4	[70]		
110060260000100	100			10 1/4	[260]	2 3/4	[70]		
110060300000100	100			11 7/8	[300]	2 3/4	[70]		
110080080000300	75	5/16 [8]		3 1/8	[80]	2	[50]	0.591 [15]	AW 40
110080090000300	75			3 1/2	[90]	2 3/8	[60]		
110080100000300	75			4	[100]	2 3/8	[60]		
110080120000300	75			4 3/4	[120]	3 1/8	[80]		
110080140000300	75			5 1/2	[140]	3 1/8	[80]		
110080160000300	75			6 1/4	[160]	3 1/8	[80]		
110080180000300	75			7 1/8	[180]	3 1/8	[80]		
110080200000300	75			7 7/8	[200]	3 1/8	[80]		
110080220000300	75			8 5/8	[220]	4	[100]		
110080240000300	75			9 1/2	[240]	4	[100]		
110080260000300	75			10 1/4	[260]	4	[100]		
110080280000300	75			11	[280]	4	[100]		
110080300000300	75			11 7/8	[300]	4	[100]		
110080340000300	100			13 3/8	[340]	4	[100]		
110080360000300	100			14 1/4	[360]	4	[100]		
110080400000300	100			15 3/4	[400]	4	[100]		



Notes:
1. For more ASSY fastener options, visit the **MTC Solutions Website** at mtcsolutions.com.

Item#	Box size	D		L		L_{Thread}		D_{Head}	Bit	
#	pieces	in. [mm]		in.	[mm]	in.	[mm]	in. [mm]		
110100080000300	50			**3 1/8**	[80]	**2**	[50]			
110100100000300	50			**4**	[100]	**2 3/8**	[60]			
110100120000300	50			**4 3/4**	[120]	**3 1/8**	[80]			
110100140000300	50			**5-1/2**	[140]	**3-1/8**	[80]			
110100160000300	50			**6-1/4**	[160]	**4**	[100]			
110100180000300	50			**7-1/8**	[180]	**4**	[100]			
110100200000300	50		**3/8** [10]	**7-7/8**	[200]	**4**	[100]	**0.728** [18.5]		**AW 40**
110100220000300	50			**8-5/8**	[220]	**4**	[100]			
110100260000300	50			**10-1/4**	[260]	**4**	[100]			
110100300000300	50			**11-7/8**	[300]	**4**	[100]			
110100360000300	50			**14-1/4**	[360]	**4-3/4**	[120]			
110100380000300	50			**15**	[380]	**4 3/4**	[120]			
110100400000300	50			**15 3/4**	[400]	**4 3/4**	[120]			

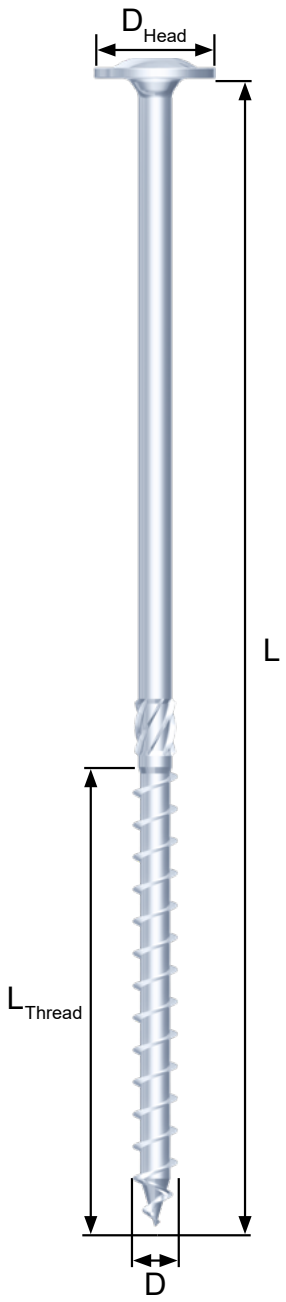
Notes:
1. For more ASSY fastener options, visit the **MTC Solutions Website** at mtcsolutions.com.



ASSY SK

Item#	Box size	D	L		L_{Thread}		D_{Head}	Bit
#	pieces	in. [mm]	in.	[mm]	in.	[mm]	in. [mm]	
120060060000303	100	1/4 [6]	2-1/8	[60]	1-1/2	[37]	0.551 [14]	AW 30
120060070000303	100		2-3/4	[70]	1-5/8	[42]		
120060080000303	100		3-1/8	[80]	2	[50]		
120060090000303	100		3-1/2	[90]	2	[50]		
120060100000300	100		4	[100]	2 3/8	[60]		
120060120000300	100		4-3/4	[120]	2-3/4	[70]		
120060140000303	100		5-1/2	[140]	2-3/4	[70]		
120060160000303	100		6-1/4	[160]	2-3/4	[70]		
120060180000303	100		7-1/8	[180]	2-3/4	[70]		
120060200000303	100		7-7/8	[200]	2-3/4	[70]		
120060220000303	100		8-5/8	[220]	2-3/4	[70]		
120060260000303	100		10 1/4	[260]	2 3/4	[70]		
120060300000303	100		11 7/8	[300]	2 3/4	[70]		

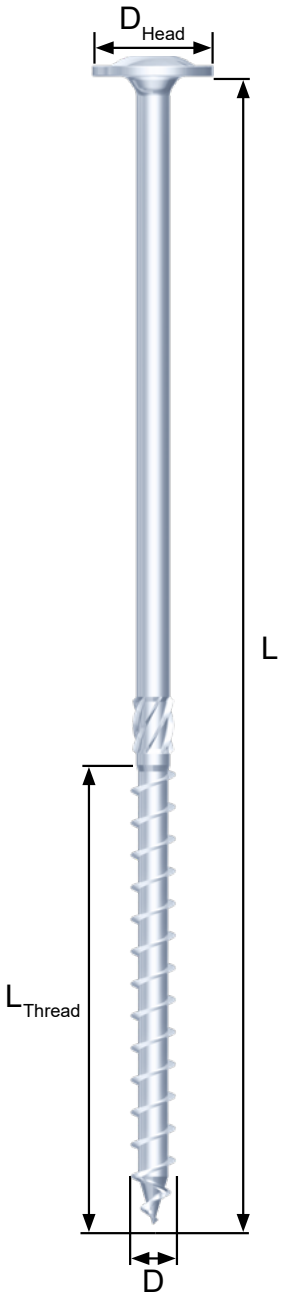
Item#	Box size	D	L		L_{Thread}		D_{Head}	Bit
#	pieces	in. [mm]	in.	[mm]	in.	[mm]	in. [mm]	
120080080000303	50	5/16 [8]	3 1/8	[80]	2	[50]	0.870 [22.1]	AW 40
120080100000303	50		4	[100]	2 3/8	[60]		
120080120000300	50		4 3/4	[120]	3 1/8	[80]		
120080140000303	50		5 1/2	[140]	3 1/8	[80]		
120080160000303	50		6 1/4	[160]	3 1/8	[80]		
120080180000303	50		7 1/8	[180]	3 1/8	[80]		
120080200000303	50		7 7/8	[200]	3 1/8	[80]		
120080220000303	50		8 5/8	[220]	4	[100]		
120080240000303	50		9 1/2	[240]	4	[100]		
120080260000303	50		10 1/4	[260]	4	[100]		
120080280000303	50		11	[280]	4	[100]		
120080300000303	50		11 7/8	[300]	4	[100]		
120080320000303	50		12 5/8	[320]	4	[100]		
120080340000303	50		13 3/8	[340]	4	[100]		
120080400000303	50		15 3/4	[400]	4	[100]		
120080480000103	25		19	[480]	4	[100]		
120080520000103	25		20 1/2	[520]	4	[100]		



Notes:
1. For more ASSY fastener options, visit the **MTC Solutions Website** at mtcsolutions.com.

Item#	Box size	D		L		L Thread		D Head	Bit
#	pieces	in. [mm]		in.	[mm]	in.	[mm]	in. [mm]	
120100100000303	50	3/8 [10]		4	[100]	2 3/8	[60]	0.992 [25.2]	AW 50
120100120000300	50			4 3/4	[120]	3 1/8	[80]		
120100140000303	50			5 1/2	[140]	3 1/8	[80]		
120100160000303	50			6 1/4	[160]	4	[100]		
120100180000303	50			7 1/8	[180]	4	[100]		
120100200000303	50			7 7/8	[200]	4	[100]		
120100220000303	50			8 5/8	[220]	4	[100]		
120100260000303	50			10 1/4	[260]	4	[100]		
120100300000303	50			11 7/8	[300]	4	[100]		
120100360000303	50			14 1/4	[360]	4 3/4	[120]		
120100380000303	50			15	[380]	4 3/4	[120]		
120100400000303	50			15 3/4	[400]	4 3/4	[120]		
120100460000303	25			18 1/8	[460]	4 3/4	[120]		

Item#	Box size	D		L		L Thread		D Head	Bit
#	pieces	in. [mm]		in.	[mm]	in.	[mm]	in. [mm]	
120120020000300	25	1/2 [12]		7 7/8	[200]	4	[100]	1.157 [29.4]	AW 50
120120026000300	25			10 1/4	[260]	4 3/4	[120]		
120120040000300	25			15 3/4	[400]	5 3/4	[145]		
120120048000300	25			19	[480]	5 3/4	[145]		
120120052000300	25			20 1/2	[520]	5 3/4	[145]		

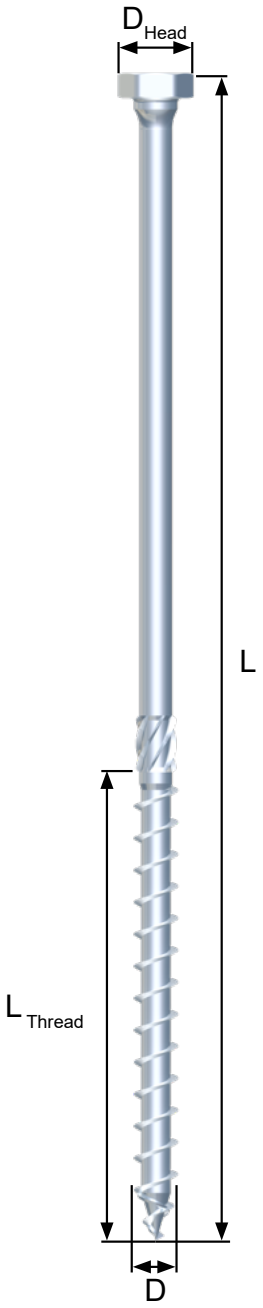


Notes:
1. For more ASSY fastener options, visit the **MTC Solutions Website** at mtcsolutions.com.

ASSY Kombi

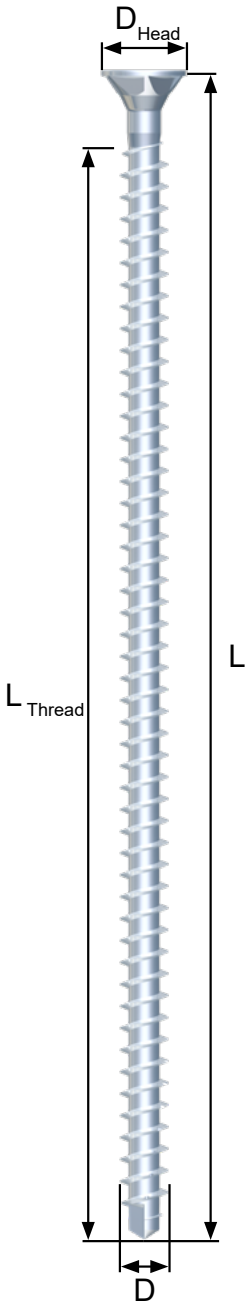
Item#	Box size	D		L		L_{Thread}		D_{Head}	Bit
#	pieces	in. [mm]		in.	[mm]	in.	[mm]	in. [mm]	
130080060000103	75		**5/16 [8]**	**2 3/8**	[60]	**1 1/2**	[40]	**0.472** [12]	**AW 40 or 1/2 socket**
130080080000103	75			**3 1/8**	[80]	**2**	[50]		
130080100000103	75			**4**	[100]	**2 3/8**	[60]		
130080120000103	75			**4 3/4**	[120]	**3 1/8**	[80]		
130080160000103	75			**6 1/4**	[160]	**3 1/8**	[80]		
130080200000103	75			**7 7/8**	[200]	**3 1/8**	[80]		
130100060000103	50		**3/8 [10]**	**2 3/8**	[60]	**2**	[50]	**0.591** [15]	**AW 40 or 19/32 socket**
130100080000103	50			**3 1/8**	[80]	**2**	[50]		
130100100000103	50			**4**	[100]	**2 3/8**	[60]		
130100120000103	50			**4 3/4**	[120]	**3 1/8**	[80]		
130100140000103	50			**5 1/2**	[140]	**3 1/8**	[80]		
130100160000103	50			**6 1/4**	[160]	**4**	[100]		
130100200000103	50			**7 7/8**	[200]	**4**	[100]		
130120080000103	50		**1/2** [12]	**3-1/8**	[80]	**2-3/4**	[70]	**0.669** [17]	**AW 40 or 11/16 socket**
130120100000103	50			**4**	[100]	**2 3/8**	[60]		
130120120000103	50			**4 3/4**	[120]	**3 1/8**	[80]		
130120140000103	50			**5 1/2**	[140]	**3 1/8**	[80]		
130120160000103	50			**6 1/4**	[160]	**5 3/4**	[145]		
130120200000103	50			**7 7/8**	[200]	**4**	[100]		

Notes:
1. For more ASSY fastener options, visit the **MTC Solutions Website** at mtcsolutions.com.



ASSY VG CSK

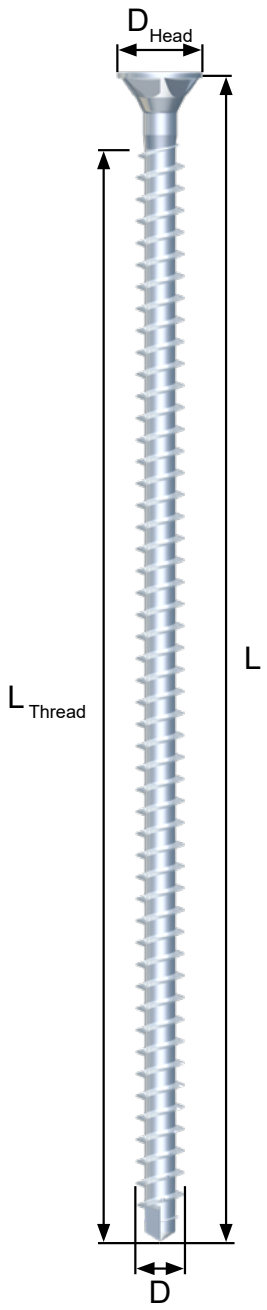
Item#	Box size	D		L		L Thread		D Head	Bit	
#	pieces	in. [mm]		in.	[mm]	in.	[mm]	in. [mm]		
140080080000102	75			**3-1/8**	[80]	**2-1/2**	[61]			
140080120000102	75			**4-3/4**	[120]	**4**	[103]			
140080140000100	75			**5-1/2**	[140]	**4-7/8**	[123]			
140080160000102	75			**6-1/4**	[160]	**5-5/8**	[143]			
140080180000102	75			**7-1/8**	[180]	**6-3/8**	[163]			
140080200000102	75		**5/16** [8]	**7-7/8**	[200]	**7-1/4**	[183]	**0.591** [15]		**AW 40**
140080220000102	75			**8-5/8**	[220]	**8**	[203]			
140080240000102	75			**9-1/2**	[240]	**8-3/4**	[223]			
140080260000102	75			**10-1/4**	[260]	**9-5/8**	[243]			
140080280000102	75			**11**	[280]	**10-3/8**	[263]			
140080300000102	75			**11-7/8**	[300]	**11-1/8**	[283]			
140100100000102	50			**4**	[100]	**3**	[77]			
140100160000102	50			**6 1/4**	[160]	**5 3/4**	[145]			
140100180000102	50			**7 1/8**	[180]	**6 1/2**	[165]			
140100200000102	50			**7 7/8**	[200]	**7 1/4**	[185]			
140100220000102	50			**8 5/8**	[220]	**8 1/8**	[205]			
140100240000102	50			**9 1/2**	[240]	**8 7/8**	[225]			
140100260000102	50			**10 1/4**	[260]	**9 5/8**	[245]			
140100300000102	50			**11 7/8**	[300]	**11 1/4**	[285]			
140100320000102	50			**12 5/8**	[320]	**12**	[305]			
140100340000102	50		**3/8** [10]	**13 3/8**	[340]	**12 3/4**	[325]	**0.728** [18.5]		**AW 50**
140100360000102	50			**14 1/4**	[360]	**13 5/8**	[345]			
140100400000102	50			**15 3/4**	[400]	**15 1/8**	[100]			
140100430000102	25			**17**	[430]	**16 3/8**	[415]			
140100480000102	25			**19**	[480]	**18 1/4**	[465]			
140100530000102	25			**20 7/8**	[530]	**20 1/8**	[512]			
140100580000102	25			**22 7/8**	[580]	**22 1/8**	[562]			
140100650000102	25			**25 5/8**	[650]	**24 7/8**	[632]			
140100750000102	25			**29 1/2**	[750]	**28 7/8**	[732]			
140100800000102	25			**31 1/2**	[800]	**30 3/4**	[782]			



Notes:
1. For more ASSY fastener options, visit the **MTC Solutions Website** at mtcsolutions.com.

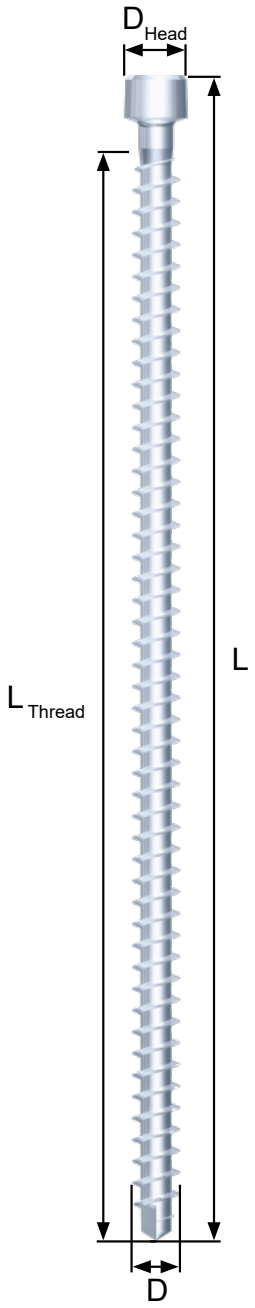
Item#	Box size	D		L		L_{Thread}		D_{Head}	Bit	
#	pieces	in. [mm]		in.	[mm]	in.	[mm]	in. [mm]		
140120120000102	50			**4 3/4**	[120]	**4 1/8**	[105]			
140120140000100	50			**5 1/2**	[140]	**4 7/8**	[125]			
140120160000102	50			**6 1/4**	[160]	**5 3/4**	[145]			
140120200000102	50			**7 7/8**	[200]	**7 1/4**	[185]			
140120260000102	50		**1/2 [12]**	**10 1/4**	[260]	**9 5/8**	[245]	**0.885** [22.5]		**AW 50**
140120280000102	50			**11**	[280]	**10 4/9**	[265]			
140120300000102	50			**11 7/8**	[300]	**11 1/4**	[285]			
140120380000102	50			**15**	[380]	**14 3/8**	[365]			
140120480000102	50			**19**	[480]	**18 1/4**	[465]			
140120600000102	50			**23 5/8**	[600]	**23**	[585]			

Notes:
1. For more ASSY fastener options, visit the **MTC Solutions Website** at mtcsolutions.com.



ASSY VG Cyl

Item#	Box size	D		L		L_{Thread}		D_{Head}	Bit	
#	pieces	in.	[mm]	in.	[mm]	in.	[mm]	in. [mm]		
150060080000302	100	1/4 [6]		3 1/8	[80]	2 7/8	[73]	0.323 [8.2]		AW 30
150060100000302	100			4	[100]	3 5/8	[93]			
150060120000302	100			4 3/4	[120]	4 1/2	[113]			
150060140000302	100			5 1/2	[140]	5 1/4	[133]			
150060160000302	100			6 1/4	[160]	6	[153]			
150060180000302	100			7 1/8	[180]	6 3/4	[173]			
150060200000302	100			7 7/8	[200]	7 5/8	[193]			
150080160000302	50	5/16 [8]		6 1/4	[160]	5 5/8	[144]	0.394 [10]		AW 40
150080180000302	50			7 1/8	[180]	6 1/2	[164]			
150080200000302	75			7 7/8	[200]	7 1/4	[184]			
150080220000302	75			8 5/8	[220]	8	[204]			
150080240000302	75			9 1/2	[240]	8 7/8	[224]			
150080260000302	75			10 1/4	[260]	9 5/8	[244]			
150080280000302	75			11	[280]	10 3/8	[264]			
150080300000302	75			11 7/8	[300]	11 1/8	[284]			
150080330000302	50			13	[330]	12 3/8	[314]			
150080360000302	50			14 1/4	[360]	13 1/2	[344]			
150080380000302	50			15	[380]	14 3/8	[364]			
150080430000302	25			17	[430]	16 1/4	[414]			
150080480000302	25			19	[480]	18 1/4	[464]			
150080530000302	25			20 7/8	[530]	20 1/4	[514]			
150080580000302	25			22 7/8	[580]	22 1/4	[564]			
150100180000302	50	3/8 [10]		7 1/8	[180]	6 1/2	[165]	0.528 [13.4]		AW 50
150100220000302	50			8 5/8	[220]	8 1/8	[205]			
150100260000302	50			10 1/4	[260]	9 5/8	[245]			
150100300000302	50			11 7/8	[300]	11 1/4	[280]			
150100340000302	50			13 3/8	[340]	12 3/4	[325]			
150100360000302	50			14 1/4	[360]	13 5/8	[345]			
150100400000302	50			15 3/4	[400]	15	[380]			
150100430000302	25			17	[430]	16 3/8	[415]			
150100480000302	25			19	[480]	18	[456]			
150100530000302	25			20 7/8	[530]	19 7/8	506]			
150100580000302	25			22 7/8	[580]	21 7/8	[556]			
150100650000302	25			25 5/8	[650]	24 5/8	[656]			
150100700000302	25			27 5/8	[700]	26 3/4	[680]			
150100750000302	25			29 1/2	[750]	28 5/8	[726]			
150100800000302	25			31 1/2	[800]	30 5/8	[780]			

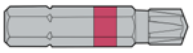


Notes:
1. For more ASSY fastener options, visit the **MTC Solutions Website** at mtcsolutions.com.

Bits - AW Drive

AW Bits are engineered and patented for proper installation of all ASSY screws and offer exceptional fit and durability. They are available in three standard sizes.


AW 30


AW 40


AW 50

45° Washer

The 45° wedge washer is a cast-iron part suitable for use with all ASSY Countersunk head screw types. Use of the washer eliminates the need for inclined predrilled countersunk holes in steel plates and thus offers cost reductions by using standard machined elliptical holes and thinner steel plates. The possibility of setting a wood screw with its washer at a 45° angle enables engineers and designers to achieve high-performance connection systems.

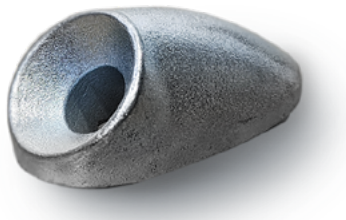
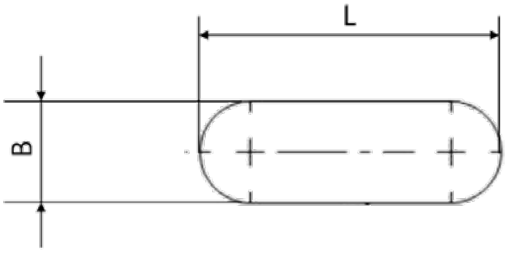


Table W.1, 45° Washer Installation - Geometry Requirements

Screw Diameter	B		L		Steel Plate Thickness	
	min	max	min	max	min	max
	in. [mm]					
5 / 16" [8]	0.394 [10]	0.433 [11]	1.26 [32]	1.299 [33]	0.157 [4]	0.591 [15]
3 / 8" [10]	0.433 [11]	0.472 [12]	1.732 [44]	1.772 [45]	0.197 [5]	0.787 [20]
1 / 2" [12]	0.512 [13]	0.551 [14]	1.969 [50]	2.008 [51]	0.236 [6]	0.934 [25]



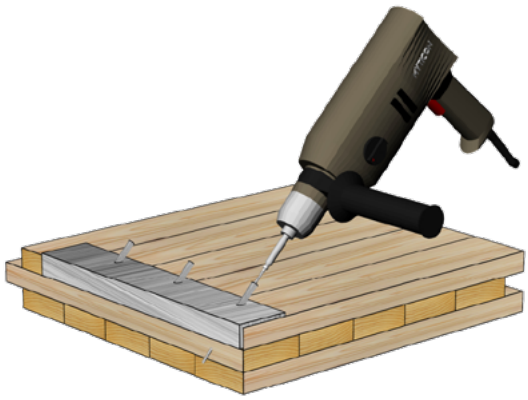
Notes:
1. For coated steel plates the hole size needs to be oversized taking the thickness of the coating into account. Test fitting of wedge washers into steel plate holes is required to assure required tolerances are in place.

Drill recommendation

Use low rpm drill with high torque:

- ½ drill for 1/4" and 5/16" screws
- ¾ drill for 3/8" and 1/2" screws

Avoid use of impact drills, do not over-torque. Use AW drive bits for all ASSY screws.



Installation

- Do not stop drill during installation. ASSY screws shall be installed without stopping in one run.
- Use safety gear as required.
- Use drill with torque clutch when installing screws in steel-to-wood connections.

Brock Commons

Vancouver, British Columbia

MTC Solutions provides sustainable, high quality mass timber connection solutions to a rapidly evolving and thriving industry. We drive innovation through certified research and development and contribute our part to the education of young talent and experienced professionals in the technology used in sustainable design.

Credit Stephane Groleau

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