Design

DESIGN

Floor and roof slabs	Cross laminated timber (« CLT ») panels are typically designed in single direction, which results in most cases in a conservative solution. The designer must ensure to use an appropriate deflection criteria and consider the effects of floor vibration when applicable.
Shearwalls and diaphragms	Design of CLT shearwalls and diaphragms shall be conducted using the methods of mechanics, assuming the CLT wall and diaphragm panels and segments as rigid bodies. The seismic force modification factors R_d of 2.0 and R_0 of 1.5 are recommended. For more details, refer to Chapter 4 of CLT Handbook.
Wall panels	Only the layers parallel to the axial load shall be taken into account. The shear resistances for shear walls and lintels are based on a reseach project at the Graz University of Technology[1].
Lintel design	CLT elements under axial in-plane loads acting as deep beams or lintels may be designed using the strengths shown below and an effective cross-section based on the layers perpendicular to the load.
DOL and creep	The equation specified in Clause 4.3.2.3 of CSA O86-09 shall be used for calculating the duration of load factor, K_D. The use of a 25% reduction in shear stiffness is recommended when checking the elastic deflection limit under total load and a 50% reduction in shear stiffness for the permanent deformation limit in order to account for the deformations caused by shear perpendicular to grain (rolling shear). These factors have been considered in the selection tables.
Deflection	The designer is advised to check the elastic deflection and permanent deformation for CLT slab elements as to not exceed the total load deflection limit in the code.
Vibration design	The designer is advised to check the maximum floor vibration for CLT slab elements. The proposed design method for controlling vibrations in CLT floors is based on a research project at the Technical University of Munich[2].
Fire resistant design	The fire-resistance rating of CLT panels can be calculated using the reduced (or effective) cross-section method and the use of the published design values. For more details, refer to Chapter 8 of CLT Handbook.

CHARACTERISTICS

Material design properties

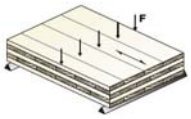
Stress grade	E1	
Orientation	Longitudinal	Transversal
Species group	S-P-F	S-P-F
Stress class	1950F_b MSR	No. 3/Stud
Bending at extreme fibre, f_b (MPa)	28,2	7,0
Longitudinal shear, f_v (MPa)	1,5	1,5
Rolling shear, f_s (MPa)	0,5	0,5
Compression parallel to grain, f_c (MPa)	19,3	9,0
Compression perp. to grain, f_{cp} (MPa)	5,3	5,3
Tension parallel to grain, f_t (MPa)	15,4	3,2
Modulus of elasticity, E_0 (MPa)	11 700	9 000
Shear modulus, G_0 (MPa)	731	563
Rolling shear modulus, G_s (MPa)	73,1	56,3

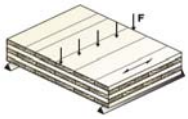
[1] Bogensperger T., Moosbrugger T., Silly G., Verification of CLT-plates under loads in plane. WCTE 2010
[2] Hamm P.,Richter A., Winter S. Floor vibrations - new results. WCTE 2010

Design Properties, Nordic X-Lam

FACTORED RESISTANCES AND RIGIDITIES - floor/roof slabs

Product	Nordic X-Lam							
Application	Floor and roof slabs							
Appearance grades	Industrial or architectural							
Stress grade	E1 (L 1950F_b and T No. 3/Stud)							
Layup Combinations	78-3s	105-3s	131-5s	175-5s	220-7s	244-7s	244-7l	314-9l
Bending about the major strength axis								
Bending moment, $M_{r,0}$ (10^6 N-mm/m)	21	38	49	87	134	154	199	308
Shear, $V_{r,0}$ (10^3 N/m)	23	30	31	42	51	53	68	82
Bending rigidity, $EI_{eff,0}$ (10^9 N-mm^2/m)	452	1081	1735	4140	8019	10240	13194	26272
Shear rigidity, $GA_{eff,0}$ (10^6 N/m)	5,4	7,3	11	15	22	22	31	37
Bending about the minor strength axis								
Bending moment, $M_{r,90}$ (10^6 N-mm/m)	0,76	1,3	6,4	11	18	42	11	25
Shear, $V_{r,90}$ (10^3 N/m)	8,0	10	23	30	33	115	30	41
Bending rigidity, $EI_{eff,90}$ (10^9 N-mm^2/m)	14	32	363	831	1884	3163	831	3163
Shear rigidity, $GA_{eff,90}$ (10^6 N/m)	6,9	9,0	14	18	22	28	28	37





(1) The tabulated design values are for dry service conditions and standard term duration of load. The factored resistance values, M_r and V_r, include the resistance factor, ϕ.
(2) Nordic X-Lam bending panels are symmetrical throughout the thickness of the member (balanced layups).
(3) The compression perpendicular to grain values shall be based on S-P-F No. 3/Stud lumber (f_{cp} = 5.3 MPa).
(4) The factored resistances were derived analytically using the shear analogy model[3] and validated by testing (the calculated moment resistances in the major strength axis were further multiplied by a factor of 0.85 for conservatism). The design of cross-laminated timber members shall be in accordance to CSA O86-09 and the CLT Handbook.
(5) The specific gravity for dowel-type fastener design, G, is 0.42. Member weight shall be based on density of 515 kg/m^3 (5.1 kN/m^3).
* Nordic X-Lam products are certified by APA (Product Report PR-L306C), per the ANSI/APA PRG 320 Standard.

PANEL LAYUPS

Product	Composition (L = longitudinal, T = transversal)	Number of plies	Thickness (mm)	Thickness (in.)	Weight (kPa)
78-3s	26L - 27T - 26L	3	78	3 1/8	0,40
105-3s	35L - 35T - 35L	3	104	4 1/8	0,53
131-5s	26L - 27T - 26L - 27T - 26L	5	131	5 1/8	0,67
175-5s	35L - 35T - 35L - 35T - 35L	5	175	6 7/8	0,89
220-7s	35L - 27T - 35L - 27T - 35L - 27T - 35L	7	220	8 5/8	1,12
244-7l	35L - 35L - 35T - 35L - 35T - 35L - 35L	7	244	9 5/8	1,24
314-9l	35L - 35L - 35T - 35L - 35T - 35L - 35T - 35L - 35L	9	314	12 3/8	1,60

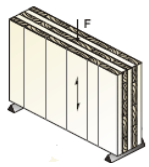
Note: The grade designation refers to the panel thickness (in mm), the number of layers, and the layup combination ("s" for standard perpendicular layers, and "l" for doubled outermost parallel

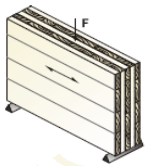
[3] Gagnon, S. and M. Popovski. 2011. CLT Handbook. FPInnovations, Canada. Chapter 3.

Design Properties, Nordic X-Lam (continued)

FACTORED RESISTANCES AND RIGIDITIES - walls and lintels

Product	Nordic X-Lam							
Application	Walls and Lintels							
Appearance grades	Industrial or Architectural							
Stress grade	E1 (L 1950F_b and T No. 3/Stud)							
Layup Combinations	78-3s	105-3s	131-5s	175-5s	220-7s	244-7s	244-7l	314-9l
Loaded to major strength axis								
Compression, $P_{r,0}$ (10^3 N/m)	797	1078	1195	1618	2157	2157	2696	3235
Tension, $T_{r,0}$ (10^3 N/m)	715	968	1073	1452	1936	1936	2420	2904
Effective area, A_{eff} (10^3 mm^2/m)	52	70	77	105	140	140	175	210
Effective inertia, I_{eff} (10^6 mm^4/m)	39	92	147	351	680	866	1125	2236
Radius of gyration, r_{eff} (mm/m)	27	36	44	58	70	79	80	103
In-plane shear, $V_{r,0}$ (10^3 N/m)	86	95	168	190	257	284	284	379
Loaded to minor strength axis								
Compression, $P_{r,90}$ (10^3 N/m)	193	251	386	503	579	754	503	754
Tension, $T_{r,90}$ (10^3 N/m)	77	101	154	201	232	302	201	302
Effective area, A_{eff} (10^3 mm^2/m)	27	35	54	70	80	105	70	105
Effective inertia, I_{eff} (10^6 mm^4/m)	1,6	3,5	40	92	209	351	92	351
Radius of gyration, r_{eff} (mm/m)	7,7	10	27	36	51	58	36	58
In-plane shear, $V_{r,90}$ (10^3 N/m)	86	95	168	190	257	284	284	379





(1) The tabulated design values are for dry service conditions and standard term duration of load. The factored resistance values, P_r, T_r and V_r, include the resistance factor, ϕ.
(2) Nordic X-Lam bending panels are symmetrical throughout the thickness of the member (balanced layups).
(3) The compression parallel to grain resistance values, P_r, shall be adjusted by the size and slenderness factors, K_{ZC} and K_C, respectively, as defined in CSA O86-09.
(4) The compression perpendicular to grain values shall be based on S-P-F No. 3/Stud lumber (f_{cp} = 5.3 MPa).
(5) The bending moment resistance and stiffness shall be based on S-P-F No. 3/Stud (fb = 7.0 MPa, E = 9000 MPa) or S-P-F MSR 1950F_b (f_b = 28.2 MPa, E = 11,700 MPa) lumber for vertical or horizontal panel, respectively, and an effective cross-section based on the layers perpendicular to the load.
(6) The in-plane shear resistances, V_r, are given in kN/m of member height. These values are based on the TUGraz study with the specified strengths $f_{v,clt,k}$ = 5.0 MPa and $f_{t,clt,k}$ = 2.5 MPa, adjusted with the following factors: k_{mod} = 0.8 and γ_M = 1.25. *(Ref. BSPhandbuch, TUGraz)*
(7) The design of cross-laminated timber members shall be in accordance to CSA O86-09 and the CLT Handbook.
(8) The specific gravity for dowel-type fastener design, G, is 0.42. Member weight shall be based on density of 515 kg/m^3 (5.1 kN/m^3).
* Nordic X-Lam products are certified by APA (Product Report PR-L306C), per the ANSI/APA PRG 320 Standard.