MTC SOLUTIONS

Connectors Design Guide

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Disclaimer

The information in this document is for general information purposes. While we aim to keep the information provided in this document complete, accurate and in line with state-of-the-art design methods, we cannot make warranties of any kind.

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Mass Timber Hardware Specialist

MEC Head Office

Vancouver, BC

MTC Solutions is a supplier of connection solutions for modern mass timber applications in commercial, industrial, and residential projects. MTC Solutions is proud to work with the most innovative partners on cutting-edge projects across North America.

INDUSTRY EXPERT

We provide the support necessary to design efficient connection solutions with our **team of in-house experienced design professionals.**

We deliver hardware solutions where and when you need them with a logistics chain stretching **from Alaska to Florida.**

We conduct exhaustive research, partnering with leading North American research facilities to push innovation in mass timber connection solutions.

PROVEN SOLUTION

We have supplied hardware to **thousands** of Mass Timber and Heavy Timber **projects in North America** over the past decade.

We provide the right tools to design **code-compliant buildings,** such as detailed design guides and ICC-ES approvals for our hardware.

First Tech Credit Union

Hillsbroro, Oregon

Clayton Community Center

Surrey, BC

Courtesy of Western Archrib

General Notes To The Designer

1. 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.
2. Listed allowable loads are obtained based on tested values and analyzed using ASTM D7147 and D1761 standards.
3. Test based allowable loads are a minimum of ultimate load divided by 3, load at 1/8" displacement and system capacity based on individual fastener capacity with a factor of safety of 5.
4. Listed allowable loads are in the linear-elastic range of the connection.
5. Designers 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.
6. Allowable loads must be adjusted in accordance with all applicable adjustment factors of NDS-2018 Chapter 12, unless otherwise indicated.
7. Connectors in combination with carbon steel fasteners are to be used in dry service conditions only, with temperatures below 100F such that C_M = 1.0 and C_t=1.0.
8. For standard term loading, the load duration factor is C_D=1. For short-term loading, the load duration factor is C_D=1.6, per NDS-2018 Chapter 11.3.2.
9. Listed allowable loads apply to different timber species according to their respective specific gravities (G) per NDS-2018.
10. Cyclic test data have been analyzed using ASTM E2126 Equivalent Energy Elastic Plastic (EEEP) method and is used to report the ductility value for the connector. Based on North American standards, an energy dissipative connection must be moderately ductile, with ductility defined as the ratio of the ultimate displacement and the yield displacement during cyclic loading per ASTM E2126. These standards define moderately ductile connections as connections with a ductility ratio of 3.0 or higher. The ductility ratio for the tested connectors is listed in the appropriate tables.
11. Connections must respect the geometry requirements as specified in the connection Geometry Requirement sections of this guide.
12. Installation of the connector fasteners into voids, splits and gaps is to be avoided.
13. A design professional must be contacted immediately, and appropriate measures must be taken if splitting of the wood or wood-based material is observed during installation or prior to installation of the fasteners. A design professional must also be notified in instances of fastener damage or breakage.

MTBL - Mass Timber Bracket Light

The Mass Timber Brackets Light are engineered from thin 1/16” galvanized steel with a reinforced perimeter and are easily installed with ASSY self-tapping screws. The MTBLs can withstand loads similar to thicker 1/8” steel brackets, providing a cost-effective solution.

Fast Installation

Performance Based Design

Ductile Connection

Code Approval	ETA

MTBL 90

MTBL 105

Associated Hardware

Fasteners and Installation Tools

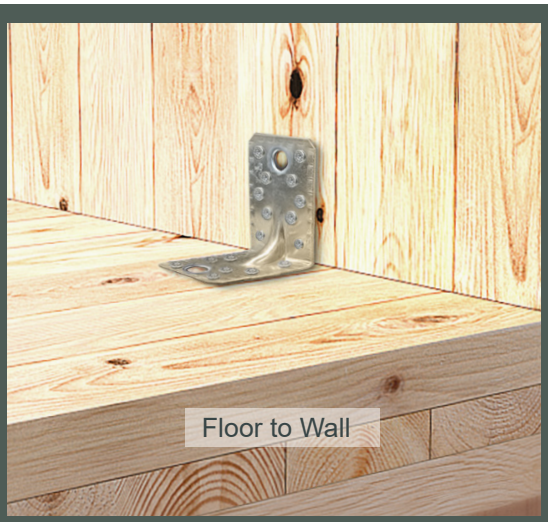
ASSY Ecofast 3/16” x 2”

Countersunk Head

AW 20 Bit

Applications

Wall to Ceiling



Floor to Wall

Wall to Wall

Reference Design Values in CLT

Table 1, F1 - Allowable Lateral Loads in CLT Using MTBL

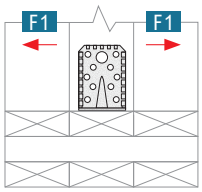
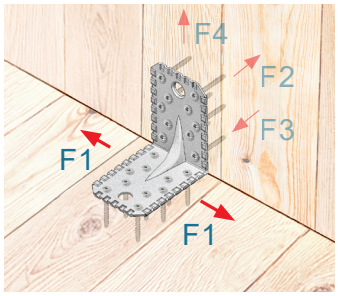
Configuration			Fasteners		Allowable Loads [lbs]		Estimated Slip Modulus [lbs / in]	Ductility Ratio
	Angle Bracket	Specific Gravity	Type	Quantity	F1 - Lateral Loads			
					Standard Loading C_D = 1.0	Short Term Loading C_D = 1.6		
	MTBL 90	0.42 (SPF)	Ecofast 3/16" x 2"	20	960	1,540	11,700	7.5
	MTBL 105			26	1,400	2,240	17,500	10

Table 2, F1 - Estimated Ultimate Lateral Loads in CLT Using MTBL

Configuration		Fasteners		Ultimate Loads [lbs]	
Angle Bracket	Specific Gravity	Type	Quantity	F1 - Lateral Loads	
				Estimated 5th Percentile	Estimated 95th Percentile
MTBL 90	0.42 (SPF)	Ecofast 3/16" x 2"	20	2,270	3,950
MTBL 105			26	2,320	3,570

Load Direction



Notes:
1. See detailed notes under table 4.

Table 3, F4 - Allowable Uplift Loads in CLT Using MTBL

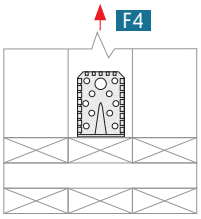
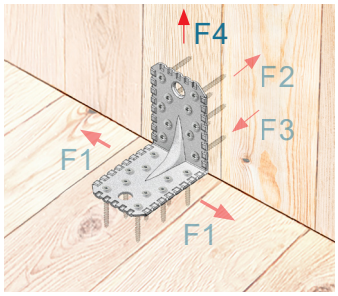
Configuration			Fasteners		Allowable Loads [lbs]		Estimated Slip Modulus [lbs / in]	Ductility Ratio
	Angle Bracket	Specific Gravity	Type	Quantity	F4 - Uplift Loads			
					Standard Loading C_D = 1.0	Short Term Loading C_D = 1.6		
	MTBL 90	0.42 (SPF)	Ecofast 3/16" x 2"	20	870	1,400	30,700	15.8
	MTBL 105			26	940	1,500	24,350	14.6

Table 4, F4 - Estimated Ultimate Uplift Loads in CLT Using MTBL

Configuration		Fasteners		Ultimate Loads [lbs]	
Angle Bracket	Specific Gravity	Type	Quantity	F4 - Uplift Loads	
				Estimated 5th Percentile	Estimated 95th Percentile
MTBL 90	0.42 (SPF)	Ecofast 3/16" x 2"	20	2,370	3,000
MTBL 105			26	2,300	2,870

Load Direction



Notes:
1. Listed allowable loads are only valid for Allowable Stress Design in the USA.
2. Listed allowable loads are only valid for listed ASSY screws.
3. All connection design must meet all relevant requirements of General Notes to the Designer, page 7.
4. The MTBL were tested in monotonic and reverse cyclic loading configurations. Listed allowable loads are calculated using test data and test-based calculation methods.
5. The estimated slip modulus was derived from cyclic loading, in accordance with the EEEP method as detailed in ASTM E2126.
6. The ultimate load values at 5th and 95th percentile was derived based on at least 12 brackets tested in each loading orientation, in accordance with the EN 14358 standard.
7. For the MTBL 105, the reference design values presented in this guide assume side B is always perpendicular to the load direction "F4" and parallel to the load directions "F2" and "F3". The load direction "F1" is independent of install direction. See page 11.
8. Connector placement must respect the requirements presented in the MTBL Geometry Requirements section, page 11.
9. The maximum installation torque for the 3/16" diameter ASSY Ecofast screws is 2.5 lbs·ft.

Table 5, F2 - Allowable Withdrawal Loads in CLT Using MTBL

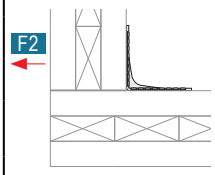
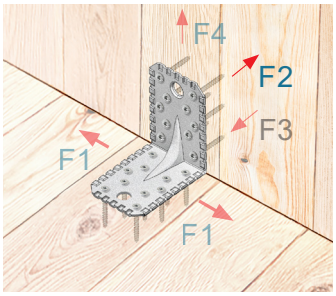
Configuration			Fasteners		Allowable Loads [lbs]		Estimated Slip Modulus [lbs / in]
	Angle Bracket	Specific Gravity	Type	Quantity	F2 - Withdrawal Loads		
					Standard Loading C_D = 1.0	Short Term Loading C_D = 1.6	
	MTBL 90	0.42 (SPF)	Ecofast 3/16" x 2"	20	830	1,300	21,200
	MTBL 105			26	1,160	1,850	29,700

Table 6, F2 - Estimated Ultimate Withdrawal Loads in CLT Using MTBL

Configuration		Fasteners		Ultimate Loads [lbs]	
				F2 - Withdrawal Loads	
Angle Bracket	Specific Gravity	Type	Quantity	Estimated 5th Percentile	Estimated 95th Percentile
MTBL 90	0.42 (SPF)	Ecofast 3/16" x 2"	20	2,250	2,780
MTBL 105			26	2,790	4,320

Load Direction



Notes:
1. See detailed notes under table 8.

Table 7, F3 - Allowable Compression Loads in CLT Using MTBL

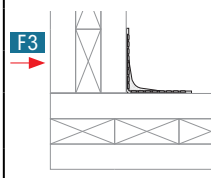
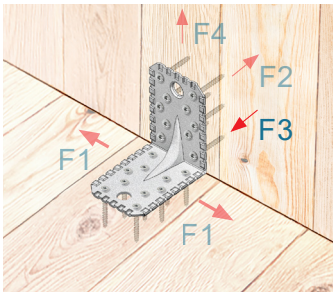
Configuration			Fasteners		Allowable Loads [lbs]		Estimated Slip Modulus [lbs / in]
	Angle Bracket	Specific Gravity	Type	Quantity	F3 - Compression Loads		
					Standard Loading C_D = 1.0	Short Term Loading C_D = 1.6	
	MTBL 90	0.42 (SPF)	Ecofast 3/16" x 2"	20	1,150	1,840	10,450
	MTBL 105			26	1,150	1,840	18,000

Table 8, F3 - Estimated Ultimate Compression Loads in CLT Using MTBL

Configuration		Fasteners		Ultimate Loads [lbs]	
				F3 - Compression Loads	
Angle Bracket	Specific Gravity	Type	Quantity	Estimated 5th Percentile	Estimated 95th Percentile
MTBL 90	0.42 (SPF)	Ecofast 3/16" x 2"	20	3,000	3,970
MTBL 105			26	3,260	3,620

Load Direction



Notes:
1. Listed allowable loads are only valid for Allowable Stress Design in the USA.
2. Listed allowable loads are only valid for listed ASSY screws.
3. All connection design must meet all relevant requirements of General Notes to the Designer, page 7.
4. The MTBL were tested in monotonic and reverse cyclic loading configurations. Listed allowable loads are calculated using test data and test-based calculation methods.
5. The estimated slip modulus was derived from cyclic loading, in accordance with the EEEP method as detailed in ASTM E2126.
6. The ultimate load values at 5th and 95th percentile was derived based on at least 12 brackets tested in each loading orientation, in accordance with the EN 14358 standard.
7. For the MTBL 105, the reference design values presented in this guide assume side B is always perpendicular to the load direction "F4" and parallel to the load directions "F2" and "F3". The load direction "F1" is independent of install direction. See page 11.
8. Connector placement must respect the requirements presented in the MTBL Geometry Requirements section, page 11.
9. The maximum installation torque for the 3/16" diameter ASSY Ecofast screws is 2.5 lbs·ft.

Geometry Requirements

MTBL 90

Front View

MTBL 105

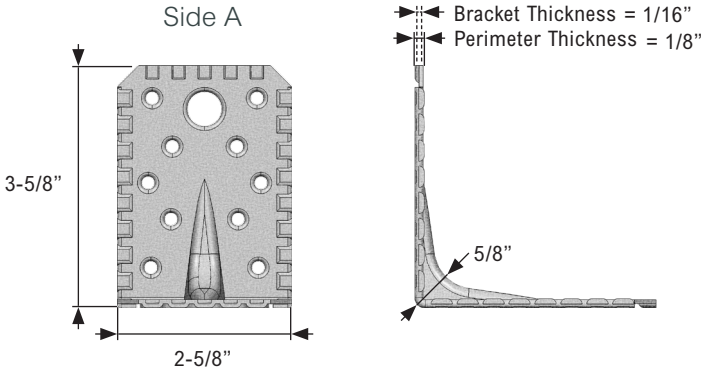
Front View

Notes:
1. Distances “e” are minimum edge distances.

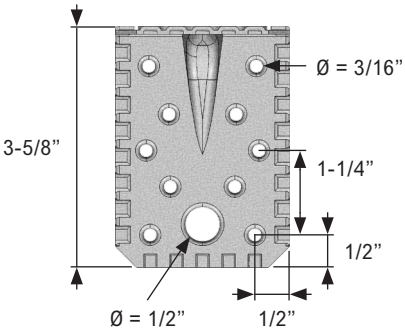
Connector Detailing

MTBL 90

Side A

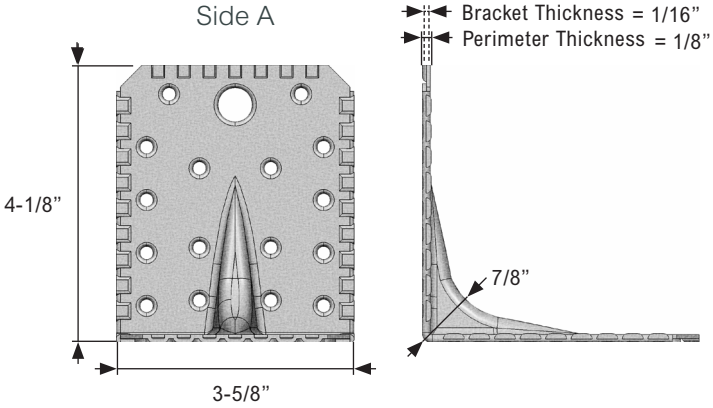


Side B

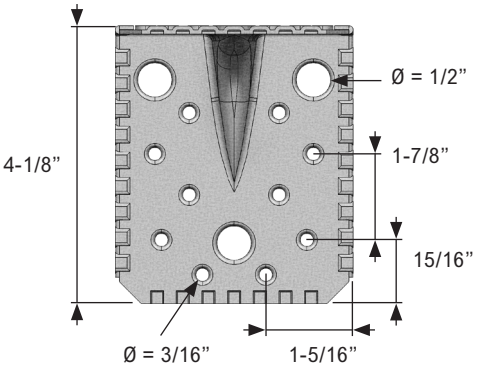


MTBL 105

Side A



Side B



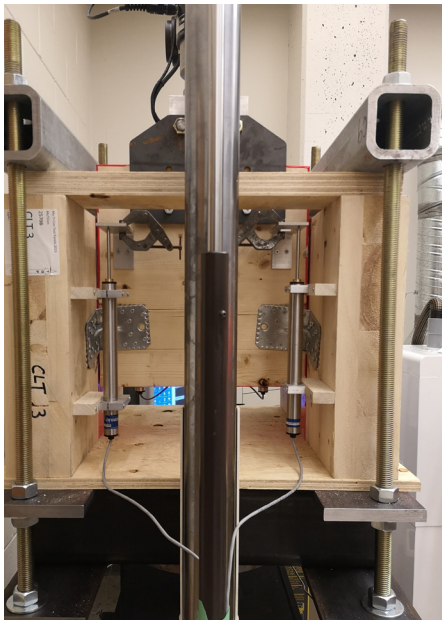
Notes:
1. All 3/16” holes are to be filled.
2. For the MTBL 105, the reference design values presented in this guide assume side B always perpendicular to the load direction "F4" and parallel to the load directions "F2" and "F3". The load direction "F1" is independent of install direction.

Testing

Data Analysis

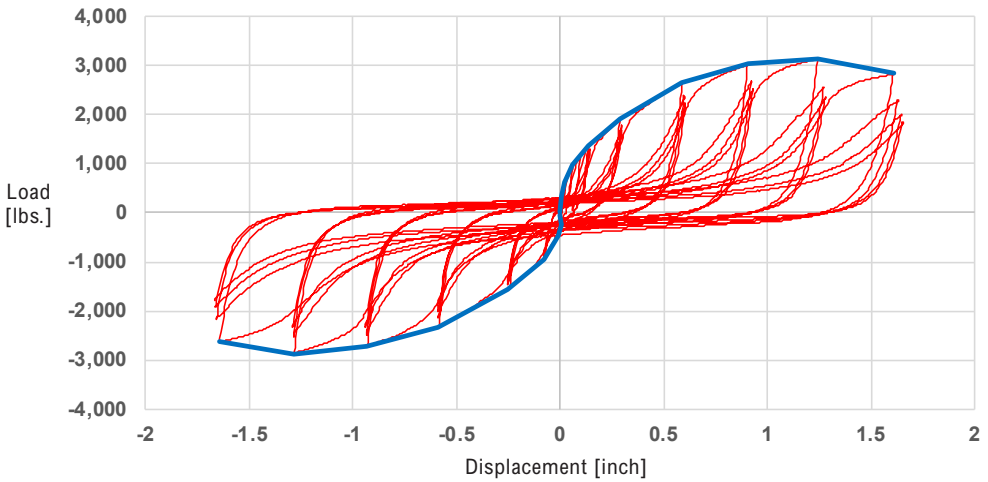
The load-displacement graphs presented in this section show hysteresis loops and envelope curves and have been selected to show an average result from a set of tests. The envelope curves were obtained from the hysteresis loop created by the reverse cyclic tests.

For the reverse cyclic test, ASTM E2126 was followed to analyze the results. Analysis has shown that the MTBL angle brackets have an average ductility ratio of 3 or more in all loading directions following the Equivalent Energy Elastic-Plastic (EEEP) method in both monotonic and cyclic loading conditions.

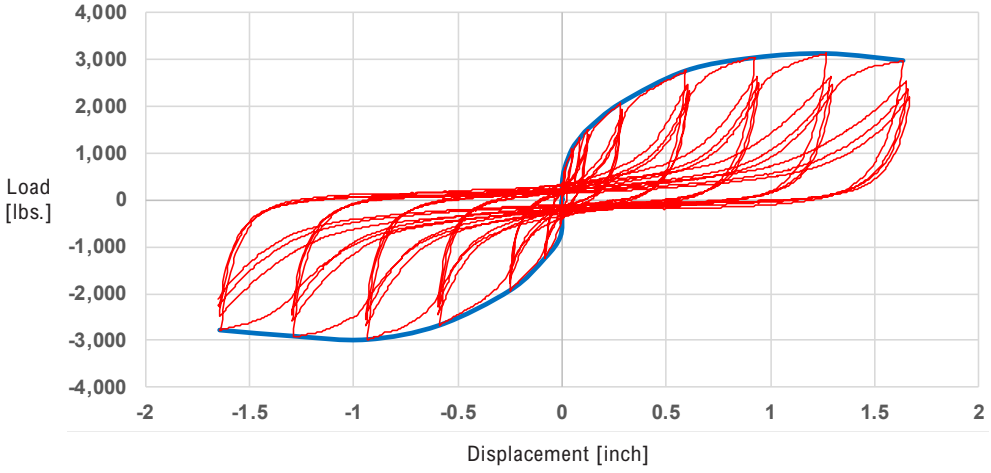


F1 - Lateral Load / Displacement Curves in CLT

MTBL 90



MTBL 105

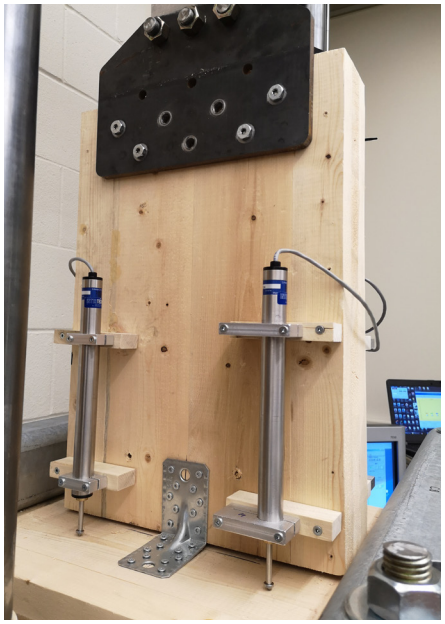


Notes:
1. The MTBLs were tested in monotonic and reverse cyclic loading configurations.
2. Graphs shown represent an average result recorded in the tests.

Data Analysis

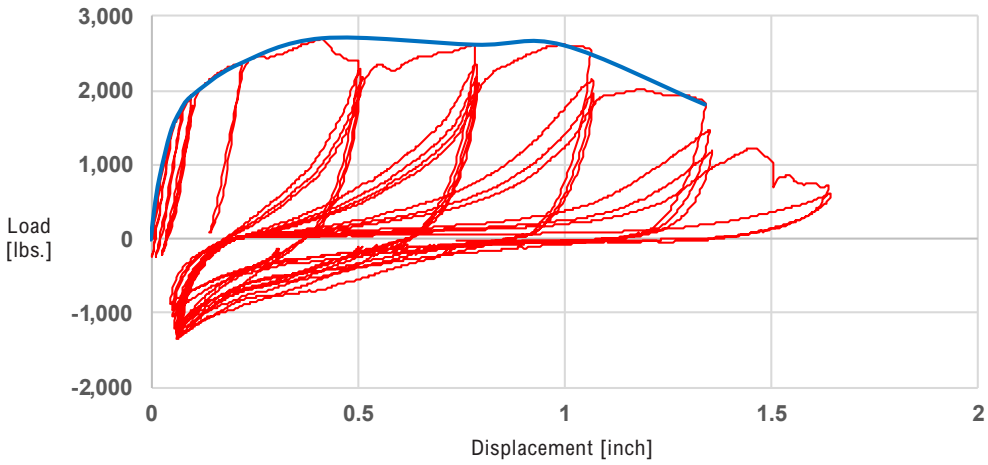
The witnessed failure modes varied depending on loading direction, however, ductile steel failure and ductile screw yielding were the prevalent failure modes observed. In load directions F1 Lateral and F3 Compression, steel yielding was recorded. In load directions F2 Withdrawal and F4 Uplift, both screw withdrawal and steel yielding was observed.

Throughout the testing, it was observed that the MTBL 90 and the MTBL 105 performed similarly in a variety of selected test setups. This result is due to similarities in the design of each MTBL with respect to hole patterns and the amount and location of fasteners on each leg.

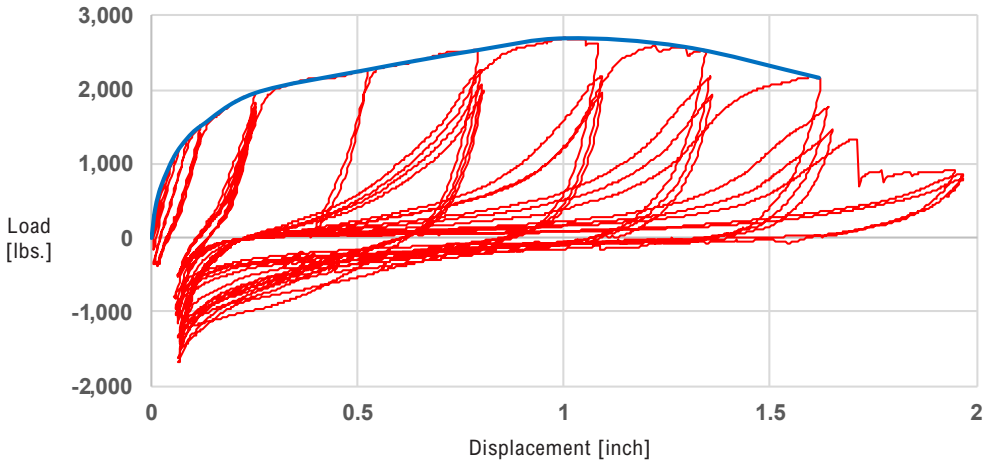


F4 - Uplift Load / Displacement Curves in CLT

MTBL 90



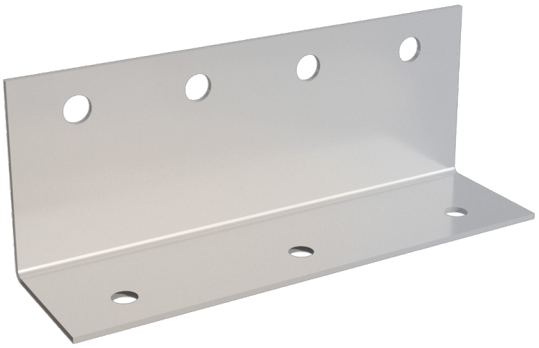
MTBL 105



Notes:
1. The MTBLs were tested in monotonic and reverse cyclic loading configurations.
2. Graphs shown represent an average result recorded in the tests.

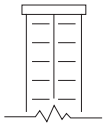
BSP-S - Solid Base Shear Plate

The BSP-S Solid Base Shear Plate connector is designed for high strength shear connections in seismic applications. The BSP-S is easily installed on CLT shear walls using high-capacity code approved ASSY self-tapping screws. The failure mechanism of the BSP-S connector is designed to be the screw yielding in failure mode IIIS or IV.



BSP-S

High Capacity Connector



Seismic Applications

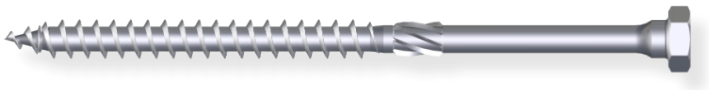
Fast Installation

Code Approval

TESTED IN NORTH AMERICA

Associated Hardware

Fasteners and Installation Tools



ASSY Kombi 1/2" x 5-1/2"

Hexagonal Head

11/16" Magnetic Socket
Specified Magnetic Socket Bit for Installation

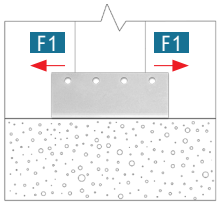
**Hardware package does not include the concrete anchors

Applications

CLT Shear Wall to Concrete Foundation

Reference Design Values in CLT Shear Wall

Table 9, F1 - Allowable Lateral Loads in CLT Using BSP-S

Configuration		Fasteners		Allowable Loads [lbs]	
				F1 - Lateral Loads	
	Specific Gravity	Type	Quantity	Standard Loading C_D = 1.0	Short Term Loading C_D = 1.6
	0.42 (SPF)	Kombi 1/2" x 5-1/2"	4	6,066	9,706

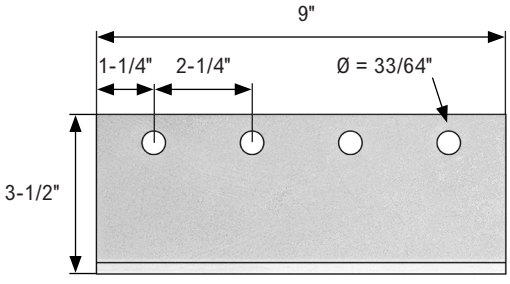
Notes:
1. Listed allowable loads are only valid for Allowable Stress Design in the USA.
2. Listed allowable loads are only valid for listed ASSY screws.
3. All connection design must meet all relevant requirements of General Notes to the Designer, page 7.
4. Listed allowable loads are calculated using test data and test-based calculation methods.
5. Connector placement must respect the requirements presented in the BSP-S Geometry Requirements section.
6. The maximum installation torque for the 1/2" diameter ASSY Kombi screw is 38.5 lbs·ft.
7. The failure mode observed for the steel to wood portion of the BSP-S is yielding of the self-tapping screws in mode IIIS or IV.
8. No uplift forces shall be assigned to the base shear connections.
9. The BSP-S system must be fastened using anchor rods that are designed to transfer the full allowable load or more as shown in Table 9.

Geometry Requirements

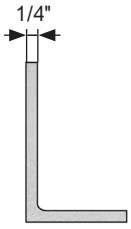
Front View

Notes:
1. Distances "e" are minimum end distances.

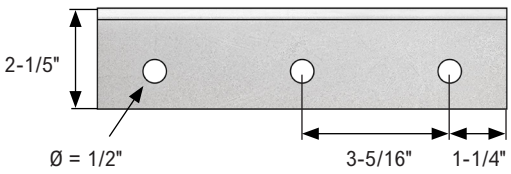
Connector Detailing



Front View



Side View



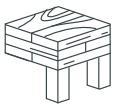
Top View

Notes:
1. All 33/64" holes are to be filled with ASSY Kombi 1/2" x 5-1/2".
2. All 1/2" holes are to be filled with anchor rods (refer to note 9 under Table 9).

MTS15 - Mass Timber Strap

The Mass Timber Strap 15 is a tested high-capacity connector designed for use in various mass timber elements. The MTS15 is an ideal solution for tension applications using strong code approved ASSY self-tapping screws for a fast and easy installation.

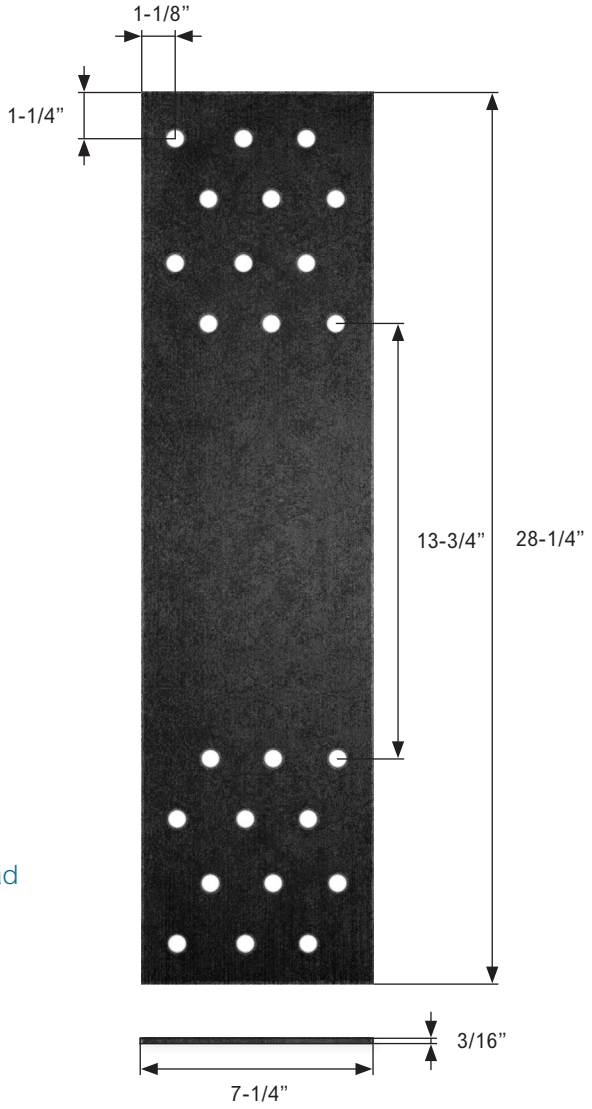
Fast Installation



Mass Timber Panels

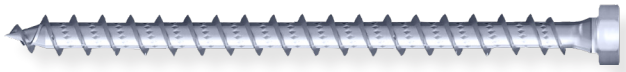
Performance Based Design

Code Approval



Associated Hardware

Fasteners and Installation Tools



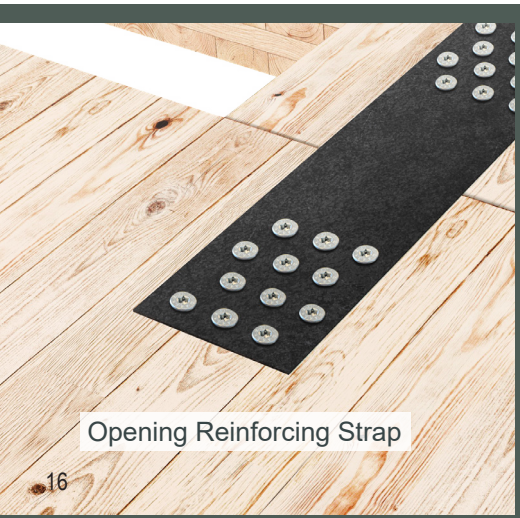
ASSY Kombi LT 1/2" x 6-1/4"

Hexagonal Head

11/16" Magnetic Socket

Specified Magnetic Socket Bit for Installation

Applications



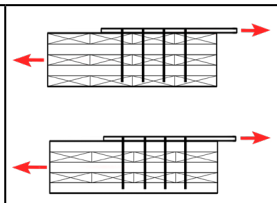
Opening Reinforcing Strap

Wall Strap

Diaphragm Strap

Reference Design Values in CLT

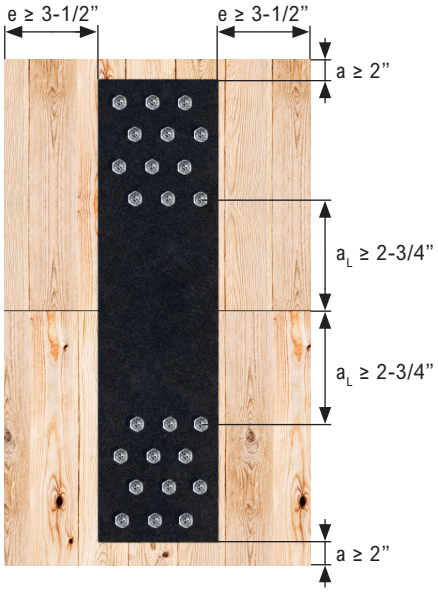
Table 10, Tested Allowable Loads in CLT Using MTS15

CLT Panel & Plate Configuration			Specific Gravity	Panel Thickness [in]	Fasteners: Type	Fasteners: Quantity	Allowable Loads [lbs]: Standard Loading C_D = 1.0	Allowable Loads [lbs]: Short Term Loading C_D = 1.6	Estimated Slip Modulus [lbs / in]
5 PLY +	Z		SPF (0.42)	≥ 6-7/8"	Kombi LT 1/2" x 6-1/4"	24	13,900	22,240	147,500

Notes:

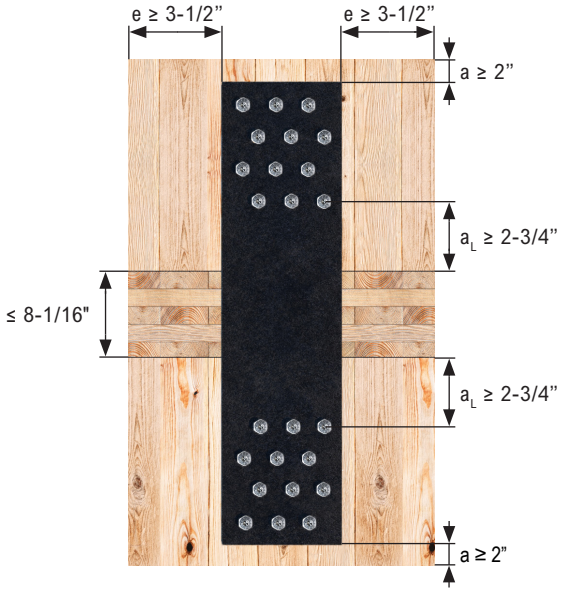
1. Listed allowable loads are only valid for Allowable Stress Design in the USA.
2. Listed allowable loads are only valid for listed ASSY screws.
3. All connection design must meet all relevant requirements of General Notes to the Designer, page 7.
4. Listed allowable loads are calculated using test data and test-based calculation methods.
5. Connector placement must respect the requirements presented in the MTS 15 - Geometry Requirements section.
6. Shall pre-drilling be required, a 1/4" diameter drill bit may be used for pre-drilling.
7. The maximum installation torque for the 1/2" diameter ASSY Kombi screws is 38.5 lbs·ft.

Geometry Requirements



Diaphragm Strap Installation

Top View



Wall Strap Installation

Front View

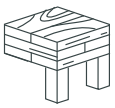
Notes:

1. All geometry requirements are in accordance with the testing performed.
2. Distances "a" are minimum end distances.
3. Distances "a_L" are minimum loaded end distances.
4. Distances "e" are minimum edge distances.

MTS-i - Mass Timber Straps Incline

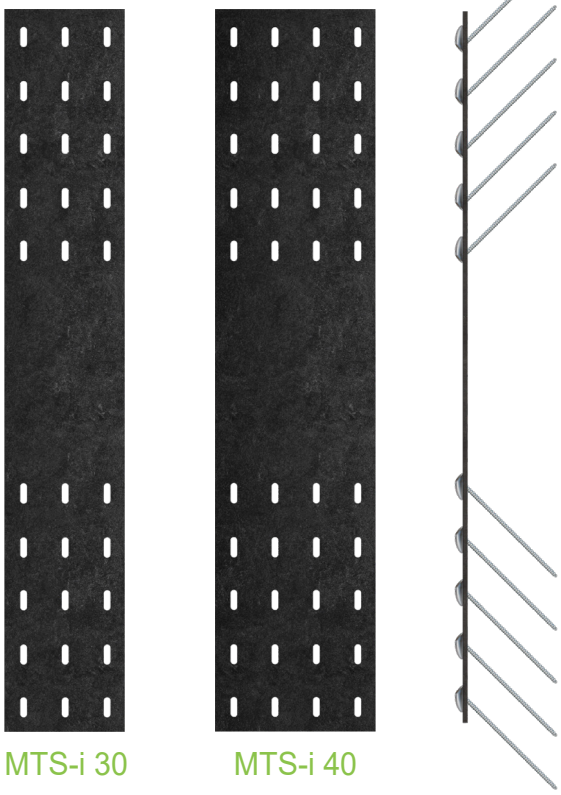
The MTS-i Mass Timber Strap series offers two solutions: the MTS-i 30 and the MTS-i 40 series. The MTS-i 30 and MTS-i 40 are designed to be a capacity protected connection in mass timber structures and are easy to install with code approved ASSY self-tapping screws and 45-degree washers. By using high strength inclined screws, the MTS-i offers higher stiffness and capacity for various tension applications, making it a one-of-a-kind off the shelf connecting solution.

Fast Installation



Mass Timber Panels

High Capacity Connector



MTS-i 30 MTS-i 40

Associated Hardware

Fasteners and Installation Tools

ASSY VG CSK 5/16" x 8-5/8"

Countersunk Head

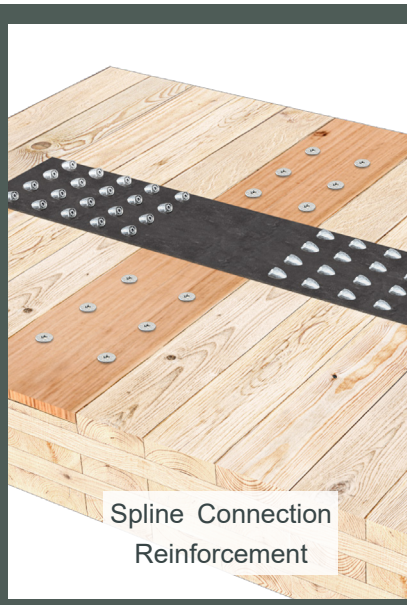
45° Washer

Applications

Opening Reinforcing Strap

Wall Strap

Diaphragm Strap



Spline Connection Reinforcement

Reference Design Values in CLT

Table 11, Allowable Loads in CLT Using MTS-i 30

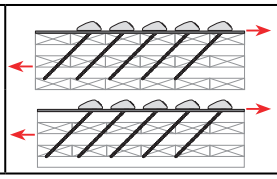
CLT Panel & Plate Configuration					Fasteners		Allowable Loads [lbs]	
			Panel Thickness [in]	Specific Gravity	Type	Quantity	Standard Loading C_D = 1.0	Short Term Loading C_D = 1.6
5 PLY +	Z		≥ 5-1/2"	SPF (0.42)	VG CSK 5/16" x 8-5/8"	30	11,067	17,707
				D.Fir (0.49)			11,765	18,824

Table 12, Estimated Ultimate Loads in CLT Using MTS-i 30

Configuration		Fasteners		Ultimate Loads [lbs]	
				F1 - Lateral Resistance	
Tension Strap	Specific Gravity	Type	Quantity	Estimated 5th Percentile	Estimated 95th Percentile
MTS-i 30	SPF (0.42)	VG CSK 5/16" x 8-5/8"	30	41,272	56,511
	D.Fir (0.49)			48,238	58,099

Notes:
1. See detailed notes under Table 14.

Table 13, Allowable Loads in CLT Using MTS-i 40

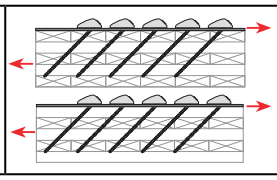
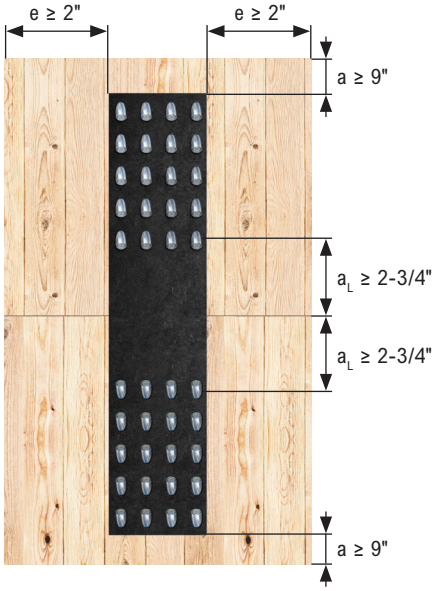
CLT Panel & Plate Configuration					Fasteners		Allowable Loads [lbs]	
			Panel Thickness [in]	Specific Gravity	Type	Quantity	Standard Loading C_D = 1.0	Short Term Loading C_D = 1.6
5 PLY +	Z		≥ 5-1/2"	SPF (0.42)	VG CSK 5/16" x 8-5/8"	40	14,756	23,610
				D.Fir (0.49)			15,687	25,099

Table 14, Estimated Ultimate Loads in CLT Using MTS-i 40

Configuration		Fasteners		Ultimate Loads [lbs]	
				F1 - Lateral Resistance	
Tension Strap	Specific Gravity	Type	Quantity	Estimated 5th Percentile	Estimated 95th Percentile
MTS-i 40	SPF (0.42)	VG CSK 5/16" x 8-5/8"	40	55,030	75,348
	D.Fir (0.49)			64,317	77,465

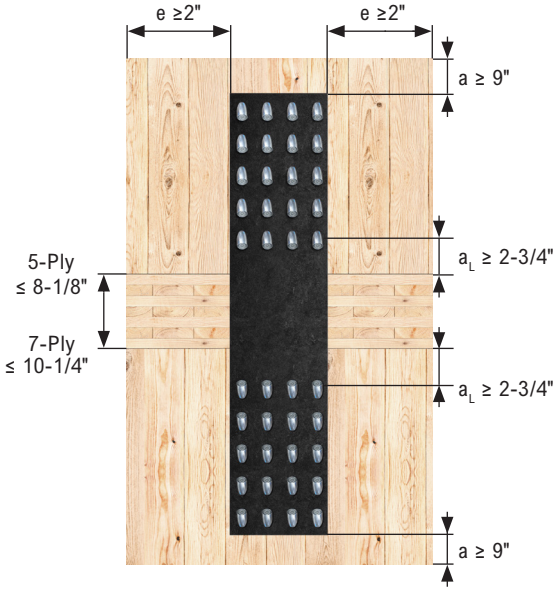
Notes:
1. Listed allowable loads are only valid for Allowable Stress Design in the USA.
2. Listed allowable loads are only valid for listed ASSY screws.
3. All connection design must meet all relevant requirements of General Notes to the Designer, page 7.
4. Fasteners and 45-degree washers must be placed according to the Installation Considerations section "B" on page 21.
5. Screw installation shall start with the inner most screw of the tension strap as shown in Installation Consideration section "C" on page 21.
6. Connector placement must respect the requirements presented in the MTS-i Geometry Requirements section on page 20.
7. Shall pre-drilling be required, a 3/16" diameter drill bit may be used for pre-drilling.
8. The maximum installation torque for the 5/16" diameter VG CSK screws is 13.6 lbs·ft.

Geometry Requirements



Diaphragm Strap Installation

Top View



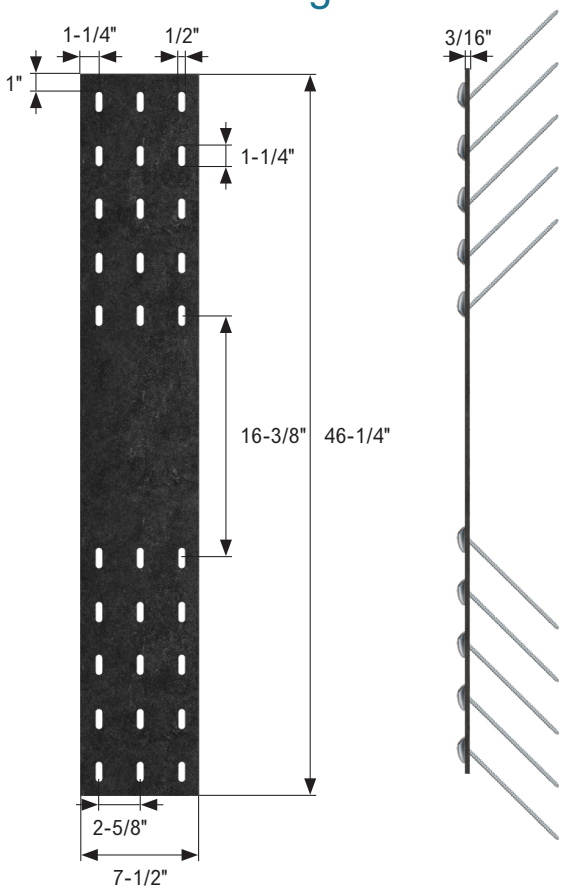
Wall Strap Installation

Front View

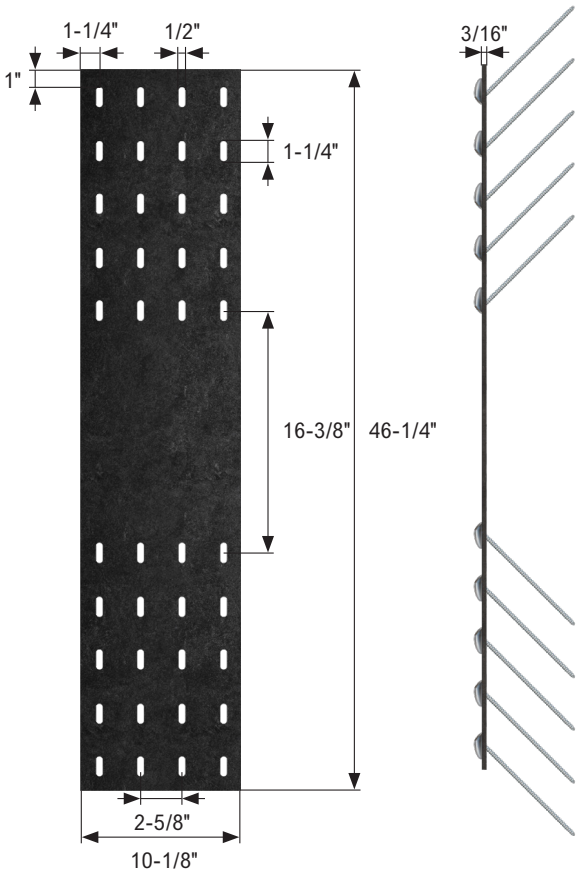
Notes:

1. Listed geometry requirements are valid for both MTS-i 30 and MTS-i 40
2. Distances "a" are minimum end distances.
3. Distances "a_L" are minimum loaded end distances.
4. Distances "e" are minimum edge distances.
5. Dimensions not to scale.

Connector Detailing



MTS-i 30

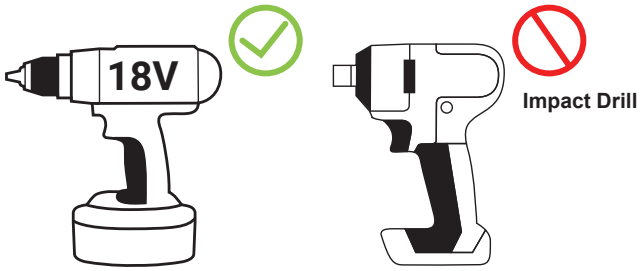


MTS-i 40

Installation Consideration

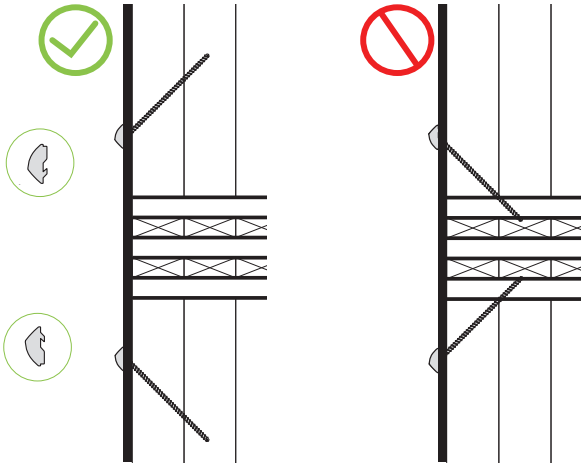
A Correct Drill for Installation

A cordless or corded drill with at least 18V must be used for the screw installation. The use of impact drills is prohibited. The maximum torque for 5/16" diameter screw is 13.57 lbs·ft.



B Washer Orientation

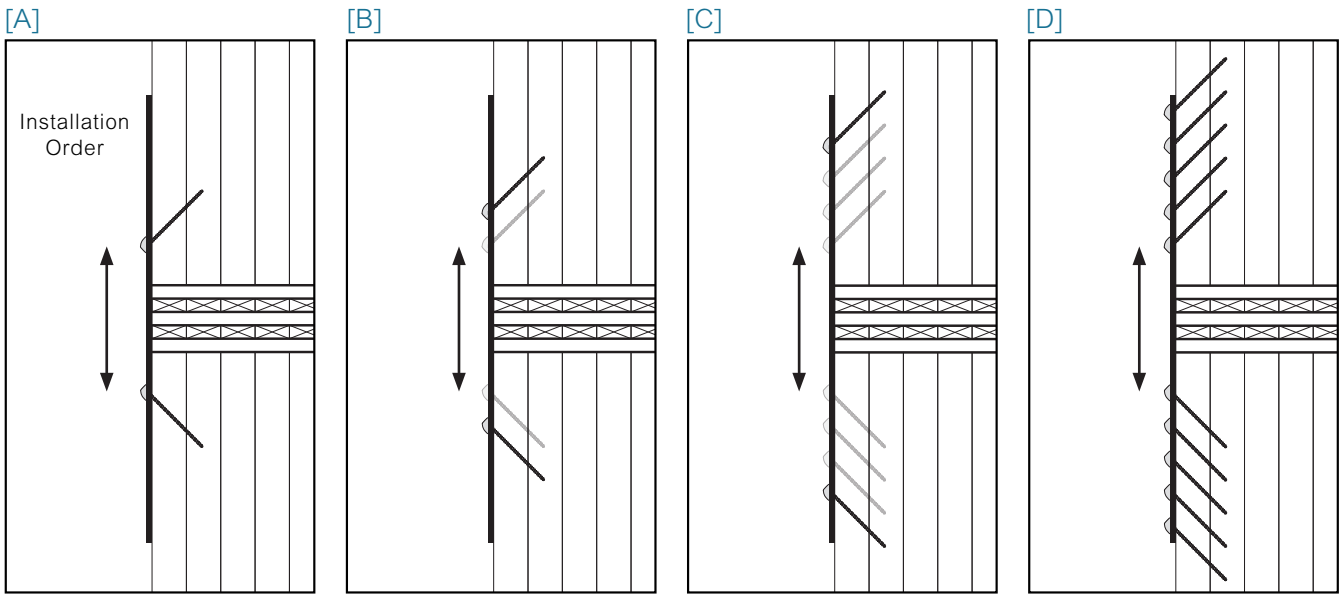
Washers must be installed so that the screw tip is pointing to the outside of the tension strap, not the middle.



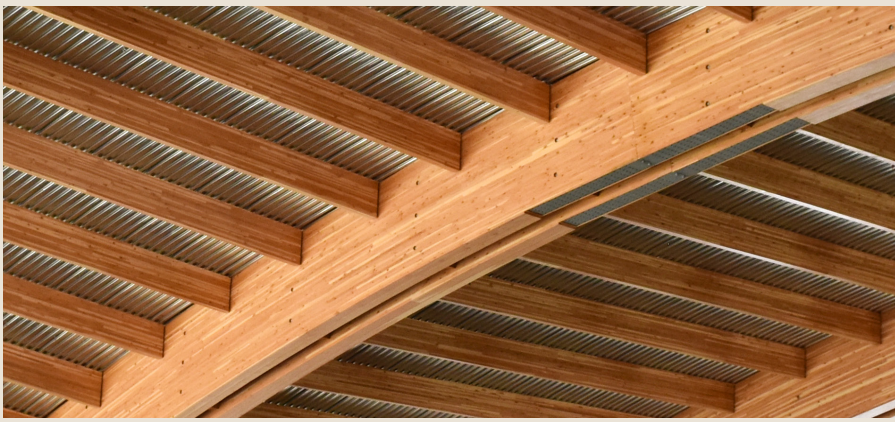
C Order of Screw Installation

To ensure the tension screws are properly engaged and loads are tranferred through the tension strap, the screws must be installed starting from the inner most screw row [A] to the outermost screws [D]. See the order of installation shown below.

Failure to install the tension strap with the correct screw order may result in the tension screws engaging and pushing the connector out of place.



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.



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