

CROSS LAMINATED TIMBER DESIGN GUIDE



Introduction

Cross Laminated Timber (CLT) has been manufactured in Europe for over a decade. CLT is a revolutionary building system that substitutes for concrete, masonry and steel in some applications. Ideal for floors, walls, and roofs, CLT has been described as the perfect structural solution.

Structurlam has created its own line of Cross Laminated Timber called CrossLam. Using layers of locally sourced softwood stacked at right angles and glued together, CrossLam provides load distribution and dimensional stability in all directions.

With its cross-layered construction, reduced carbon footprint, formaldehyde free adhesive and ready to assemble system, CrossLam™ is the green choice for schools, health care facilities public buildings, commercial buildings, and multi-family housing.

The contents of this guide provide technical information to allow architects and engineers to specify CrossLam.

Carbon Footprint

The environmental benefits of CrossLam speak for themselves. Because CrossLam is made of wood, it possesses a number of inherent positive environmental characteristics common to all wood products.

According to life cycle assessment studies, these include carbon storage, lower greenhouse gas emissions during the manufacturing process, and an overall lighter environmental footprint than non-wood materials.

Our Approach

Structurlam's CrossLam has all the advantages of prefabricated buildings in addition to the Structurlam Advantage:

- Our state of the art manufacturing facility allows us to efficiently produce large volumes of world class, certified panels.
- Our planer can finish smooth all 4 sides to expose panel surfaces and ensure a perfect fit.
- Our Design Team can provide fully engineered design solutions for floors, roof, walls, and all connection details.
- Our Installation Partners can install any size of project.
- We manufacture panels using environmentally friendly resins that are free from formaldehyde and colour.
- The Structurlam Team is here to make your project a success.



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Benefits of CrossLam™

CrossLam has many of the benefits that other building materials just don't have.

- Up to 6 times lighter than concrete.
- Dimensional stability and static strength in all directions.
- Cost competitive against steel and concrete.
- Reduced construction time.
- Space creator, 1/3 thinner than concrete.
- Less demand for skilled workers on site.

Technical Approvals

CrossLam™ is certified to meet the requirements of the Standard for Performance Rated CLT ANSI/ APA PRG 320. **APAEWS**



FLOOR SLAB COMPARISON CROSSLAM VS. CONCRETE

MAX SPANS (m)	CrossLam PANEL THICKNESS (mm)	SLAB THICKNESS REQUIRED (mm)	RATIO CLT/CONC THICKNESS (%)	VIBRATION CONTROLLED SPAN (m)	CONCRETE SLAB ONE END CONT dx24 (m)
SLT3	99	150	66	3.5	2.4
SLT5	169	200	85	4.9	4.1
SLT7	239	260	92	6.2	5.8
SLT9	309	310	100	7.4	7.4

Text in *red* indicates CrossLam thickness advantage.

Architects and Designers can design with freedom.

Engineers receive a strong, stable building.

General Contractors receive a predictable experience onsite.

Owners receive a green building that is on budget and on time.

Panel Properties

Limit States Design (LSD) Bending Resistances^(a) for Structurlam CrossLam

CLT Grade ^(b)	Name	Layers	Depth (mm)	Weight (lbs) per sq. ft	Weight (kg) per sq. metre	Major Strength Direction				Minor Strength Direction			
						$F_b S_{eff,0}$ (10 ⁶ N-mm/m)	$EI_{eff,0}$ (10 ⁹ N-mm ² /m)	$GA_{eff,0}$ (10 ⁶ N/m)	$V_{r,0}$ (kN/m)	$F_b S_{eff,0}$ (10 ⁶ N-mm/m)	$EI_{eff,0}$ (10 ⁹ N-mm ² /m)	$GA_{eff,0}$ (10 ⁶ N/m)	$V_{r,0}$ (kN/m)
V2M1	SLT3	3 layers	99	10.5	51.2	16	735	7.0	32	2.40	34	7.5	12
	SLT5	5 layers	169	17.0	83.0	37	2,968	15	44	21	883	15	34
	SLT7	7 layers	239	25.0	122.0	67	7,559	22	56	48	3,360	23	46
	SLT9	9 layers	309	32.0	156.2	105	15,351	30	68	84	8,282	30	58

- (a) Tabulated values are Limit States design values and not permitted to be increased for the lumber size adjustment factor in accordance with CSA O86.
- (b) The CLT grades are developed based on ANSI/APA PRG 320, as permitted by the standard using all visually graded No. 2 SPF lumber in both major and minor strength directions.

Specified Strengths and Modulus of Elasticity^(a) for Structurlam CrossLam CLT

CLT Grade	Major Strength Direction						Minor Strength Direction					
	$f_{b,0}$ (MPa)	E_0 (MPa)	$f_{t,0}$ (MPa)	$f_{c,0}$ (MPa)	$f_{v,0}$ (MPa)	$f_{s,0}$ (MPa)	$f_{b,90}$ (MPa)	E_{90} (MPa)	$f_{t,90}$ (MPa)	$f_{c,90}$ (MPa)	$f_{v,90}$ (MPa)	$f_{s,90}$ (MPa)
V2M1	11.8	9,500	5.5	11.5	1.5	0.50	11.8	9,500	5.5	11.5	1.5	0.50

- (a) Tabulated values are Limit States design values and not permitted to be increased for the lumber size adjustment factor in accordance with CSA O86. The design values shall be used in conjunction with the section properties provided by the CLT manufacturer based on the actual layup used in manufacturing the CLT panel (see Table above).



Panel Properties

Maximum Panel Size	3.0m x 12.2m (10' X 40')
Maximum Planed Panel Size	2.4m x 12.2m (8' x 40')
Maximum Thickness	309 mm
Production Widths	2.4m & 3.0m (8' & 10')
Panel Edges:	¼" chamfer on long edges
Moisture Content	12% (+/-2%) at time of production
Glue Specifications	Purbond polyurethane adhesive
Wood Species	SPF No.1/No. 2, other species available upon request
Squareness	Panel face diagonals shall not differ by more than 3.2mm
Straightness	Deviation of edges from a straight line between adjacent panel corners shall not exceed 1.6 mm
Dimensional Tolerances	
Thickness:	+/- 1.6mm (1/16") or 2% of the CrossLam thickness whichever is greater
Width:	+/- 1.6 mm (1/16") per foot (305 mm) of CrossLam width
Length:	+/- 3.2 mm (1/8") up to 6100 mm (20 ft) and +/- 3.2 mm (1/8") for each additional 6100 mm (20 ft) in length

Appearance Classification

Visual

- *Intended use:* A structural CLT panel that is used where one or both faces are left exposed.
- *Internal Fibre Layers:* SPF, NLGA Standard Grading Rules "No. 2 Structural" characteristics.
- *Face Layer:* SPF, "J" Grade (Japanese Grade), Douglas-fir (L3 Grade).

Allowable Fibre Characteristics

- *Shake and checks:* Several up to 2 feet long, none through.
- *Stain:* Up to a max of 5% blue stain, heart stain allowed.
- *Knots:* Firm & Tight (NLGA #2) .
- *Pitch Streaks:* Not limited.
- *Wane on Face:* None.
- *Side Pressure on Visual Face:* Yes.

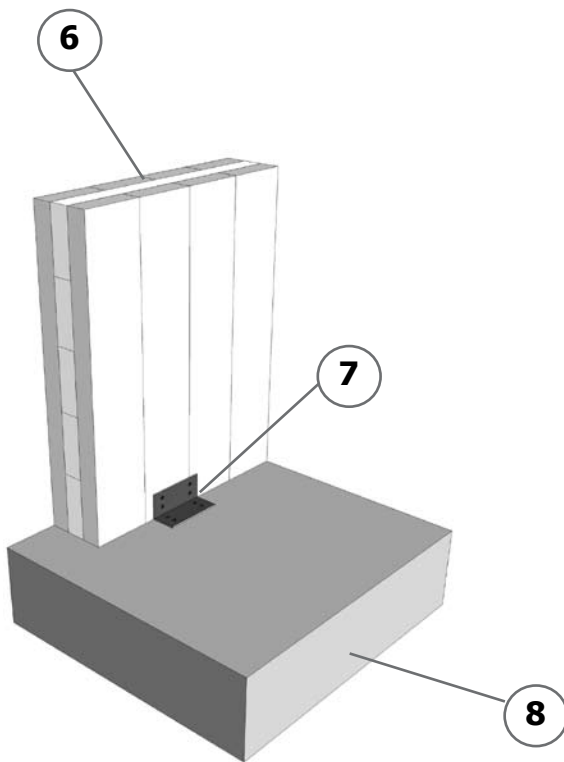
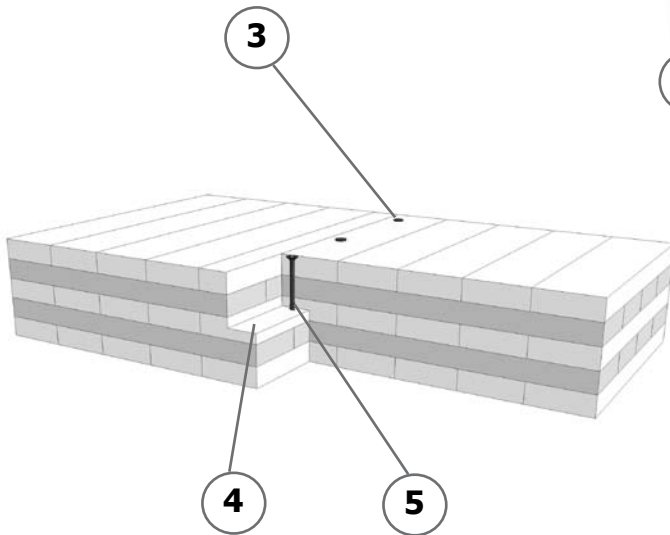
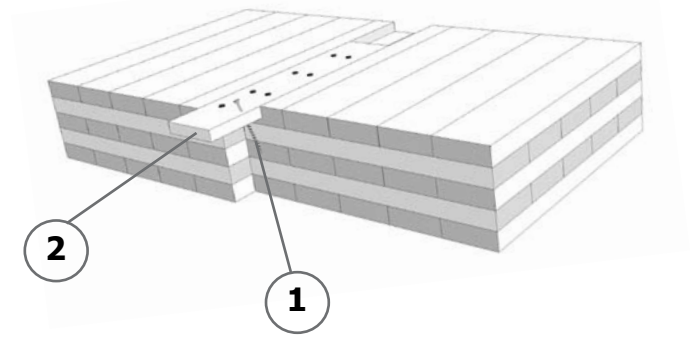
Non-Visual

- *Intended Use:* A structural CLT panel that is used where both faces are covered by another material.
- *Internal Fibre Layers:* SPF, NLGA Standard Grading Rules "No. 2 Structural" characteristics.
- *Face Layer:* SPF, NLGA Standard Grading Rules "No. 2 Structural" characteristics.

Allowable Fibre Characteristics

- *Shake and checks:* Allowed, shall not exceed 3' or ¼ the length.
- *Stain:* Allowed, not limited.
- *Knots:* Firm & Tight (NLGA #2).
- *Pitch Streaks:* Not limited.
- *Wane on Face:* Minimal.
- *Side Pressure on Faces:* None.

Connection Details - Floor/Roof Panel Joints

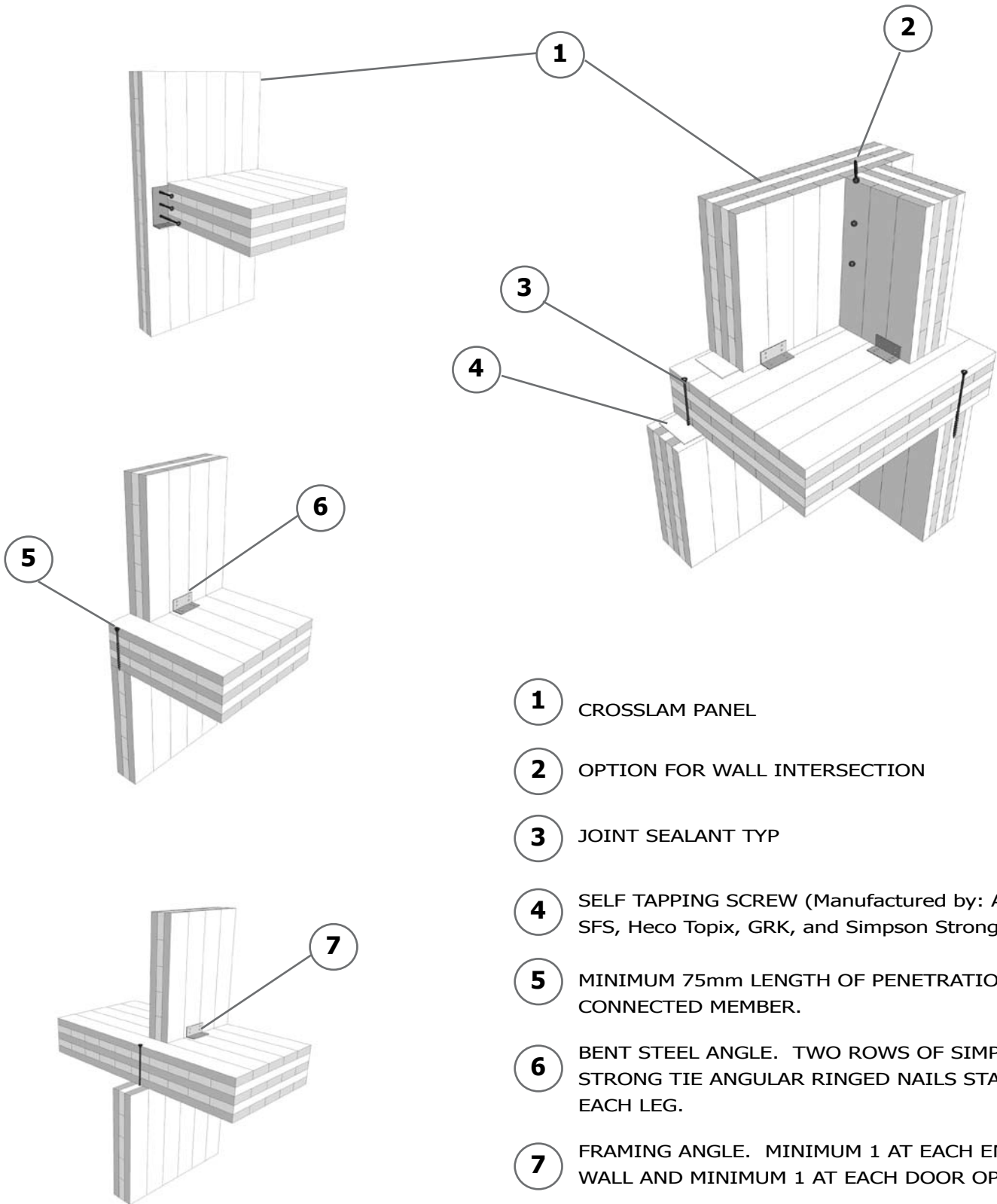


BASE POINT SOLE BRACKET

- 1** ONE ROW OF SELF TAPPING SCREWS ON EACH SIDE OF JOINT INSERTED AT AN ANGLE OF 15 DEGREES.
- 2** PLYWOOD SPLINE IS 25mm THICK x 130mm WIDE.
- 3** ONE ROW OF SELF TAPPING SCREWS.
- 4** CONFIRM 90mm OVERLAP.
- 5** SHEAR FORCE TRANSMISSION FROM PANEL TO PANEL. SCREW SIZE AND SPACING AS REQUIRED FOR APPLICATION.
- 6** CROSSLAM PANEL.
- 7** BENT STEEL ANGLE. TWO ROWS OF CONCRETE SCREWS FOR SHEAR FORCE TRANSMISSION.
- 8** CONCRETE COMPONENT (WALL, CEILING, SLAB).

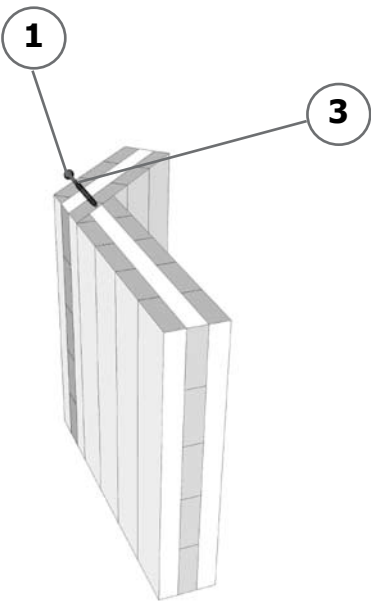
Connection Details - Panel to Panel

TYPICAL WALL TO FLOOR CONNECTIONS



- 1** CROSSLAM PANEL
- 2** OPTION FOR WALL INTERSECTION
- 3** JOINT SEALANT TYP
- 4** SELF TAPPING SCREW (Manufactured by: Assy, SFS, Heco Topix, GRK, and Simpson Strong Tie).
- 5** MINIMUM 75mm LENGTH OF PENETRATION INTO CONNECTED MEMBER.
- 6** BENT STEEL ANGLE. TWO ROWS OF SIMPSON STRONG TIE ANGULAR RINGED NAILS STAGGER EACH LEG.
- 7** FRAMING ANGLE. MINIMUM 1 AT EACH END OF WALL AND MINIMUM 1 AT EACH DOOR OPENING.

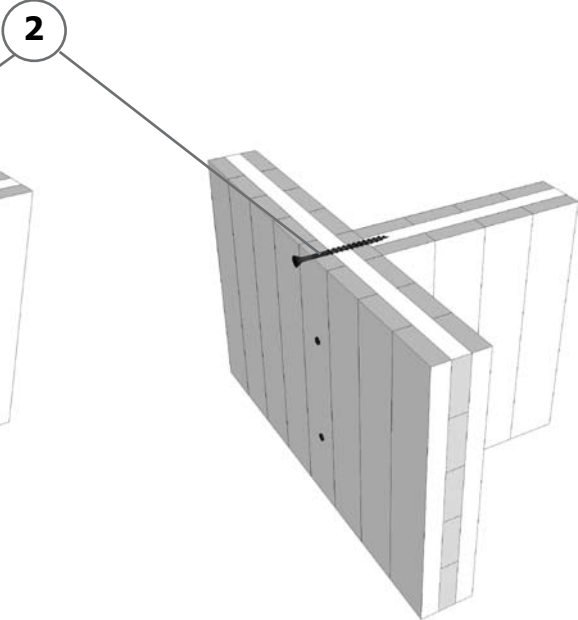
Connection Details - Panel to Panel



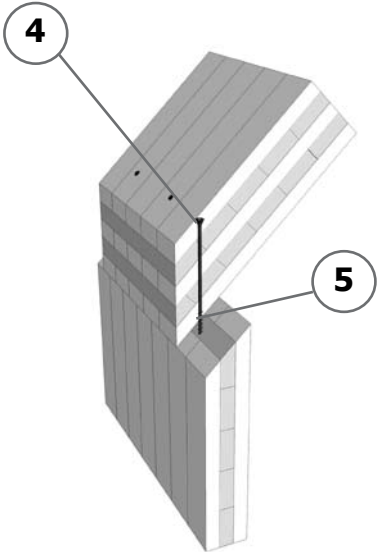
ANGLE WALL JOINT



CORNER WALL JOINT



T-WALL JOINT



ROOF EXTERNAL WALL JOINT

- 1 SELF TAPPING SCREW.
- 2 MINIMUM 75mm LENGTH OF PENETRATION INTO CONNECTED MEMBER.
- 3 EFFECTIVENESS OF SCREW CONNECTIONS DIMINISH FOR VERY SHALLOW ANGLES.
- 4 SCREWS ABSORB SHEAR FORCES PARALLEL TO BEARING OR WIND SUCTION FORCES.
- 5 FOR INCREASED FORCES TOWARDS THE INSIDE USE FULLY THREADED SCREWS.

Roof

CrossLam Roof Panel Load Table									
	MAX. SPAN (mm)		ROOF SNOW LOAD (kPa, unfactored)						
	PANEL TYPE	SIZE (mm)	1.1	1.6	2.2	2.9	3.3	8.5	
single span	SLT3	99	4450	4120	3820	3550	3420	2510	
	SLT5	169	6800	6360	5950	5570	5390	4050	
	SLT7	239	8920	8420	7920	7450	7220	5520	
	SLT9	309	10900	10330	9770	9230	8970	6940	
double span	SLT3	99	5400	4950	4550	4200	4050	2900	
	SLT5	169	<i>Double span is governed by maximum panel length of 12,190mm - design as simple span using table values above.</i>						4650
	SLT7	239							6095
	SLT9	309							

Notes:

- Material is S-P-F No. 1/No. 2 for all laminations.
- Outer laminations are 32mm thick; inner laminations are 35mm thick.
- Specified modulus of elasticity and strength in major strength direction:
 $E_0 = 9500 \text{ MPa}$; $f_{b,0} = 11.8 \text{ MPa}$; $f_{v,0} = 1.5 \text{ MPa}$; $f_{vr,0} = 0.5 \text{ MPa}$; $f_{c,0} = 11.5 \text{ MPa}$; $f_{t,0} = 5.5 \text{ MPa}$
 (ref: Table 5.3.1A of CSA-O86-09).
- Specified modulus of elasticity and strength in minor strength direction:
 $E_{90} = 9500 \text{ MPa}$; $f_{b,90} = 11.8 \text{ MPa}$; $f_{v,90} = 1.5 \text{ MPa}$; $f_{vr,90} = 0.5 \text{ MPa}$;
 (ref: Table A3 ANSI/APA PRG 320).
- Dead load includes panel self-weight plus 0.5 kPa roofing load.
- Maximum span is governed by dead plus snow load deflection limit of $L/300$.
- All spans are assumed to be equal for multi-span panels.
- Spans shown represent distance between the centerlines of supports.
- Maximum spans shown are only to be used for preliminary design.
- Engineer to ensure that $L/300$ deflection limit is appropriate for intended use.
- The following factors were used for calculations: $K_D = 1.0$; $K_S = 1.0$; $K_T = 1.0$; $K_H = 1.0$.
- Shear stiffness has been reduced by 50% to account for creep deformation.
- Snow load is based on BCBC 2006 with the following factors:
 $I_s = 1.0$ for ULS; $I_s = 0.9$ for SLS; $C_w = 1.0$; $C_s = 1.0$; $C_a = 1.0$.



Floor

<i>CrossLam Floor Panel Load Table</i>							
	MAX. SPAN (mm)		FLOOR LIVE LOAD (kPa, unfactored)				
	PANEL TYPE	SIZE (mm)	1.9 RESIDENTIAL	2.4 OFFICE/ CLASSROOM	3.6 MECHANICAL ROOM	4.8 ASSEMBLY/ STORAGE	7.2 LIBRARY
single span	SLT3	99	3490	3490	3220	2980	2650
	SLT5	169	4920	4920	4920	4730	4220
	SLT7	239	6200	6200	6200	6200	5720
	SLT9	309	7370	7370	7370	7370	7180
double span	SLT3	99	3700	3700	3650	3350	2920
	SLT5	169	5150	5150	5150	5150	4650
	SLT7	239	<i>Double span is governed by maximum panel length of 12,190mm - design as simple span using table values above.</i>				6095
	SLT9	309					

<i>CrossLam Floor Panel Load Table with 2" (50mm) Concrete Topping</i>							
	MAX. SPAN (mm)		FLOOR LIVE LOAD (kPa, unfactored)				
	PANEL TYPE	SIZE (mm)	1.9 RESIDENTIAL	2.4 OFFICE/ CLASSROOM	3.6 MECHANICAL ROOM	4.8 ASSEMBLY/ STORAGE	7.2 LIBRARY
single span	SLT3	99	3350	3230	2990	2800	2520
	SLT5	169	4920	4920	4730	4450	4030
	SLT7	239	6200	6200	6200	6020	5480
	SLT9	309	7370	7370	7370	7370	6890
double span	SLT3	99	3700	3700	3420	3180	2820
	SLT5	169	5150	5150	5150	5050	4500
	SLT7	239	<i>Double span is governed by maximum panel length of 12,190mm - design as simple span using table values above.</i>				6095
	SLT9	309					

Notes:

1. Material is S-P-F No.1/No.2 for all laminations.
2. Outer laminations are 32mm thick; inner laminations are 35mm thick.
3. Specified modulus of elasticity and strength in major strength direction:
 $E_o = 9500 \text{ MPa}$; $f_{b,o} = 11.8 \text{ MPa}$; $f_{v,o} = 1.5 \text{ MPa}$; $f_{vr,o} = 0.5 \text{ MPa}$; $f_{c,o} = 11.5 \text{ MPa}$; $f_{t,o} = 5.5 \text{ MPa}$
 (ref: Table 5.3.1A of CSA-O86-09).
4. Specified modulus of elasticity and strength in minor strength direction:
 $E_{90} = 9500 \text{ MPa}$; $f_{b,90} = 11.8 \text{ MPa}$; $f_{v,90} = 1.5 \text{ MPa}$; $f_{vr,90} = 0.5 \text{ MPa}$;
 (ref: Table A3 ANSI/APA PRG 320).
5. Dead load includes panel self-weight plus 1.0 kPa flooring load.
6. **Bold text** indicates span governed by vibration; regular text indicates span governed by dead plus live load deflection limit of L/300.
7. All spans are assumed to be equal for multi-span panels.
8. Spans shown represent distance between the centerlines of supports.
9. Maximum spans shown are only to be used for preliminary design.
10. Engineer to ensure that L/300 deflection limit is appropriate for intended use.
11. The following factors were used for calculations: $K_D = 1.0$; $K_S = 1.0$; $K_T = 1.0$; $K_H = 1.0$.

Wall

CrossLam Wall Panel Load Table (Axial Loading Only)					
Panel d (mm)	SLT3 99	SLT5 169	SLT7 239	SLT9 309	
L (m)	Pr (kN/m)				
2.0	385	699	949	1179	
2.5	332	650	904	1134	
3.0	276	599	861	1093	
3.5	223	547	818	1054	
4.0	178	494	773	1014	
4.5	143	442	728	975	
5.0	114	392	681	934	
5.5		345	633	893	
6.0		303	587	851	
6.5		265	541	808	
7.0		232	496	764	
7.5		203	454	721	
8.0		177	415	678	
8.5				378	637
9.0				344	596

Notes:

- $P_r = \Phi F_{cb} A K_{zc} K_c$
- Material is S-P-F No.1/No.2 for all laminations.
- Outer laminations are 32mm thick; inner laminations are 35mm thick.
- Specified modulus of elasticity and strength in major strength direction:
 $E_o = 9500 \text{ Mpa}$; $f_{b,o} = 11.8 \text{ Mpa}$; $f_{v,o} = 1.5 \text{ Mpa}$; $f_{vr,o} = 0.5 \text{ Mpa}$; $f_{c,o} = 11.5 \text{ Mpa}$; $f_{t,o} = 5.5 \text{ Mpa}$
 (ref: Table 5.3.1A of CSA 086-09).
- Specified modulus of elasticity and strength in minor strength direction:
 $E_{90} = 9500 \text{ Mpa}$; $f_{b,90} = 11.8 \text{ Mpa}$; $f_{v,90} = 1.5 \text{ Mpa}$; $f_{vr,90} = 0.5 \text{ Mpa}$
 (ref: Table A3 ANSI/APA PRG 320).
- Wind load has not been included.
- Where the P_r values are not given, the slenderness ratio exceeds 50 (maximum permitted; CSA 086-09).
- The following factors were used for calculations: $K_D=0.65$; $K_S=1.0$; $K_T=1.0$; $K_H=1.0$; $K_e=1.0$.
- Eccentricity of axial load has not been included.
- Table values are to be used for preliminary design only.

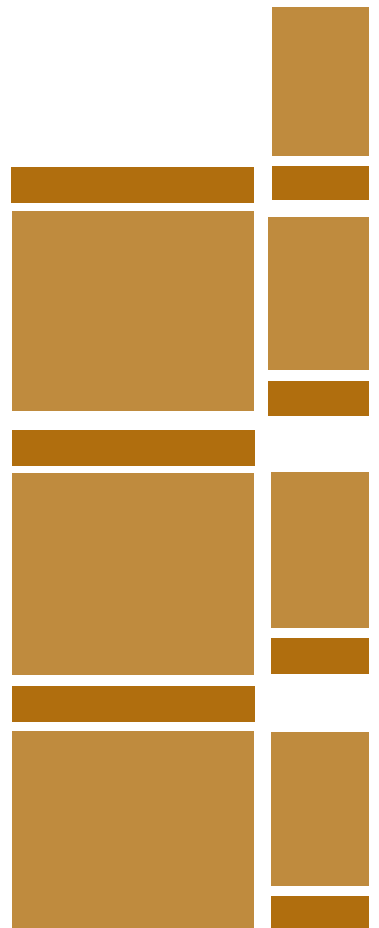


Shear Wall and Diaphragm Applications

CrossLam In-Plane Shear Loading				
Panel d (mm)	SLT3 99	SLT5 169	SLT7 239	SLT9 309
	Vr (kN/m)			
	95	190	285	380

Notes:

1. Computed values based on *"In-Plane Shear Capacity and Verification Methods"* by Prof. G. Schickhofer, University of Graz.
2. Material is S-P-F No. 1/No. 2 for all laminations.
3. Outer laminations are 32mm thick; inner laminations are 35mm thick.
4. Specified modulus of strength: $f_{v,ct,k} = 5.0$ Mpa; $f_{t,ct,k} = 2.5$ Mpa
ref: *"BSPhandbuch Holz-Massivbauweise in Brettsperrholz"* Technical University of Graz).
5. The following factors were used for calculations: $k_{mod} = 0.8$; $\gamma_m = 1.25$.
6. Minimum width of wood used in lay-up is 89mm.
7. Values are for SLT panel only, not for shear connectors.
8. Table values are to be used for preliminary design only.





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