TECHNICAL ENGINEERING BULLETIN

Lifting Device Design Guide

SIMPSON Strong-Tie

Introduction

As the mass timber and offsite construction market continues to expand in Europe, 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.

Table of Contents

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 according to CEN/TR 15428.

2. Allowable table loads are based on the lower of lifting device capacity and calculation of the Solid-Drive screw's capacity (with k_{mod}=0.9, γM=1.3, γG=1.35, and lifting safety coefficient = 1.5).

3. The Simpson Strong-Tie lifting products use Simpson Strong-Tie screw products. Solid-Drive® ESCRFTC Screws and SSH Screws are listed in ETA-13/0796 and ETA-21/0670.

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

5. 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.

6. 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. MANUAL-EU-MTLD describes lifting device inspection. Records of all inspections should be kept.

7. Screws may be installed with either drill motors or impact driver tools in accordance with MANUAL-EU-MTLD.

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

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

10. Do not use the MTLD until you have read all warnings, disclaimers, instructions and information in MANUAL-EU-MTLD.

Lifting Device Design Guide

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 (density = 500 kg/m^3) for the purposes of fastener design, while having an actual density greater than 500 kg/m^3. Check with the engineered wood manufacturer for product densities.

Table 1 - Common Elements and Densities

Material	Density (kg/m^3)
Sawn Lumber – Douglas Fir-Larch	530
Sawn Lumber – Spruce-Pine-Fir	420
CLT – Douglas Fir-Larch	550
CLT – Spruce-Pine-Fir	450
Plywood – Standard	580
OSB – Standard	650

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 2.5 m x 6 m x 180 mm.

$$F_{tot} = \text{Density} \times \text{Volume} \qquad \text{Eq. 1}$$

$$F_{tot} = 550\ \text{kg/m}^3 * 2.5\ \text{m} * 6\ \text{m} * 0.18\ \text{m}$$

$$F_{tot} = 1485\ \text{kg}$$

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.

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
Lifting and Moving on Flat Terrain	2.0 – 2.5
Lifting and Moving on Rough Terrain	3.0 – 4.0 (minimum)

1. Source: CEN/TR 15728

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 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

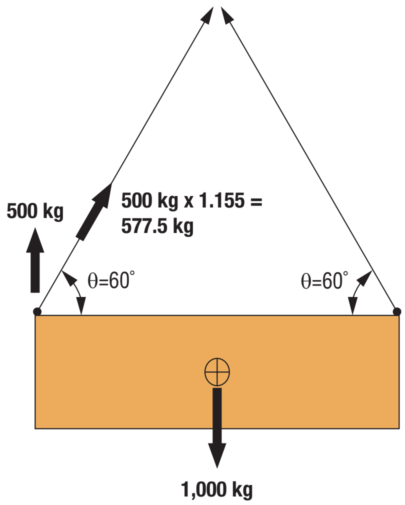


Figure 1 – Example calculation of a two-point, angled sling lift

Lifting Device Design Guide

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.

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.

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

- Glulam beams
- Solid sawn beams
- Logs

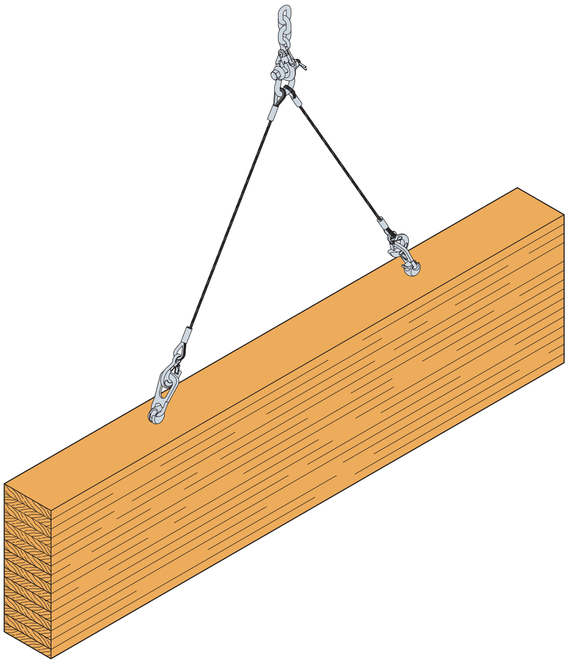


Figure 2 – Example of two-point lift

Lifting Device Design Guide

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

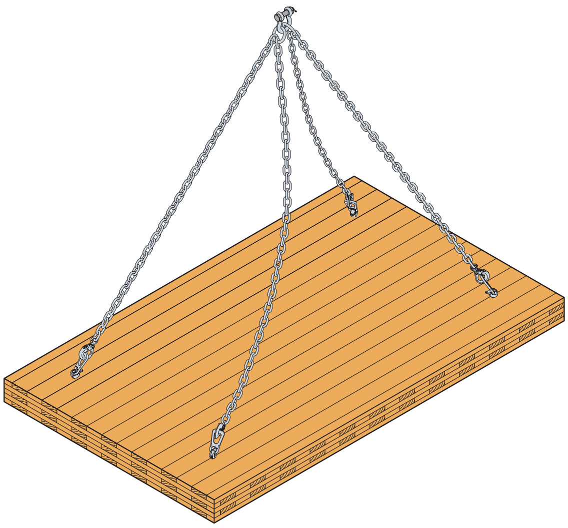


Figure 3 – Example of four-point lift with only 2 effective lifting devices, N = 2

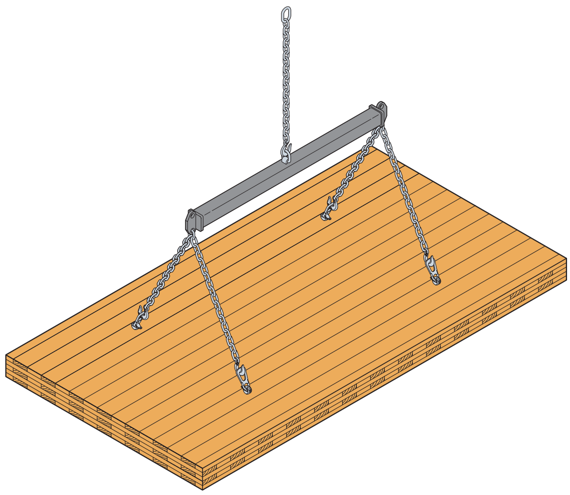


Figure 4 – Example of four-point lift with 4 effective lifting devices, N = 4

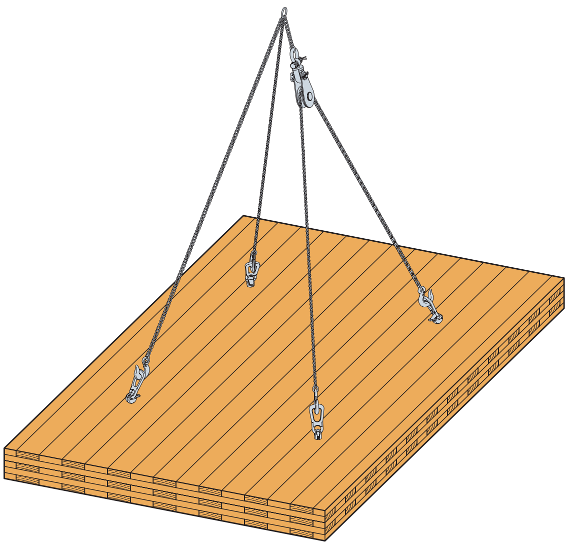


Figure 5 – Example of four-point lift with 4 effective lifting devices, N = 4

Lifting Device Design Guide

2.5 Determine the resultant lifting device force

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

$$F_i = \frac{F_{tot} * f * z}{N}$$

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 is found in the product allowable load table and must be greater than the resultant lifting to device force as shown in Eq. 3.

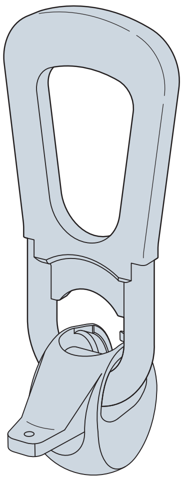
$$F \geq F_i$$

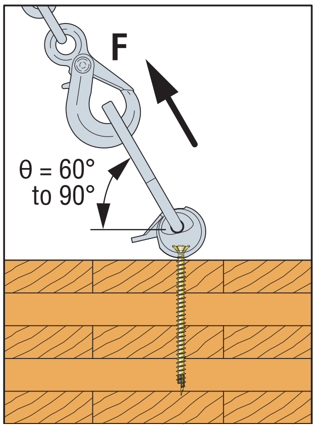
Eq. 3

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.





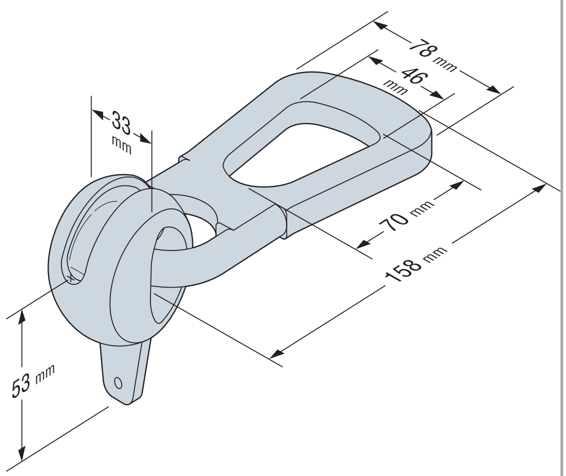


Table 4 - Allowable Loads for MTLD - 1 Screw				
Model No.	Type of Screws	Min. Wood Member Thickness (mm)	Allowable Loads, F (kg)	
			θ = 90°	θ = 60°
MTLD	SSH12,0X100	100	282	244
	SSH12,0X160	160	561	486
	ESCRFTC12,0X260	260	1126	975

1. Choose an allowable load, F 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 mean density of 420kg/m³ or greater.
5. Allowable loads may not be increased for load duration.
6. Tabulated values are not valid if θ < 60°. Linear interpolation is allowed for 60° ≤ θ ≤ 90°.
7. A qualified design professional must specify the screw which fits better to the applied load in the SSH12.0 and ESCRFTC12.0 ranges.
8. 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.

Allowable load calculation:

The loads introduced in the table come from calculation of the screw capacity and the allowable load of the lifting device. We can resume this as following: F=min ($R_{adm,MTLD}$, $R_{adm,screw/sin(theta)}$).

The allowable load of the MTLD is given by the manufacturer, $R_{adm,MTLD}$=1300 kg.

For the calculation of the screw capacity, we will use several safety factors: $R_{adm,screw} = k_{mod} * R_{ax,k,screw} / (\gamma_M * \gamma_G * \gamma_{l+h})$

With, k_{mod} = 0.9, saftey factor related to the load duration and service class from EN 1995-1-1. Even if it is an instantaneous load, we can't set a safety factor greater than 1.

γ_M = 1.3, safety factor for assembly in timber from EN 1995-1-1

γ_G = 1.35, partial factor for permanent actions from EN1990. It will allow us to compare directly the allowable load to the load to lift.

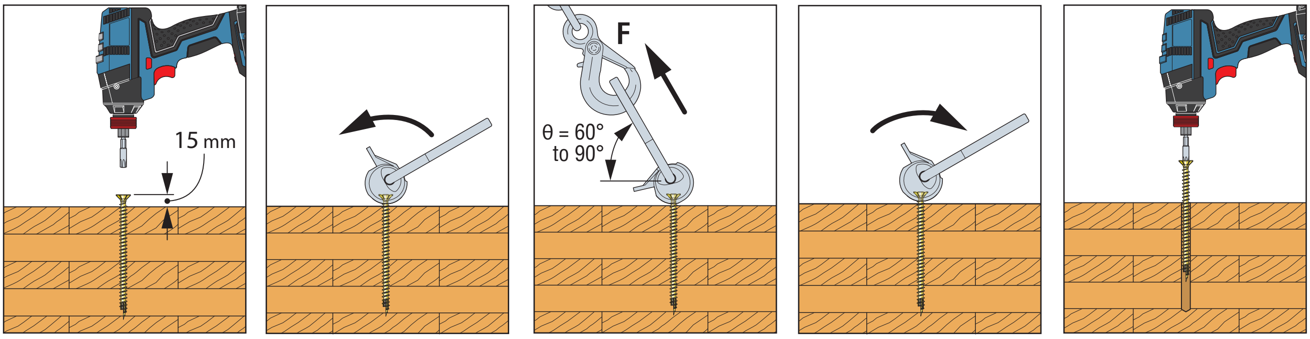
γ_{l+h} = 1.5, partial factor for lifting and handling (live load) from CEN/TR 15728.

It is to say: $R_{adm,screw}$=$R_{ax,k,screw/3}$

The characteristic capacity of screw is calculated EN1995-1-1 and related ETAs.

Installation Overview

The MTLD is installed following the steps illustrated in Figure 9. Read and follow detailed installation instructions in MANUAL-EU-MTLD.



1. Install Screw

2. Attach MTLD to screw

3. Attach rigging to MTLD and lift

4. After lift, detach MTLD from screw

5. Remove screw or drive flush with surface

Figure 9 - Installation with Screw at 90 Degree

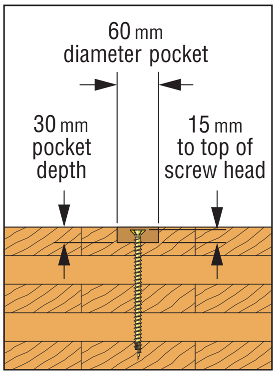


Figure 10 – Installation with Screw at 90 Degrees and Milled Pocket

Note: 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 10 will accommodate the MTLD. The designer of the lifted object should be consulted prior to the removal of any material from the surface. See MANUAL-EU-MTLD for additional installation instructions.

Helpful tip: Consider if the milled pocket needs to be protected from moisture on the jobsite.

End and Edge Distance Requirements

The screw placement for the MTLD must conform to the minimum distances shown in Figures 11 and 12. 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.

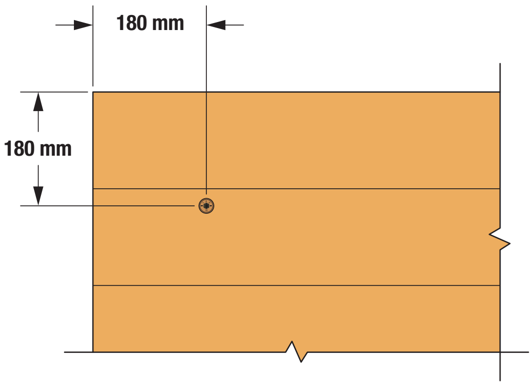


Figure 11 - MTLD Fastener Located on a CLT Panel with a Minimum End Distance = 180 mm and Minimum Edge Distance = 180 mm

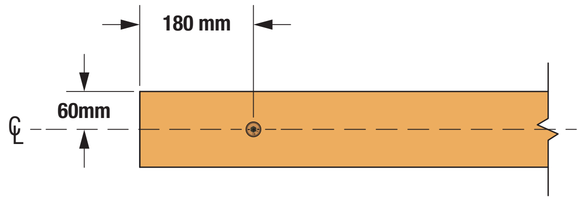


Figure 12 - MTLD Fastener Located on a Beam with a Minimum End Distance = 180 mm and Minimum Edge DIstance = 60 mm

4. Notation

f = dynamic acceleration factor

F = device allowable load [kg]

F_i = resultant lifting device force [kg]

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

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 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, a qualified designer must also review all relevant warnings, disclaimers, instructions and information in MANUAL-EU-MTLD and published at strongtie.com/MTLD.

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6. References

- Eurocode 5 - Design of timber structures
- CEN/TR 15728:2016 - Design and use of inserts for lifting and handling of precast concrete elements
- Directive 2006/42/C on machinery
- Simpson Strong-Tie. 2023. Use and Instructions for the MTLD – Mass Timber Lifting Device, MANUAL-EU-MTLD. 6 pp.
- Simpson Strong-Tie. 2023. Simpson Strong-Tie Strong-Drive Screws used in Wood, ETA-13/0796.
- Simpson Strong-Tie. 2023. Simpson Strong-Tie SSH HEAVY-DUTY CONNECTOR Screws, ETA-21/0670.
- In France: Memento de l'élingueur, INRS

strongtie.eu
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