Lifting Device Design Guide

SIMPSON Strong-Tie

Introduction

As the mass timber and offsite construction market continues to expand in the United States, there is a growing need for products to facilitate the construction of large-scale projects. This guide describes lifting device solutions offered by Simpson Strong-Tie as well as guidance on the design, selection and installation of these products.

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1. Important Information and General Notes

1. All Simpson Strong-Tie components of the rigging assembly have allowable load ratings based on a safety factor of 5 per OSHA Hoisting and Rigging standard 1926.753(e)(2).

2. Simpson Strong-Tie components are intended for use in Design Categories A and B per ASME BTH-1.

3. Simpson Strong-Tie components are intended for use in Service Class 0 (0 – 20,000 load cycles) per ASME BTH-1.

4. Allowable table loads are based on the lower of tests per ICC-ES AC13 (with a factor of safety of 5) or calculations.

5. The Simpson Strong-Tie lifting products use Simpson Strong-Tie screw products. Strong-Drive® SDCF TIMBER-CF Screw and SDHR COMBO-HEAD Screw are listed in ICC-ES ESR-3046.

6. It is the responsibility of the designer to determine material weights, centers of gravity, appropriate lift points, and if there are limitations on load angles.

7. It is the responsibility of the designer to ensure the lifted object has sufficient strength and stiffness to resist internal and external forces imposed during the lifting process.

8. Before each use, a visual inspection must be made of the lifting device for cracks, deformations, rust, or any other condition that might negatively affect the lifting capacity of the device. A lifting device that shows any such signs or that has illegible factory markings shall not be used. T-MT-MTLDUSE and T-MT-MTHLDUSE (strongtie.com) describe lifting device inspection for the MTLD and MTHLD, respectively. Records of all inspections should be kept.

9. Screws may be installed with either drill motors or impact driver tools in accordance with L-F-MTINSTALL.

10. Screws are only permitted to be used for a single lift and shall not be used for structural applications thereafter.

11. Consideration shall be taken of the environmental and corrosion conditions when selecting the appropriate fastener.

12. Do not use the MTLD or MTHLD until you have read all warnings, disclaimers, instructions and information in T-MT-MTLDUSE and T-MT-MTHLDUSE, respectively.

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2. Design Considerations for Lifting

The selection of the appropriate lifting device is based on the determination of the forces the device must resist. A number of factors can affect the magnitude of these forces. It is recommended to consider the following steps in the lifting device design.

2.1 Determine the total weight to be lifted

2.2 Determine the dynamic acceleration factor

2.3 Determine the sling angle factor

2.4 Determine the number of effective lifting devices

2.5 Determine the resultant lifting device force

2.6 Select the appropriate lifting devices

2.1 Determine the total weight to be lifted

The total weight to be lifted (F_{tot}) can often be found on the object drawings, the bill of material, or on the object itself. In lieu of these sources, the weight of the object must be calculated.

The weight of a wood object is calculated as the product of the density of the material and the object volume. The weight of the object can be evaluated as the sum of its component parts. For example, the weight of a stud wall with sheathing is calculated as the weight of the framing and sheathing. Care should be taken to consider the moisture content of wood. The examples shown in Table 1 assume a moisture content of 12%. Engineered wood products may be more dense than the solid sawn wood of the same species. For example, an LVL wood beam may be listed as having an equivalent specific gravity to Douglas fir-Larch (specific gravity = 0.50, density = specific gravity * 62.4 lb/ft^3 = 31.2 lb/ft^3) for the purposes of fastener design, while having an actual density greater than 31.2 lb/ft^3. Check with the engineered wood manufacturer for product densities.

Table 1 - Common Elements and Densities	
Material	**Density (lb/ft^3)**
Sawn Lumber – Douglas Fir-Larch	31.2
Sawn Lumber – Spruce-Pine-Fir	26.2
CLT – Douglas Fir-Larch	33.2
CLT – Spruce-Pine-Fir	28.1
Plywood – Standard	36.0
OSB – Standard	40.5
MPP	37.0

1. The examples shown in Table 1 assume a moisture content of 12%.

Example Calculation: Determine the weight of a Douglas Fir-Larch, CLT panel with dimensions of 4.125" x 8' x 16'.

F_{tot} = Density x Volume Eq. 1

F_{tot} = 33.2 lb/ft^3 * 4.125 in * (1 ft/12 in) * 8 ft * 16 ft

F_{tot} = 1461 lb

Note: Additional care should be taken when designing lifting for objects with non-uniform weight distribution, irregular geometry, or large openings, as these attributes can require more analysis to determine lifting load demands or assess the suitability of a given rigging layout. The determination of the center of gravity of the object is a necessary part of the lifting design.

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2.2 Determine the dynamic acceleration factor

The dynamic acceleration factor (*f*) depends on the lifting system being used. The following factors are provided for the consideration of the designer and should not decrease any prescribed requirements by the governing authorities. Weather conditions on site, such as wind, rain, and snow, may require additional attention.

Table 2 – Dynamic Acceleration Factor, *f*	
Lifting System	Dynamic Acceleration Factor, *f*
Fixed Crane	1.1 – 1.3
Mobile Crane	1.3 – 1.4
Bridge Crane	1.2 – 1.6
Lifting and Moving on Flat Terrain	2.0 – 2.5
Lifting and Moving on Rough Terrain	3.0 – 4.0 (minimum)

1. Source: FPInnovations, CLT Handbook, Chapter 12.

2.3 Determine the sling angle factor

When using angled slings, the load demand in the lifting device and sling increases as the angle from the horizontal decreases. It is recommended to use a sling angle, θ, in the range of 90 to 60 degrees from the horizontal. The load in the rigging sling and at the lifting device is increased by the sling angle factor, *z* as shown in Table 3. Figure 1 shows an example of the sling angle factor effect on the sling load.

Table 3 – Sling Angle Factor, *z*	
Sling Angle, θ (deg)	Sling Angle Factor, *z*
90	1.000
80	1.015
70	1.064
60	1.155

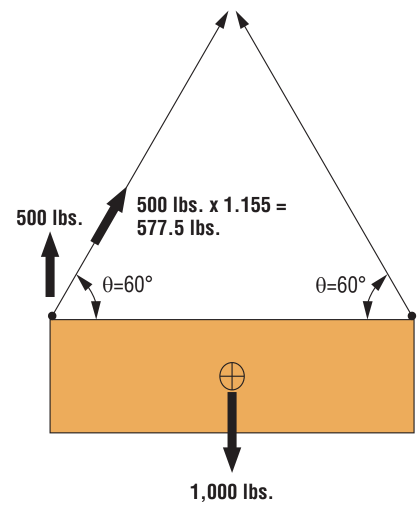

Figure 1 – Example calculation of a two-point, angled sling lift

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2.4 Determine the number of effective lifting devices

The determination of the number of effective lifting devices, *N*, is based on the size and shape of the lifted object. The most common lifts involve rigging comprised of either two points or four points.

Columns are typically lifted with one effective lifting device, $N = 1$, as columns are usually delivered to the job site in the horizontal position and then need to be tilted up to a vertical position before being lifted into its location in the structure. The lift point should be centered in the top of the column while minimum end/edge distances must be observed.

Example of elements that are typically lifted using one-point systems is:

- Glulam columns

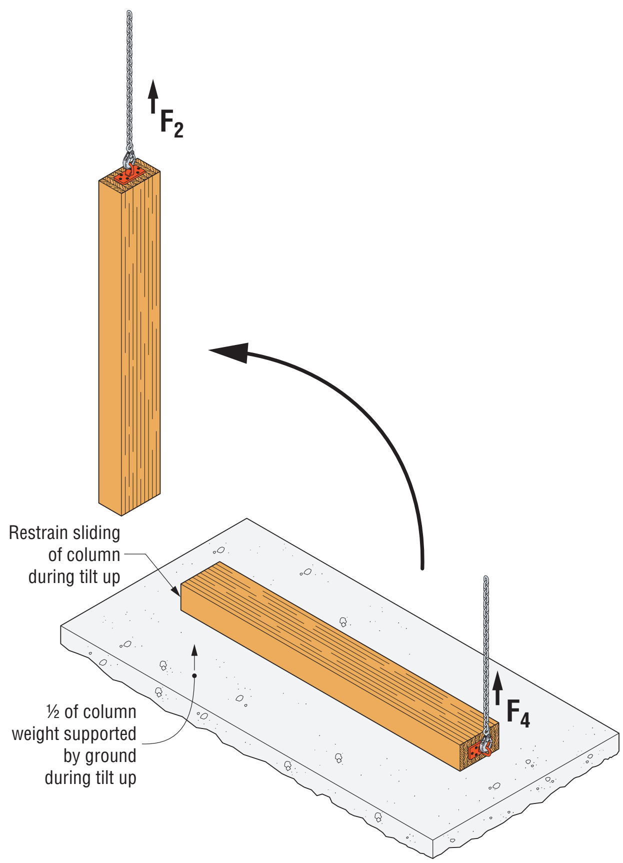

Figure 2 – Example of a one-point lift with a tilted column

Beam elements are typically lifted with two effective lifting devices, $N = 2$. The lift points should be equidistant from the center of gravity. Device location must also consider the minimum end and edge distance requirements of the lifting device. Common lifting methods for beam elements consist of either a spreader bar with vertical slings, or an angled sling system. Wall elements can also be tilted and lifted using a minimum of two effective lifting devices. For heavier wall panels, more than two effective lifting devices can be used.

Examples of elements that are typically lifted using two-point systems are:

- Glulam beams
- Solid sawn beams
- Logs
- Mass timber wall panels

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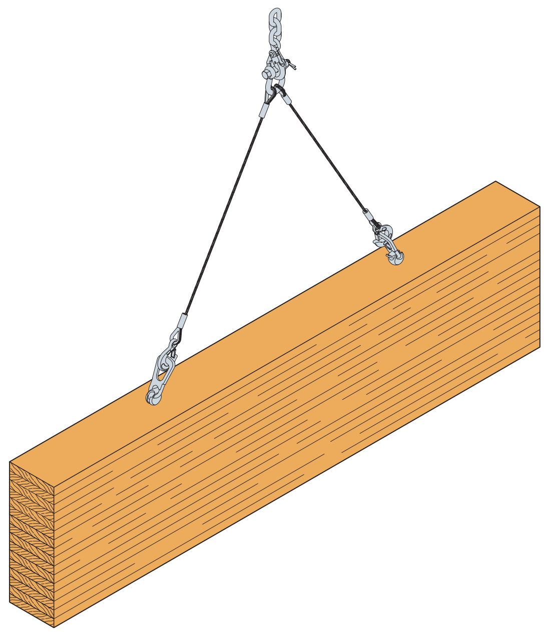

Figure 3 – Example of two-point lift

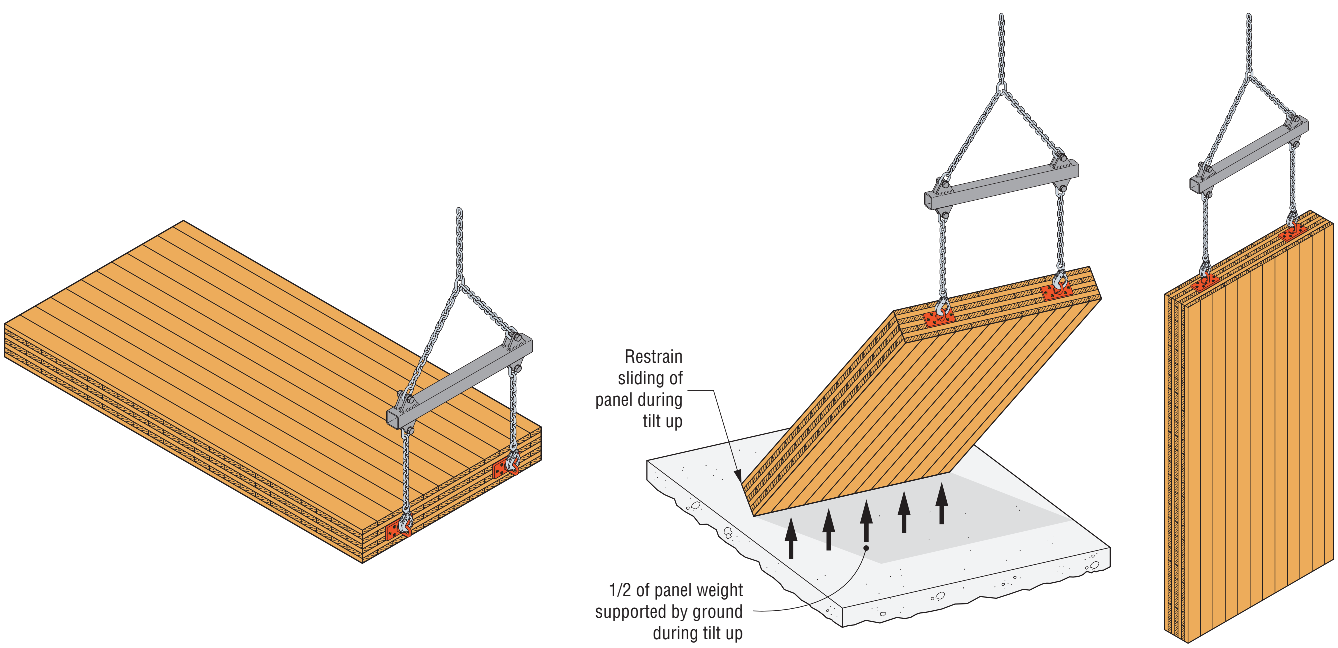

Figure 4 – Example of two-point lift with a tilted wall

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Floor and roof elements are typically lifted with four lifting devices. These should be located equi-distant from the center of gravity of the lifted object. Device location must also consider the minimum end and edge distance requirements of the lifting device. If the rigging design does not include additional components such as a load balancing device to ensure even distribution of the loads, it is recommended to ignore the contribution of two of the four lifting devices so that N = 2 in the determination of load per lifting device. Common lifting methods for flat elements consist of using an angled sling system where the sling angle is in the range of 60 to 90 degrees from horizontal.

Examples of elements that are typically lifted using four-point systems are:

- Mass timber floor panels
- Mass timber roof panels

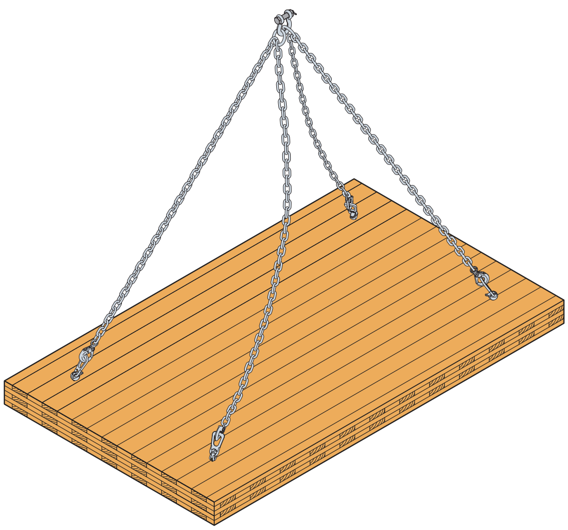

Figure 5 – Example of four-point lift with only 2 effective lifting devices, *N* = 2

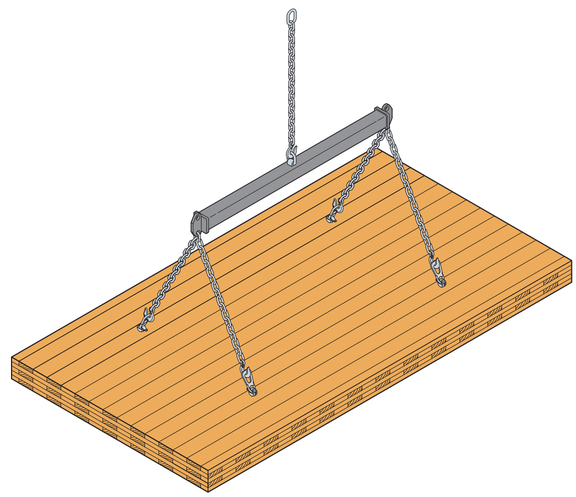

Figure 6 – Example of four-point lift with 4 effective lifting devices, *N* = 4

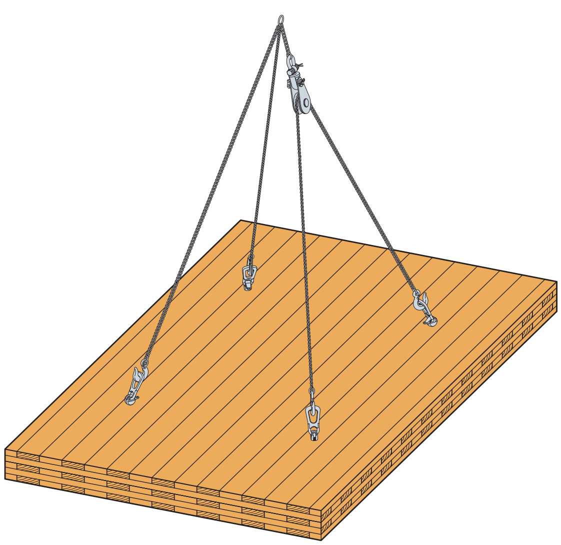

Figure 7 – Example of four-point lift with 4 effective lifting devices, *N* = 4

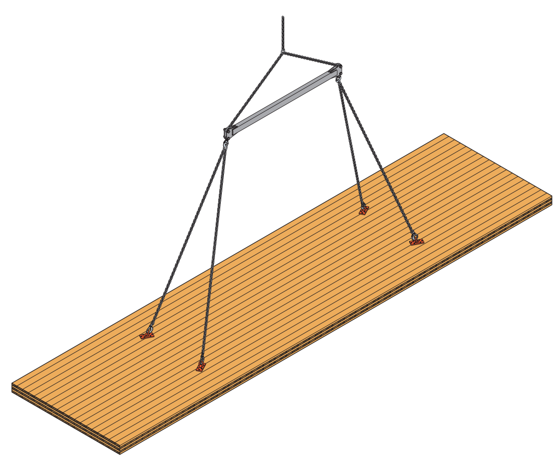

Figure 8 – Example of four-point lift with 4 effective lifting devices, *N* = 4

2.5 Determine the resultant lifting device force

The resultant force on the lifting device can be calculated as follows:

$$F_i = \frac{F_{tot} * f * z}{N} \qquad \text{Eq. 2}$$

Where: F_i = resultant lifting device force

F_{tot} = total weight to be lifted

f = dynamic acceleration factor

z = sling angle factor

N = number of effective lifting devices

Note: This equation assumes all effective lifting devices are located at the same distance from the center of gravity. Additional care should be taken when designing rigging for objects with non-uniform weight distribution, irregular geometry, or large openings. These conditions require additional analysis to ensure each lifting device is equally loaded so the lifted object will be stable during the entirety of the lift.

2.6 Select the appropriate lifting products.

Once the resultant lifting device force, F_i, is determined, the appropriate lifting device can be selected. The device allowable load, F_2 or F_4 is found in the product allowable load table and must be greater than the resultant lifting device force as shown in Eq. 3a and 3b. For lifts involving tilting an object from a horizontal to a vertical position, both F_2 and F_4 device allowable loads must be checked against the F_i force determined at different stages of the tilt. The F_i force that is used to compare to F_4 is typically determined using the assumption that half of the object weight is supported by the ground. The F_i force that is used to compare to F_2 is typically determined using the assumption that the full object weight is supported by the effective lifting device(s).

$$F_2 \geq F_i \qquad \text{Eq. 3a}$$

$$F_4 \geq F_i \qquad \text{Eq. 3b}$$

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3. Simpson Strong-Tie Lifting Products

3.1 MTLD™ Mass Timber Lifting Device

The MTLD Mass Timber Lifting Device provides a fast and efficient method for erecting panels and beams. It quickly attaches to and detaches from a single screw anchored into the mass timber element. The MTLD can be used with two or four lifting point rigging designs.

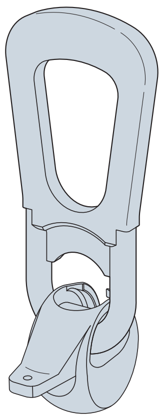

Figure 9 – MTLD

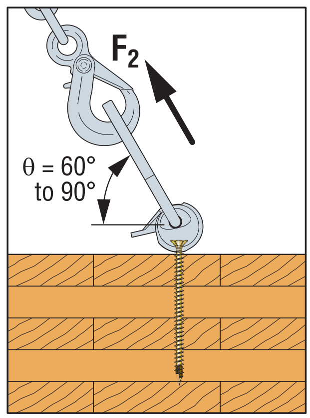

Figure 10 – MTLD Load Direction and Allowable Angle Range

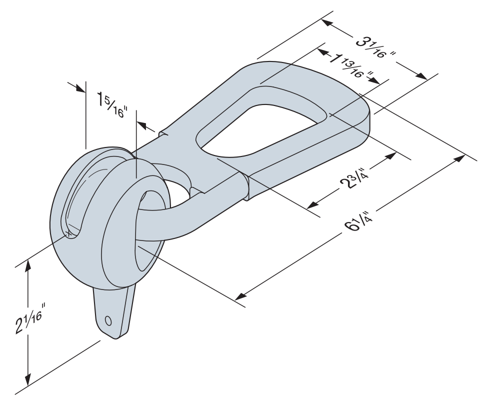

Figure 11 – MTLD Geometry

Table 4 – Allowable Loads for MTLD

Model No.	Qty. and Type of Screws	Minimum Wood Member Thickness (in.)	Allowable Load, F_2 (lb.)	
			θ = 90°	θ = 60°
MTLD	(1) 0.390" x 4" SDCF	4.00	610	550
	(1) 0.390" x 6¼" SDCF	6.25	1,090	1,040
	(1) 0.470" x 6¼" SDHR	6.25	1,090	980

1. Choose an allowable load, F_2 based on the sling angle, θ. Allowable table loads shown are based on the angle at which the MTLD was tested.
2. Screws are only permitted to be used for a single lift and shall not be used for structural applications thereafter.
3. Allowable loads are valid for a screw installed at 90° into the face-grain of the CLT panel or glulam.
4. Allowable loads apply to wood with a specific gravity of 0.42 or greater.
5. Allowable loads may not be increased for load duration.
6. For conditions where the moisture content of the wood is greater than 19%, adjust load values by the factor, C_M = 0.70.
7. Tabulated values are not valid if $\theta < 60°$. Linear interpolation is allowed for $60° \le \theta \le 90°$.
8. A qualified design professional must specify one of the following screws: 0.390" x 4" SDCF = Model SDCF27400; 0.390" x 6¼" SDCF = Model SDCF27614; 0.470" x 6¼" SDHR = Model SDHR31614.
9. All rigging components and spreader bars that are used in conjunction with the MTLD shall be of sufficient strength and stiffness to carry the required load.

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Installation Overview

The MTLD is installed following the steps illustrated in Figure 12. Read and follow detailed installation instructions in T-MT-MTLDUSE.

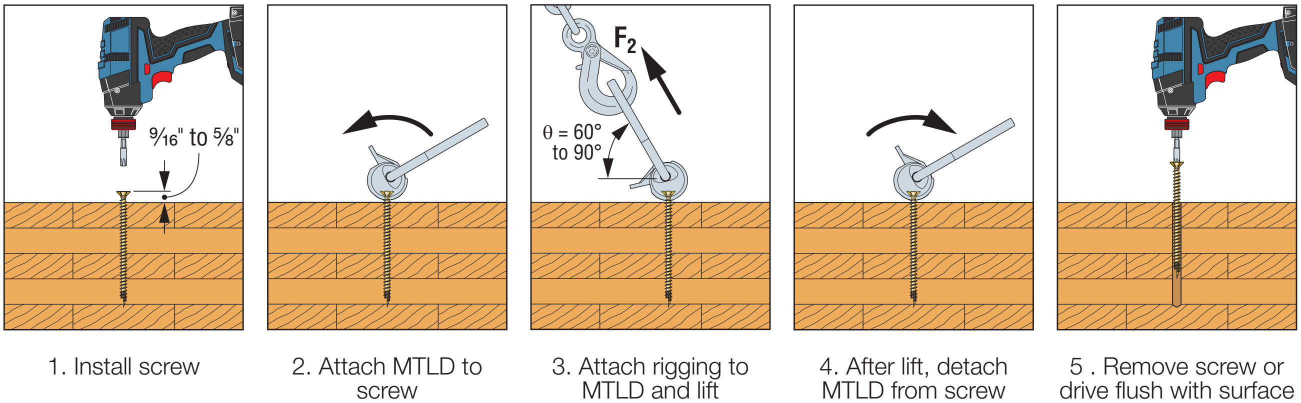

Figure 12 – Installation with Screw at 90 Degrees

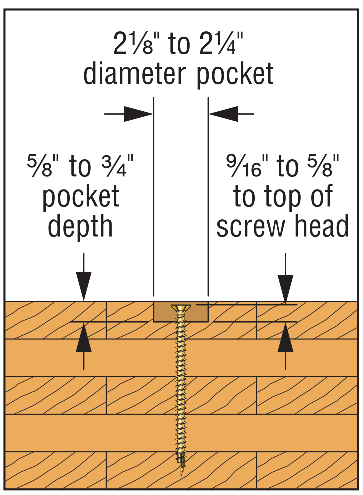

Figure 13 – Installation with Screw at 90 Degrees and Milled Pocket

<u>**Note:**</u> A milled pocket may be used to accommodate a below surface installation of the screw. This pocket is typically created at the factory when the screw is installed prior to shipment. It may also be done so that the screw can be abandoned in place after the lift is complete. A pocket of the dimensions shown in Figure 13 will accommodate the MTLD. The designer of the lifted object should be consulted prior to the removal of any material from the surface. See T-MT-MTLDUSE for additional installation instructions.

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End and Edge Distance Requirements

The screw placement for the MTLD must conform to the minimum distances shown in Figures 14 and 15. The end distance is the distance measured parallel to grain from the square-cut end of a member to the center of the screw. Edge distance is the distance from the edge of a member to the center of the screw measured perpendicular to grain.

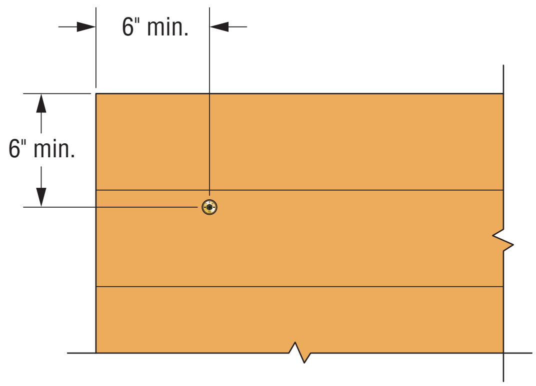

Figure 14 – MTLD Fastener Located on a CLT Panel with a Minimum End Distance = 6" and Minimum Edge Distance = 6"

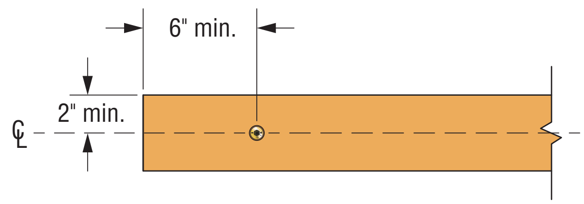

Figure 15 – MTLD Fastener Located on a Beam with a Minimum End Distance = 6" and Minimum Edge Distance = 2"

3.2 MTHLD™ Mass Timber Lifting Device

The MTHLD Mass Timber Heavy Lifting Device provides high capacity and versatility for erecting large panels, beams, and columns. The device installs with Strong Drive® SDCF Timber-CF structural screws in a variety of patterns that the designer has determined are sufficient to provide the right capacity for the lift.

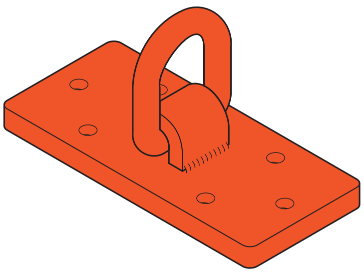

Figure 16 – MTHLD6

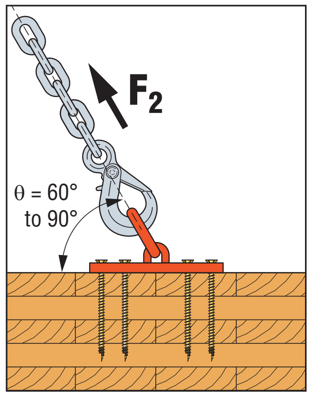

Figure 17 – MTHLD6 F_2 Load Direction and Allowable Angle Range for Installation on CLT panel face-grain per Table 5. Installation on glulam beam face-grain per Table 6 similar

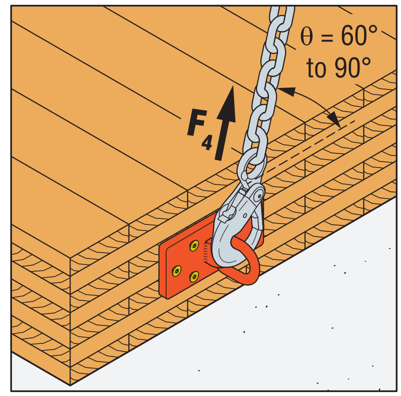

Figure 18 – MTHLD6 F_4 Load Direction and Allowable Angle Range (CLT panel edge attachment shown. Column end similar.)

Table 5 – Allowable Loads for CLT Panel Face-Grain Attachment

Model No.	Minimum Panel Thickness (in.)	Screws		Allowable Load, F_2 (lb.)	
		Type	Quantity	θ = 90°	θ = 60°
MTHLD6	3½	0.390" x 4" SDCF	(4)	2,175	1,645
			(6)	3,225	2,750
	5⅝	0.390" x 6¼" SDCF	(4)	4,020	3,330
			(6)	6,035	5,635

1. Allowable loads are valid for screws installed at 90° into the face-grain of the CLT panel.
2. See Additional Notes next page.

Table 6 – Allowable Loads for Glulam Beam Face-Grain Attachment

Model No.	Minimum Beam Width (in.)	Screws		Allowable Load, F_2 (lb.)	
		Type	Quantity	θ = 90°	θ = 60°
MTHLD6	5⅞	0.390" x 6¼" SDCF	(4)	4,245	3,385
			(6)	6,370	5,080

1. Allowable loads are valid for screws installed at 90° into the face-grain of the glulam beam.
2. See Additional Notes next page.

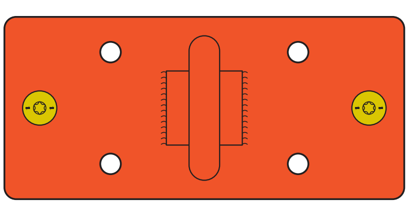

Figure 19 – MTHLD6 Installed with a 2-Screw Pattern

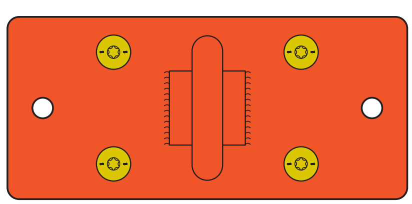

Figure 20 – MTHLD6 Installed with a 4-Screw Pattern

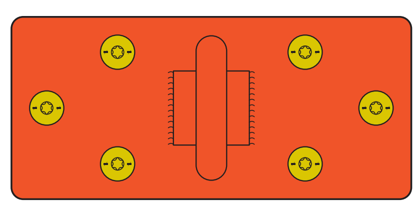

Figure 21 – MTHLD6 Installed with a 6-Screw Pattern

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Table 7 – Allowable Loads for CLT Wall Tilt-Up with Edge Attachment							
Model No.	Wall Panel CLT Layup	Screws		Allowable Load, F_2 (lb.)		Allowable Load, F_4 (lb.)	
		Type	Quantity	θ = 90°	θ = 60°	θ = 90°	θ = 60°
MTHLD6	3-ply (4" min.)	0.390" x 6¼" SDCF	(2)	1,700	1,380	785	825
	5-ply (6⅞" min.)		(4)	3,690	2,990	1,445	1,760
	7-ply (9⅝" min.)	0.390" x 7⅞" SDCF	(6)	4,980	4,035	2,035	2,755

1. Allowable loads are valid for screws installed at 90° into the edge of the CLT panel.
2. See Additional Notes below.

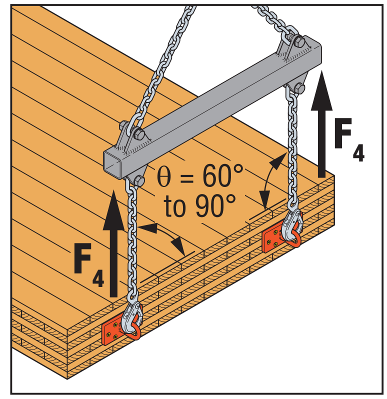

Figure 22 – F_4 Load Direction for MTHLD6 Installed on CLT panel edge-grain per Table 7. Installation on glulam column end grain per Table 8 similar

Table 8 – Allowable Loads for Glulam Column Tilt-Up with End-Grain Attachment					
Model No.	Minimum Column Width (in.)	Screws		Allowable Load, F_2 (lb.)	Allowable Load, F_4 (lb.)
		Type	Quantity	θ = 90°	
MTHLD6	6¾	0.390" x 7⅞" SDCF	(4)	2,815	1,245
			(6)	4,225	1,870

1. Allowable loads are valid for screws installed at 90° into the end-grain of the glulam column.
2. See Additional Notes below.

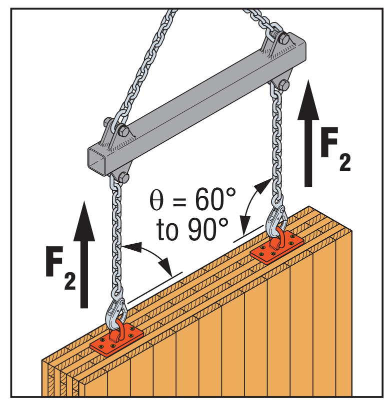

Figure 23 – F_2 Load Direction for MTHLD6 Installed on CLT panel edge-grain per Table 7. Installation on glulam column end grain per Table 8 similar

ADDITIONAL NOTES

1. Allowable loads have a factor of safety of 5 and meet the requirements of OSHA safety standards for hoisting and rigging section 1926.753(e)(2).
2. Screws are only permitted to be used for a single lift and shall not be used for structural applications thereafter.
3. Allowable loads apply to wood with a specific gravity of 0.42 or greater.
4. For conditions where the moisture content of the wood is greater than 19%, adjust load values by the factor, $C_M = 0.70$.
5. Allowable loads act in the direction of the sling angle (θ), i.e., the angle between the horizontal plane and the sling leg.
6. Tabulated values are not valid if θ < 60°. Linear interpolation is allowed for 60° < θ < 90° when allowable loads for both angles are shown in the tables.
7. **A qualified professional must specify the appropriate screw model and quantity from the load tables. Screws shall be installed according to the pattern associated with the specified quantity.**

   0.390" x 4" SDCF = Model SDCF27400;

   0.390" x 6¼" SDCF = Model SDCF27614;

   0.390" x 7⅞" SDCF = Model SDCF27778.
8. All rigging components and spreader bars that are used in conjunction with the MTHLD shall be of sufficient strength and stiffness to carry the required load.

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Installation Overview

The MTHLD is installed following the steps illustrated in Figure 24. Read and follow detailed installation instructions in T-MT-MTHLDUSE.

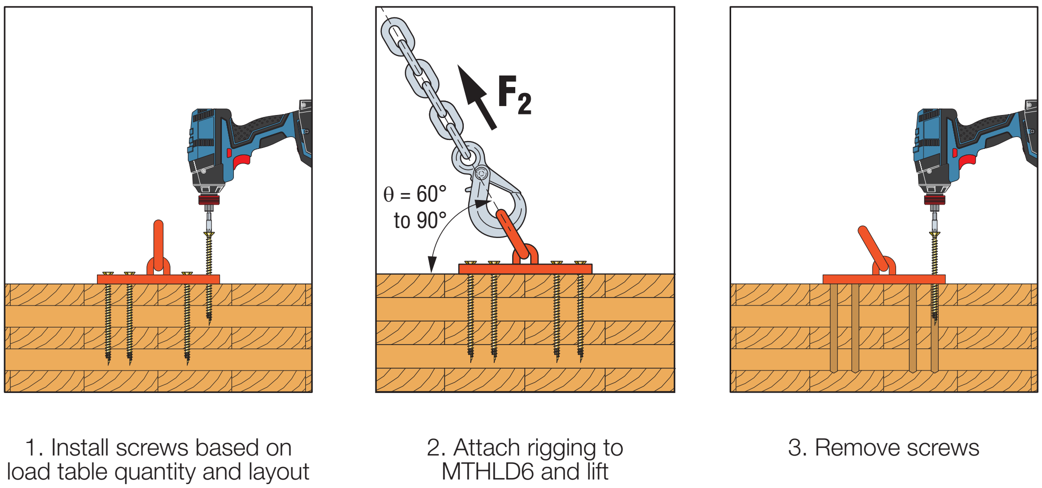

Figure 24 – Installation with Screws into the Face-Grain, installations into edge and end-grain similar

MTHLD Orientation Requirements

The MTHLD must be oriented in the direction of the sling as shown in Figures 25 and 26.

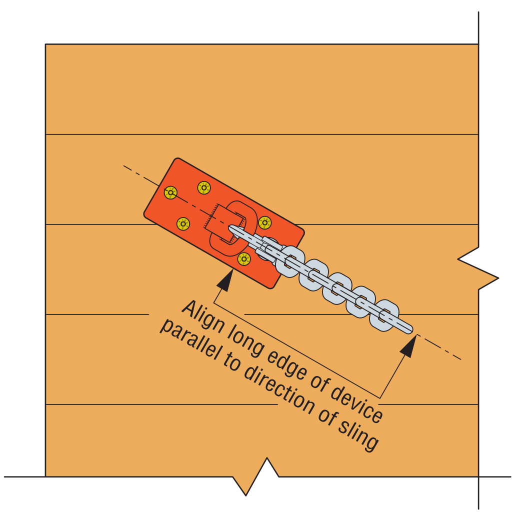

Figure 25 – MTHLD6 orientation on CLT panel face

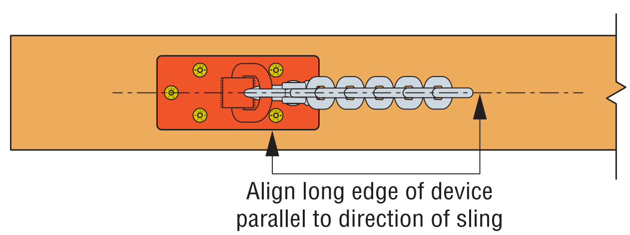

Figure 26 – MTHLD6 orientation on glulam beam

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End and Edge Distance Requirements

The placement for the MTHLD must conform to the minimum distances shown in Figures 27 – 30. The end distance is the distance measured parallel to grain from the square-cut end of a member to the center of the MTHLD. Edge distance is the distance from the edge of a member to the center of the MTHLD measured perpendicular to grain. Fastener edge distance is the distance from the edge of a member to the center of the nearest fastener measured perpendicular to grain.

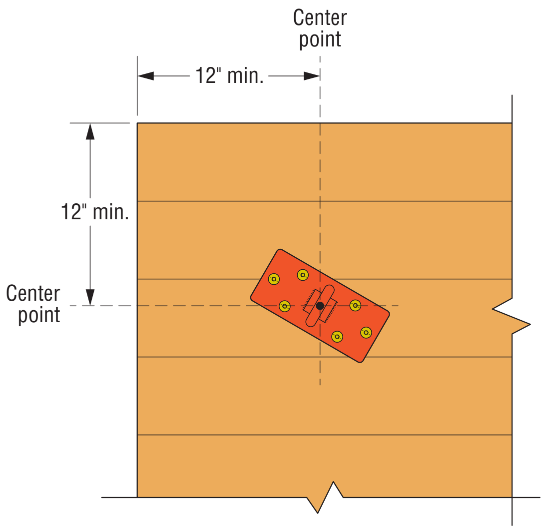

Figure 27 – MTHLD6 Minimum End and Edge Distance on the face of a CLT panel

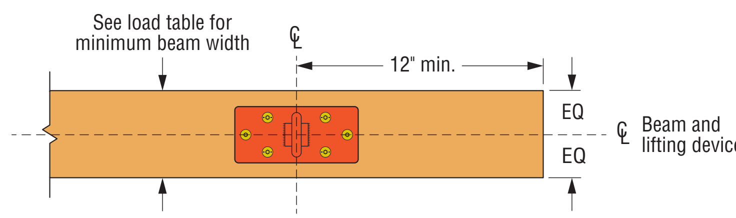

Figure 28 – MTHLD6 Minimum End and Edge Distance on the face of a glulam beam

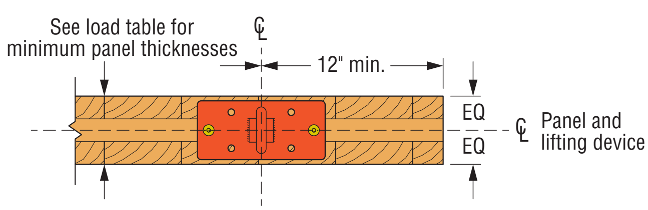

Figure 29 – MTHLD6 Minimum End and Edge Distance on the edge of a CLT panel

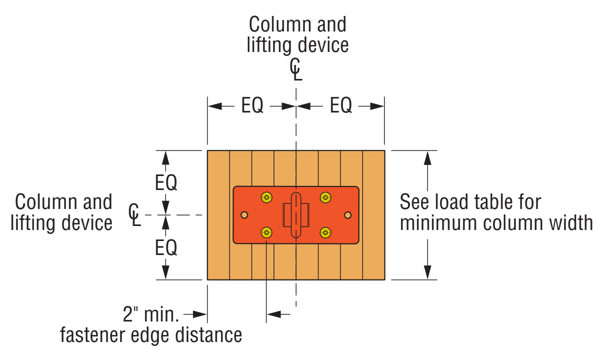

Figure 30 – MTHLD6 Minimum Edge distance on the end of a glulam column

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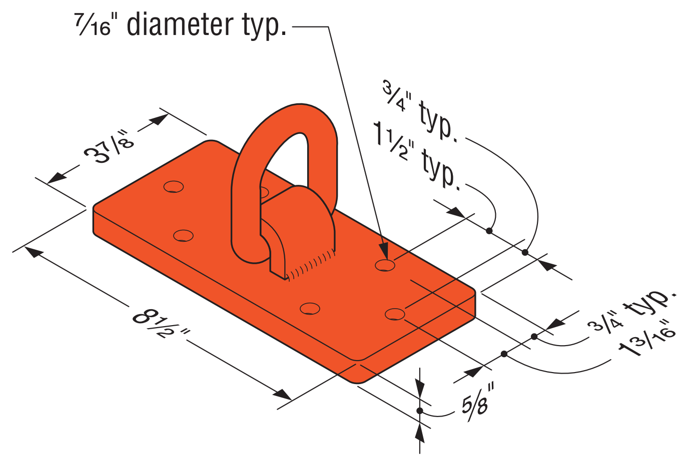

Figure 31 – MTHLD6 Plate Geometry

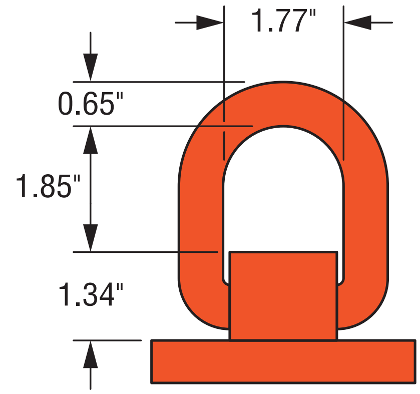

Figure 32 – MTHLD6 Ring Geometry

3.3 Screws used with lifting devices

A qualified professional must specify the appropriate screw model and quantity from the load tables. Screws shall be installed according to the pattern associated with the specified quantity where applicable.

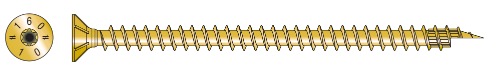

Figure 33 – SDCF27614
(Other lengths similar)

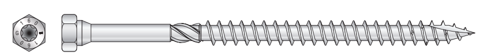

Figure 34 – SDHR31614

4. Notation

f = dynamic acceleration factor

F_2 = device allowable load, used while object is fully supported by the lifting devices [lb]

F_4 = device allowable load, used during the tilt-up process [lb]

F_i = resultant lifting device force [lb]

F_{tot} = total weight to be lifted [lb]

N = number of effective lifting devices

z = sling angle factor

5. Disclaimer

The purpose of this Design Guide is to assist qualified designers in connection with their detailed calculations and analysis that must be performed to determine whether the Simpson Strong-Tie MTLD or MTHLD may be used on a specific project, as the design and use may depend on various factors unique to the structure, the lifted object, and its location. Before specifying or using the Simpson Strong-Tie MTLD or MTHLD, a qualified designer must also review all relevant warnings, disclaimers, instructions, and information in T-MT-MTLDUSE or T-MT-MTHLDUSE and published at **strongtie.com/MTLD** or **strongtie.com/MTHLD**, respectively.

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