



Canadian lifting device design for Cross Laminated Timber (CLT)



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SECTION 1: INTRODUCTION

NOTES TO THE DESIGNER AND USER

Comments and statements provided in approvals such as the issued CCMC report “CCMC 13677-R” or the European Technical Approval ETA-11/0190, must be followed at all times and have priority over this document.

Factored resistances calculated for lifting are based on the CSA 086-09, the issued CCMC report “CCMC 13677-R” and boundary conditions outlined in the ETA-11/0190 and ETA-12/0481, unless noted otherwise.

Load assumptions

- Dynamic acceleration factor considered for lifting is assumed to be 1.40 according to FPIinnovations Chapter 12 - Lifting and Handling of CLT panels: p. 31
- Weight (unplanned panels), thickness (unplanned panels) and standard sizes of 3 ply, 5 ply, 7 ply and 9 ply Cross Laminated Timber (CLT) panels were obtained from Structurlam (<http://structurlam.com/contact/>) and from the CLT Design Guide for “CrossLam by Structurlam”: http://structurlam.com/product/images/CLT_design_guide_imperial_lo_res_sept_2013.pdf

Material properties

- When designing with full thread fasteners such as the SWG ASSY® Kombi dry wood ($K_{SF} = 1$) shall be used.
- Listed factored resistances apply to mean oven dry relative density of timbers listed
- A wood moisture content of 12% \pm 3% is assumed.
- CLT panels:
 - Specified strengths values and physical features refer to sawn lumber of Spruce-Pine-Fir (SPF No. 1/No. 2)
 - The following equations referring to the Structural CLT Design Workshop (March 2013) were used to determine the embedment strength of Canadian CLT.

Embedment strength of wood screws driven in the wide face of the panel perpendicular to the plane for face lifting:

$$f_2 = 95.6 * d_F^{-0.5} * G^{1.05} \text{ [N/mm}^2\text{]}$$

Embedment strength of lag screws loaded parallel to major strength direction for lifting with screws driven in the narrow face of the panel:

$$f_2 = 55 * (1 - 0.015 * d_F) * G^{1.16} \text{ [N/mm}^2\text{]}$$

Embedment strength of lag screws loaded perpendicular to major strength direction for tilt-up with screws driven in the narrow face of the panel:

$$f_2 = 22 * (1 - 0.01 * d_F) * G \text{ [N/mm}^2\text{]}$$
- Specified strengths of steel plates to be of ASTM A 36/A 36M steel or higher grades



SECTION 1: INTRODUCTION

NOTES TO THE DESIGNER AND USER

Design assumptions

STEEL PLATES

- Applied modification factors are $K_{SF} = 1$, $K_T = 1$ for dry service conditions and $K_D = 1.15$ for “short term loading” as per applicable design code.
- Resistances used are derived on the assumption of permanently dry conditions throughout transportation of the panel and lifting of the panel into its final position on site ($K_{SF} = 1$).
- Fasteners interaction (group factor) is considered with the effective number of fasteners $n_{ef} = n^{0.9}$ (European Code EN 1995-1-1:2010-12, 8.7.2(8)).
- For withdrawal resistance the threaded length only less one diameter for the tip is considered
- Shear design considers a shaft diameter of a fully threaded SWG ASSY VG Kombi screw i.e. $d_s = 7.1$ mm.
- Angle α between screw axis and wood grain is considered only perpendicular to the grain ($\alpha=90^\circ$). Screws must be installed accordingly.

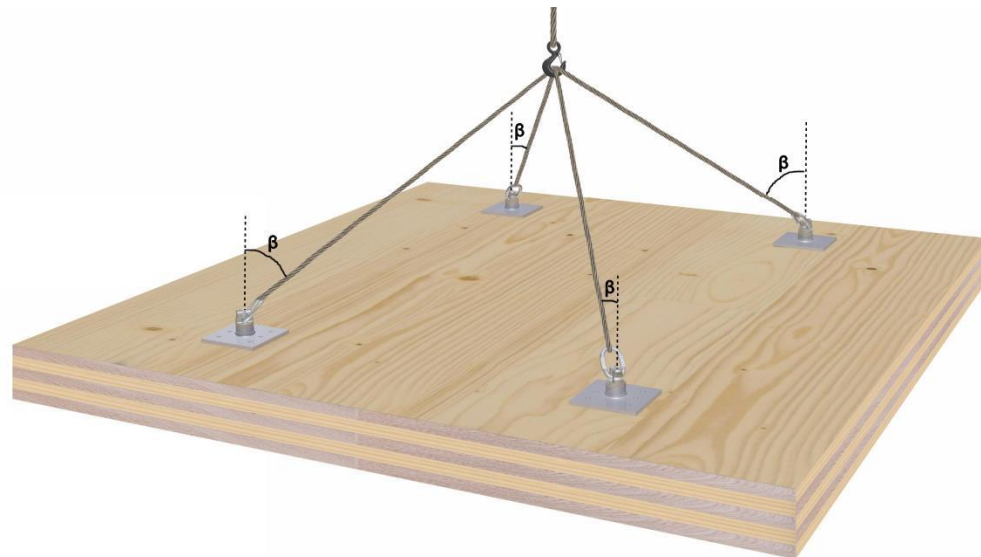


SECTION 1: INTRODUCTION

INSTALLATION AND LIMITATIONS

Installation

- Required spacings and distances are as outlined in the ETA-11/0190. For tilt-up and narrow edge lifting spacing and distance requirements are as outlined in the expert statement of Hartmut & Werner on “ASSY® 3.0 Kombi screws as transport anchors”.
 - Proper steel plate installation is required to avoid splitting of the panel when tilt up lifting is performed on narrow edge. The L-shaped steel plate must be seated fully on the timber in a way such that all steel plate surfaces firmly engage with the timber. The steel plate must be properly aligned along the panel edge along its entire axis. Tilt up loads are therefore transmitted in compression bearing on panel edge.
 - In Cross Laminated Timber (CLT) screws are not to be installed into cracks, checks or gaps.
 - Gaps in between the plies of the panel may not exceed a width of 7.1 mm.
 - To guarantee even load distribution on all lifting points a compensation system, i.e. a bridle or spreader bar (see section 3: General Information for Lifting), is suggested for lifting with more than 2 lifting points. All lifting belts must be equal lengths.
 - Ensure that the looped cable is fully seated on the RAMPA insert prior to lifting
 - The lifting angle β between the vertical axis and the straps must not exceed $0^\circ \leq \beta \leq 30^\circ$ (see respective drawing).
- Required strap length may need adjustment for conditions other than the conditions listed in this guide. It remains the responsibility of the installer/ rigger to ensure proper lifting angles $0^\circ \leq \beta \leq 30^\circ$.
- When tilting up panel materials the edge across from the tilt-up point of the panel must be in contact with firm ground constantly until the panel has reached a vertical position.
 - Safe lifting procedures always have to be observed.
 - Whenever possible “Guide Line(s)” should be used to prevent panel rotation and to stabilize panel during lifting process



Limitations

- Lifting procedures outlined in this report only apply to rectangular panels.
- Failure of the panel material itself is not considered in the tables and must be verified by a structural engineer.
- Strap design is not included in the provided design and remains responsibility of the user.
- Resistances shown are derived on the assumption of permanently dry conditions throughout the service life of the structural element. Is the fastener used in other than “dry” service condition resistance reduction factors as listed in respective design codes must be applied and additional fastener corrosion protection may be required.
- Lifting can only be performed in little or no wind unless further specified otherwise by a qualified professional.
- Do not introduce sudden loads of any kind on the panels or lifting equipment during lifting.
- 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.



SECTION 2: INSTALLER INFORMATION

TIMBER DENSITIES AND SPACING REQUIREMENTS

Timber densities

Table 2.1: Timber densities

Timber densities ¹ [$\times 10^3 \text{ kg/m}^3$]	
Spruce-Pine-Fir (S-P-F)	0.42
CLT	

Note: ¹ mean oven dry relative density

Spacing, end and edge distance requirements in CLT

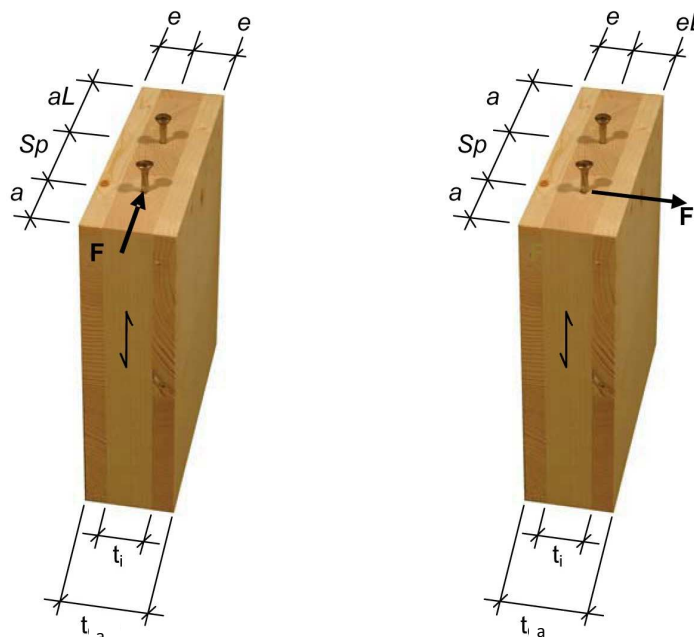
Note:

Spacing end and edge distances listed in following tables were derived according to the methods proposed in the European technical Approval ETA-11/0190 for self tapping wood screws and the ETA-12/0481 for RAMPA inserts.

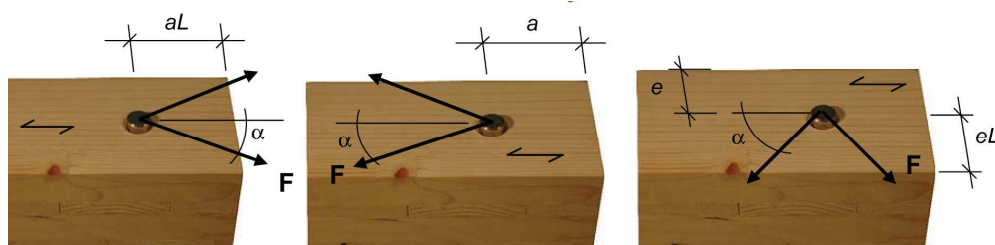
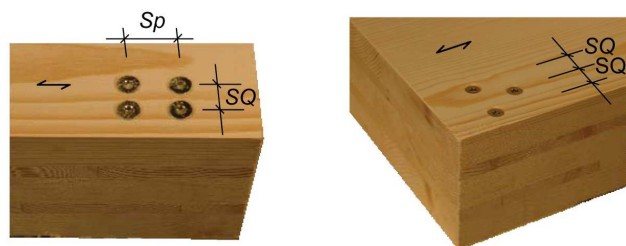
The listed values are applicable for non-predrilled holes when a minimum CLT panel thickness of 10d as well as a minimum width of CLT of 8d or 60mm (whichever is greater) are followed.

(d = screw outside thread diameter)

Spacing on narrow edge of the panel



Spacing on wide face of the panel





SECTION 2: INSTALLER INFORMATION

SPACING REQUIREMENTS IN CLT

End and edge distance requirements for SWG ASSY® Kombi screws in CLT

Table 2.2: Spacing end and edge distances of SWG ASSY® Kombi screws in CLT

Spacing end and edge distances of SWG ASSY® Kombi screws in CLT ¹					
Min. CLT thickness: 120 mm (4-3/4") ²		a _L Loaded end distance	a Unloaded end distance	e _L Loaded edge distance	e Unloaded edge distance
Screws in wide face	inch	2-7/8	2-7/8	2-7/8	1-1/4
	mm	72	72	72	30
Screws in narrow edge	inch	5-5/8	3-3/8	2-7/8	1-1/2
	mm	144	84	72	36

Note: ¹ independent of the angle between screw axis and grain direction

² in case of a 3 ply CLT panel the min. thickness requirement can not be fulfilled. Therefore to reduce splitting the steel plates for wide face lifting have been designed with 2 times the required distances



SECTION 3: GENERAL INFORMATION FOR LIFTING

TYPES OF LIFTING SYSTEMS

Types of lifting systems

With lifting at more than 3 lifting points the use of compensation systems, i.e. spreader bars¹ or bridle assemblies² (see respective drawings) it is mandatory to ensure even load distribution to each lifting point.

Table 3.1: Types of lifting systems

TYPES OF LIFTING SYSTEMS				
narrow edge lifting *		face lifting *		tilt-up*
system 1	system 3	system 2	system 4	system 5
spreader bar ¹	bridle assemblies ²	spreader bar ¹	bridle assemblies ²	spreader bar ¹ / bridle assemblies ²

Note:

* whenever possible use “Guide Line(s)” to prevent panel rotation and to stabilize panel during lifting process

¹ spreader bar: spreader beam with at least two lifting points to enable multiple pick point lifting and provide a better over all balance to keep large or irregular loads under control

² bridle assemblies: transforms statically undefined systems with more than 3 lifting points into statically defined systems to handle loads with fixed lifting points



SECTION 3: GENERAL INFORMATION FOR LIFTING

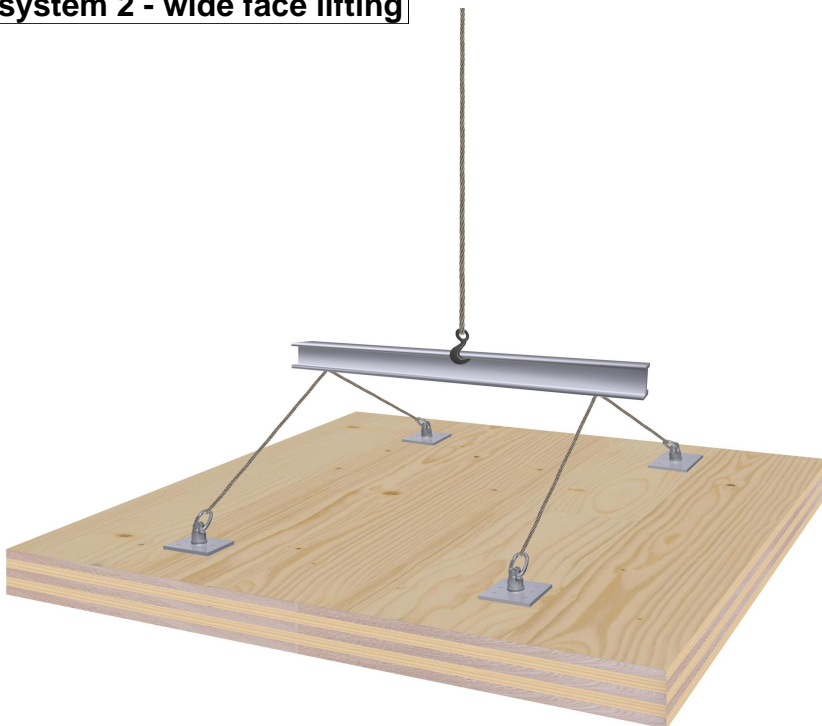
TYPES OF LIFTING SYSTEMS

Lifting with a spreader bar

system 1 - narrow edge lifting



system 2 - wide face lifting





SECTION 3: GENERAL INFORMATION FOR LIFTING

TYPES OF LIFTING SYSTEMS

Lifting with bridle assemblies

system 3 - narrow edge lifting



system 4 - wide face lifting



system 5 - tilt-up





SECTION 3: GENERAL INFORMATION FOR LIFTING

INSTALLATION ON THE PANEL

Installation of the lifting device on the panel

Balanced panel lifting is required. The below table provides guidance on where to place respective steel plates for lifting at the narrow panel edge and the wide panel face. Provided measurements apply to the lifting steel plates on rectangular panels.

Positioning of steel plate for lifting of Cross Laminated Timber (CLT)

Table 3.2: Positioning of steel plates on CLT panel

POSITIONING OF STEEL PLATES ON CLT PANEL ¹										
Panel width W [ft] (m)	Panel length L [ft] (m)	narrow edge lifting			face lifting			tilt-up		
		a ₁ [ft] (m)	b ₁ [ft] (m)	β [°]	a ₁ [ft] (m)	b ₁ [ft] (m)	β [°]	a ₁ [ft] (m)	b ₁ [ft] (m)	β [°]
8 (2.45)	18.5—27.7 (5.6—8.4)	4.5 (1.4)	-	0 ≤ β ≤ 30	4.5 (1.4)	1.5 (0.5)	0 ≤ β ≤ 30	refer to narrow edge lifting		
	27.8—40 (9.4—12.2)	8 (2.5)	-		8 (2.5)					
10 (3.05)	18.5—27.7 (5.6—8.4)	4.5 (1.4)	-		4.5 (1.4)			refer to narrow edge lifting		
	27.8—40 (9.4—12.2)	8 (2.5)	-		8 (2.5)					

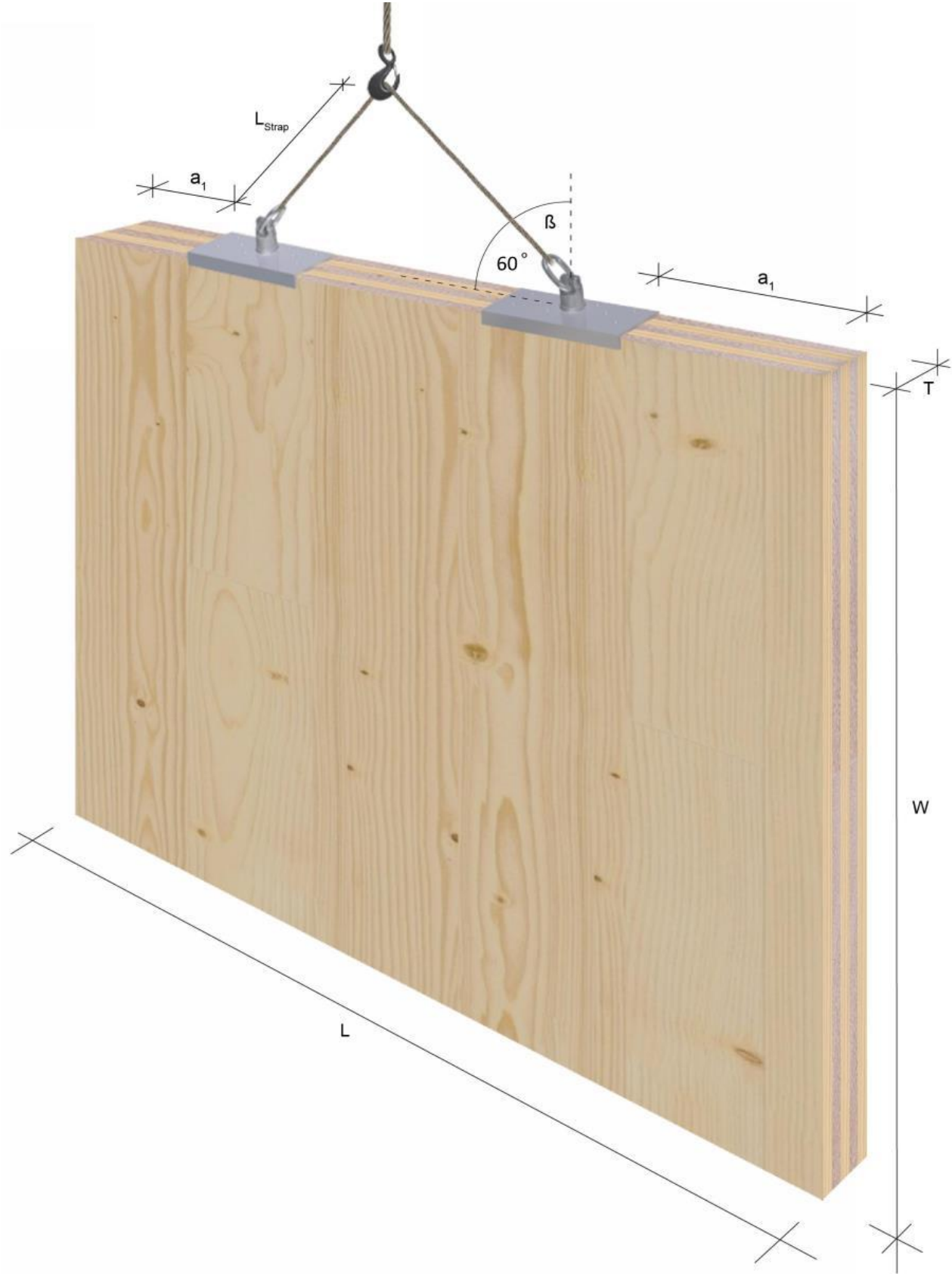
Note: ¹ measurements a₁, b₁ and β according to drawings below



SECTION 3: GENERAL INFORMATION FOR LIFTING

INSTALLATION ON THE PANEL

Narrow edge lifting and tilt-up

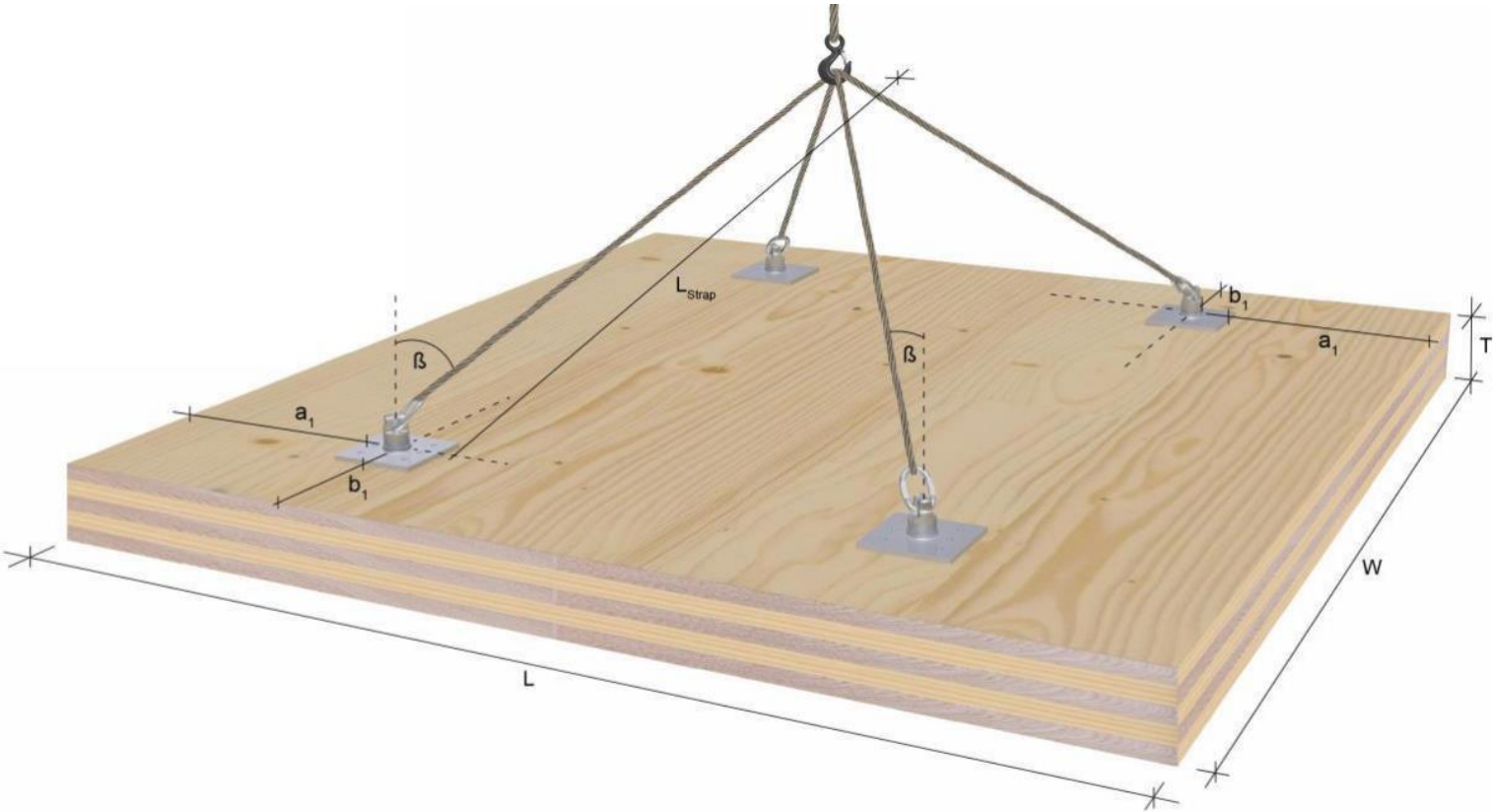




SECTION 3: GENERAL INFORMATION FOR LIFTING

INSTALLATION ON THE PANEL

Wide face lifting





SECTION 3: GENERAL INFORMATION FOR LIFTING

INSTALLATION ON THE PANEL

Minimum suggested/ required strap lengths

In order to maintain an angle of $0^\circ \leq \beta \leq 30^\circ$ minimum required strap lengths L_{strap} are given in the table below.

Required strap lengths for lifting of Cross Laminated Timber (CLT)

Table 3.3: Required strap lengths for CLT panel lifting

REQUIRED STRAP LENGTHS FOR CLT PANEL LIFTING						
panel width W [ft] (m)	panel length L [ft] (m)	required strap length ¹ [ft] (m)				
		narrow edge lifting		face lifting		tilt-up
		system 1	system 3	system 2	system 4	system 5
8 (2.45)	≤ 18.5 (5.6)	various strap length allowed	8.5 (2.6)	4.5 (1.4)	9 (2.7)	Refer to system 1 or system 3 respectively
	≤ 21.5 (6.6)		11.5 (3.5)		12 (3.7)	
	≤ 24.6 (7.5)		14.5 (4.4)		15 (4.6)	
	≤ 27.7 (8.45)		17.5 (5.4)		18.5 (5.6)	
	≤ 30.8 (9.4)		14 (4.3)		14.5 (4.4)	
	≤ 33.8 (10.3)		17 (5.2)		17.5 (5.3)	
	≤ 36.9 (11.2)		20 (6.0)		20.5 (6.3)	
	≤ 40 (12.2)		23 (7.0)		23.5 (7.2)	
10 (3.05)	≤ 18.5 (5.6)	various strap length allowed	8.5 (2.6)	6.5 (2.0)	9 (2.7)	Refer to system 1 or system 3 respectively
	≤ 21.5 (6.6)		11.5 (3.5)		12 (3.7)	
	≤ 24.6 (7.5)		14.5 (4.4)		15 (4.6)	
	≤ 27.7 (8.45)		17.5 (5.4)		18.5 (5.6)	
	≤ 30.8 (9.4)		14 (4.3)		14.5 (4.4)	
	≤ 33.8 (10.3)		17 (5.2)		17.5 (5.3)	
	≤ 36.9 (11.2)		20 (6.0)		20.5 (6.3)	
	≤ 40 (12.2)		23 (7.0)		23.5 (7.2)	

Note: ¹ shown in the pictures of narrow edge lifting and tilt-up as well as wide face lifting on the pages before



SECTION 4: CLT PANEL LIFTING DEVICES

STEEL PLATES AND SWG ASSY® KOMBI SCREWS

Steel plates and ASSY® Kombi screws

ASSY® 3.0 Kombi screw partially threaded (PT)

Table 4.1: partially threaded screw

ASSY® Kombi partially threaded screw				
d _{major}	L	L _{thread}	d _{minor}	d _{shank}
inch				
1/2	4	2-3/8	0.238	0.322
mm				
12	100	60	7.2	8.2

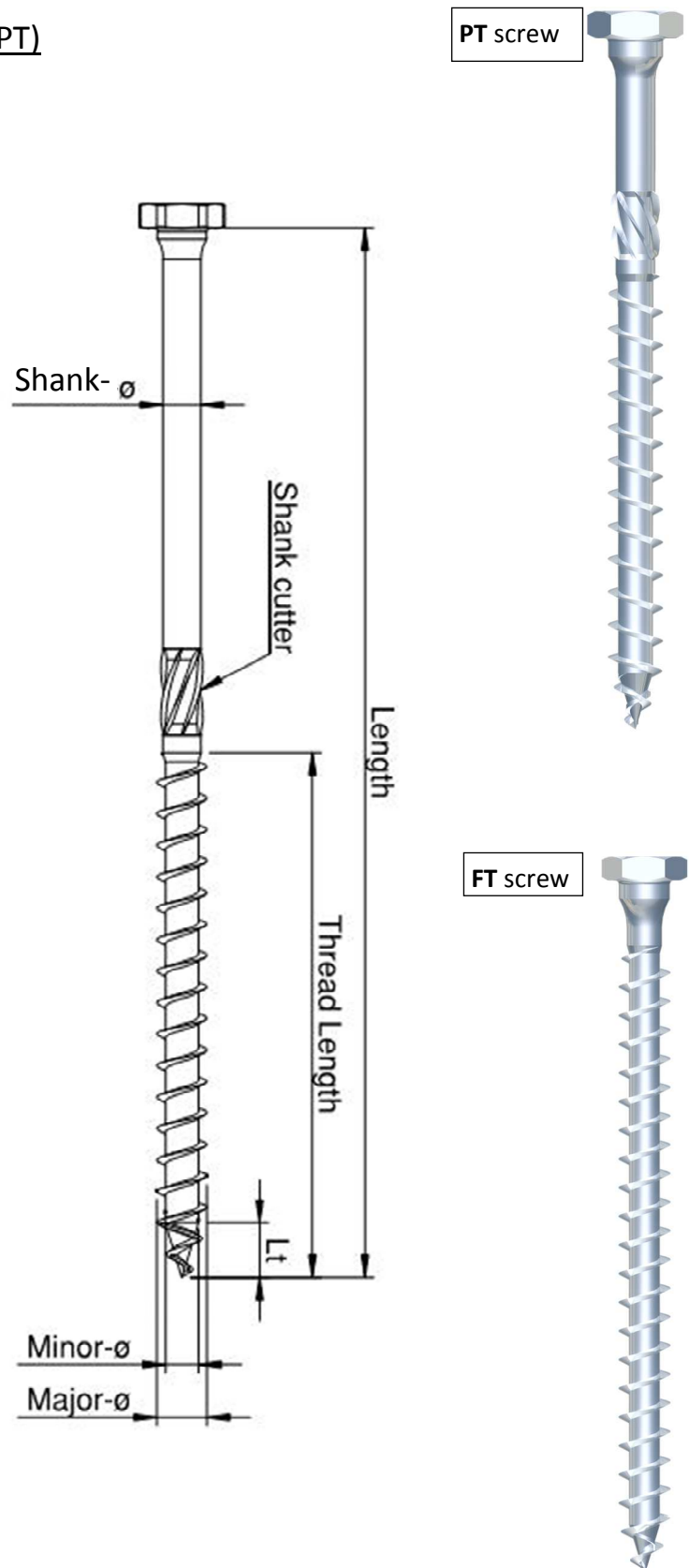
Note: values listed in the table above are average measurements

ASSY® 3.0 Kombi screw fully threaded (FT)

Table 4.2: fully threaded screw

ASSY® Kombi fully threaded screw			
d _{major}	L	L _{thread}	d _{minor}
inch			
1/2	6-1/4	5-3/4	0.279
mm			
12	160	145	7.1

Note: values listed in the table above are average measurements





SECTION 4: CLT PANEL LIFTING DEVICES

STEEL PLATES AND SWG ASSY® KOMBI SCREWS: DESIGN TABLE FOR NARROW EDGE LIFTING

Table 4.3: Narrow edge lifting of various Cross Laminated Timber (CLT) panel sizes

CLT PANEL NARROW EDGE LIFTING DEVICE								
panel width W/ H [ft] (m)	panel length L [ft] (m)	unplaned panel thickness ¹ T [in] (mm)	panel weight ² [lbs] (kg)	design load ³ [lbf] (kN)	required lifting points	Steel plate ⁴	# of screws per STP	type of screws [in] (mm)
8 (2.45)	18.5 - 27.7 (5.6 - 8.45)	3 ply: 4.14 (105)	2490 (1130)	3560 (15.8)	2	STP NEL 1	2	SWG ASSY® Kombi 1/2" x 6-1/4" (12 x 160 / 145)
		5 ply: 6.89 (175)	3940 (1790)	5620 (25.0)		STP NEL 2	6	
		7 ply: 9.65 (245)	5730 (2600)	8180 (36.4)		STP NEL 3	6	
		9 ply: 12.41 (315)	7290 (3310)	10410 (46.3)		STP NEL 4	8	
	27.8 - 40 (8.5 - 12.2)	3 ply: 4.14 (105)	3600 (1630)	5140 (22.8)		STP NEL 1	4	SWG ASSY® Kombi 1/2" x 6-1/4" (12 x 160 / 145)
		5 ply: 6.89 (175)	5690 (2580)	8120 (36.1)		STP NEL 2	8	
		7 ply: 9.65 (245)	8280 (3750)	11820 (52.5)		STP NEL 3	8	
		9 ply: 12.41 (315)	10530 (4780)	15030 (66.8)		STP NEL 4	10	
10 (3.05)	18.5 - 27.7 (5.6 - 8.45)	3 ply: 4.14 (105)	3100 (1410)	4430 (19.7)	2	STP NEL 1	4	SWG ASSY® Kombi 1/2" x 6-1/4" (12 x 160 / 145)
		5 ply: 6.89 (175)	4900 (2220)	7000 (31.1)		STP NEL 2	8	
		7 ply: 9.65 (245)	7140 (3240)	10190 (45.3)		STP NEL 3	8	
		9 ply: 12.41 (315)	9080 (4120)	13000 (57.6)		STP NEL 4	10	
	27.8 - 40 (8.5 - 12.2)	3 ply: 4.14 (105)	4480 (2030)	6390 (28.4)		STP NEL 1	4	SWG ASSY® Kombi 1/2" x 6-1/4" (12 x 160 / 145)

Note: ¹ unplaned thickness: planed panel thickness increased by 1/4" (6mm) in summary

² weight is calculated by using the longest panel length of each section

³ design values are based on dynamic load factor 1.4

⁴ STP : steel plate NEL : narrow edge lifting

EXAMPLE: panel size: 10' wide , 24' long , 7 ply panel panel weight: CLT 6180 lbs

As 18.5 < 24 < 27.7 use the 11th row provided in the table. Panel weight is below the maximum given weight of 7140 lbs. Thus use steel plate STP NEL 3 with 2 lifting points and 8 SWG ASSY® Kombi 1/2" x 6-1/4" (12 x 160 / 145) screws per steel plate.

Steel plate types for narrow edge lifting and tilt-up

Table 4.4: steel plate for lifting on the narrow edge—3ply CLT panel

STP NEL 1 *			
Steel plate for lifting on the narrow edge - 3ply CLT panel			
Length l	Width w	Height h	Depth d
in			
9	4	1-3/8	3/8
mm			
228.5	102	35	9.5

* applicable for tilt-up and narrow edge lifting of a 3ply CLT panel

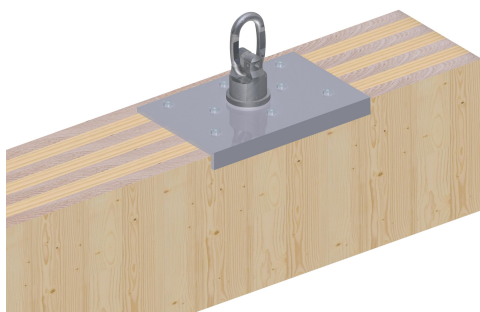
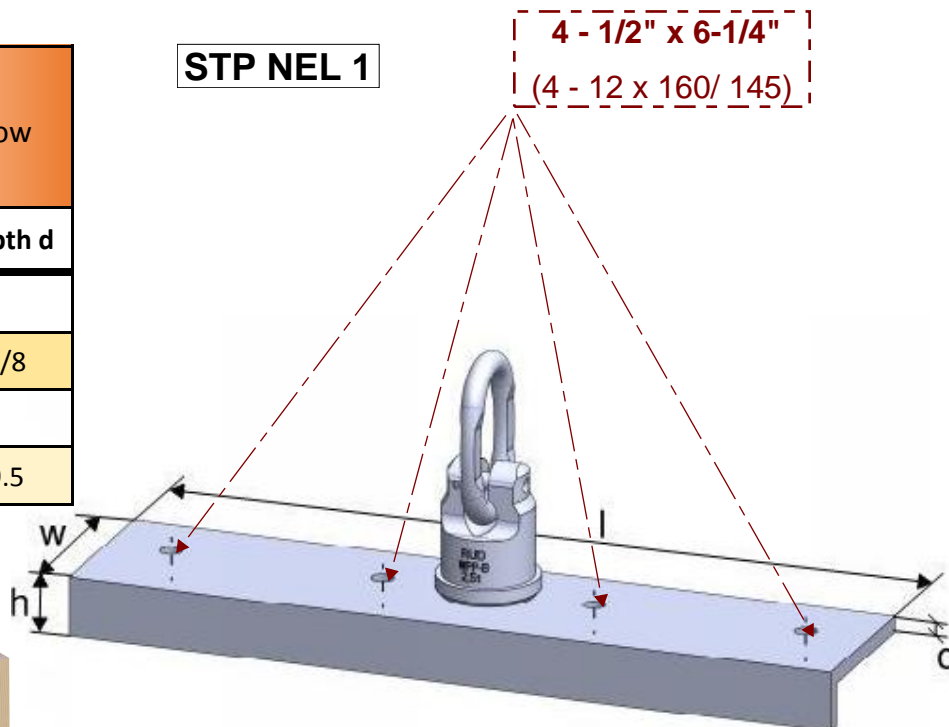


Table 4.5: steel plate for lifting on the narrow edge—5ply CLT panel

STP NEL 2 *			
Steel plate for lifting on the narrow edge - 5ply CLT panel			
Length l	Width w	Height h	Depth d
in			
15-1/2	6	1-3/8	3/8
mm			
394	152	35	9.5

* applicable for tilt-up and narrow edge lifting of a 5ply CLT panel

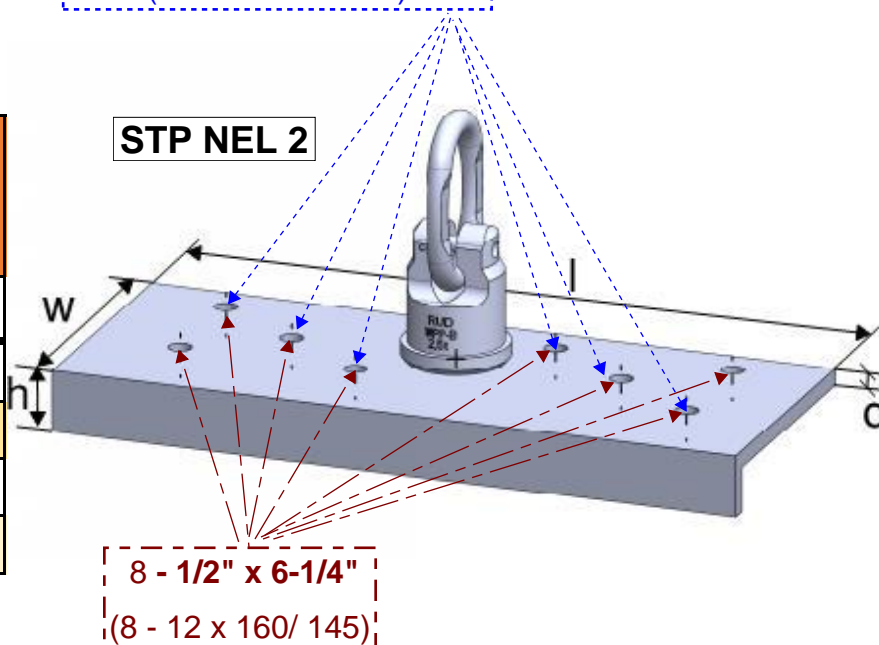
STP NEL 1



When only 6 screws on each STP NEL 2 are required:

6 - 1/2" x 6-1/4"
(6 - 12 x 160/ 145)

STP NEL 2





SECTION 4: CLT PANEL LIFTING DEVICES

STEEL PLATES AND SWG ASSY® KOMBI SCREWS

Steel plate types for narrow edge lifting and tilt-up

Table 4.6: steel plate for lifting on the narrow edge—7ply CLT panel

STP NEL 3 *			
Steel plate for lifting on the narrow edge - 7ply CLT panel			
Length l	Width w	Height h	Depth d
in			
14	9	1-3/8	3/8
mm			
355.5	228.5	35	9.5

* applicable for tilt-up and narrow edge lifting of a 7ply CLT panel

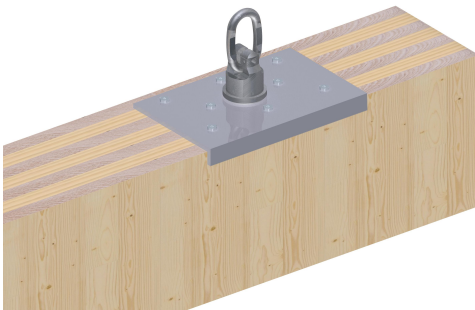
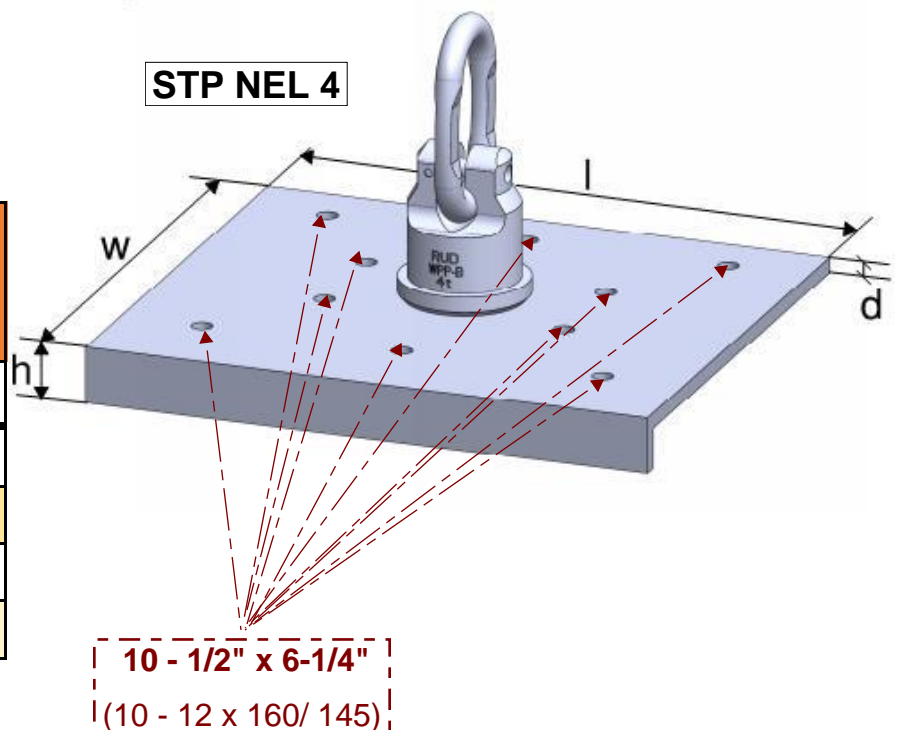
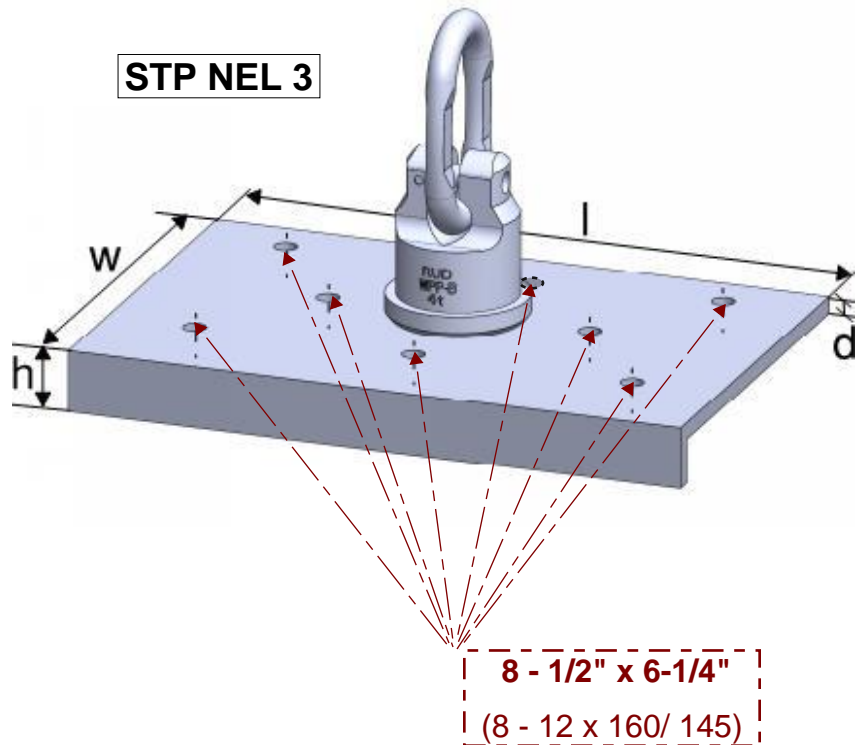


Table 4.7: steel plate for lifting on the narrow edge—9ply CLT panel

STP NEL 4 *			
Steel plate for lifting on the narrow edge - 9ply CLT panel			
Length l	Width w	Height h	Depth d
in			
14	12	1-3/8	3/8
mm			
355.5	305	35	9.5

* applicable for tilt-up and narrow edge lifting of a 9ply CLT panel





SECTION 4: CLT PANEL LIFTING DEVICES

STEEL PLATES AND SWG ASSY® KOMBI SCREWS: DESIGN TABLE FOR WIDE FACE LIFTING

Table 4.8: Wide face lifting of various Cross Laminated Timber (CLT) panel sizes

CLT PANEL WIDE FACE LIFTING DEVICE								
panel width W/ H [ft] (m)	panel length L [ft] (m)	unplaned panel thickness ¹ T [in] (mm)	panel weight ² [lbs] (kg)	design load ³ [lbf] (kN)	required lifting points	Steel plate ⁴	# of screws per STP	type of screws [in] (mm)
8 (2.45)	18.5 - 27.7 (5.6 - 8.45)	3 ply: 4.14 (105)	2490 (1130)	3560 (15.8)	4	STP FL CLT	2	SWG ASSY® Kombi 1/2" x 4" (12 x 100 / 60)
		5 ply: 6.89 (175)	3940 (1790)	5620 (25.0)		STP FL CLT	2	SWG ASSY® Kombi 1/2" x 6-1/4" (12 x 160 / 145)
		7 ply: 9.65 (245)	5730 (2600)	8180 (36.4)		STP FL CLT	2	
		9 ply: 12.41 (315)	7290 (3310)	10410 (46.3)		STP FL CLT	4	
	27.8 - 40 (8.5 - 12.2)	3 ply: 4.14 (105)	3600 (1630)	5140 (22.8)		STP FL CLT	2	SWG ASSY® Kombi 1/2" x 4" (12 x 100 / 60)
		5 ply: 6.89 (175)	5690 (2580)	8120 (36.1)		STP FL CLT	2	SWG ASSY® Kombi 1/2" x 6-1/4" (12 x 160 / 145)
		7 ply: 9.65 (245)	8280 (3750)	11820 (52.5)		STP FL CLT	4	
		9 ply: 12.41 (315)	10530 (4780)	15030 (66.8)		STP FL CLT	4	
10 (3.05)	18.5 - 27.7 (5.6 - 8.45)	3 ply: 4.14 (105)	3100 (1410)	4430 (19.7)	4	STP FL CLT	2	SWG ASSY® Kombi 1/2" x 4" (12 x 100 / 60)
		5 ply: 6.89 (175)	4900 (2220)	7000 (31.1)		STP FL CLT	2	SWG ASSY® Kombi 1/2" x 6-1/4" (12 x 160 / 145)
		7 ply: 9.65 (245)	7140 (3240)	10190 (45.3)		STP FL CLT	4	
		9 ply: 12.41 (315)	9080 (4120)	13000 (57.6)		STP FL CLT	4	
	27.8 - 40 (8.5 - 12.2)	3 ply: 4.14 (105)	4480 (2030)	6390 (28.4)		STP FL CLT	4	SWG ASSY® Kombi 1/2" x 4" (12 x 100 / 60)
		5 ply: 6.89 (175)	7080 (3210)	10110 (44.9)		STP FL CLT	4	SWG ASSY® Kombi 1/2" x 6-1/4" (12 x 160 / 145)
		7 ply: 9.65 (245)	10300 (4670)	14710 (65.4)		STP FL CLT	4	

Note: ¹ unplaned thickness: planed panel thickness increased by 1/4" (6mm) in summary

² weight is calculated by using the longest panel length of each section

³ design values are based on dynamic load factor 1.4

⁴ STP : steel plate NEL : narrow edge lifting



SECTION 4: CLT PANEL LIFTING DEVICES

STEEL PLATES AND SWG ASSY® KOMBI SCREWS

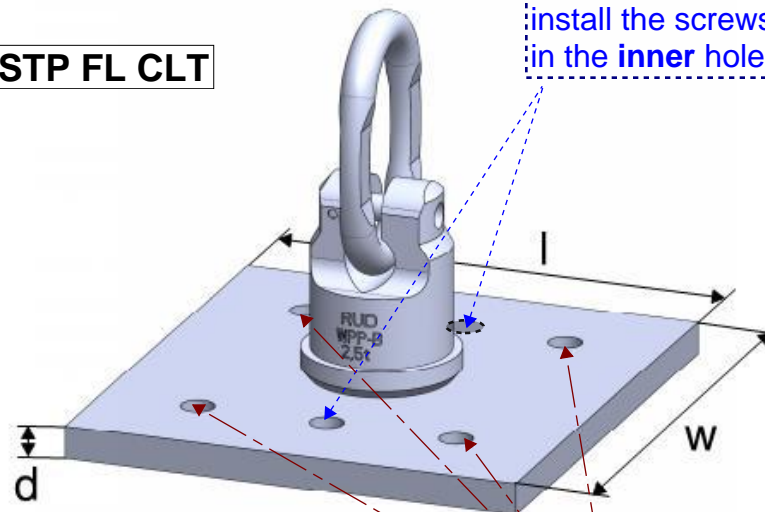
Steel plate types for face lifting

Table 4.9: steel plate for lifting on the wide face—all CLT panel sizes

STP FL CLT		
Steel plate for lifting on the wide face - all CLT panel sizes		
Length l	Width w	Depth d
in		
7	7-1/2	1/2
mm		
178	190.5	12.5



STP FL CLT



When **2 screws** on each steel plate STP FL CLT are required install the screws in the **inner** holes

When **4 screws** on each steel plate STP FL CLT are required install the screws in the **outer** holes