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.
Shear walls and diaphragms	Capacity design principles are recommended for design of CLT for seismic resistance to ensure predictable yielding in CLT wall panels and interconnection of CLT elements through fastener yielding, wood crushing, or a combination thereof prior to onset of undesirable brittle wood failure modes. The recommended seismic design coefficients values are R = 2.0, Ω_0 = 1.4, and C_d = 2.0. For more details refer to Chapter 4 of CLT Handbook, U.S. Edition.
Wall panels	Only the layers parallel to the axial load shall be taken into account. The shear capacities 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 capacities shown below and an effective cross-section based on the layers perpendicular to the load.
Duration of load	It is recommended to use the load duration factor, C_D, for ASD as specified in Table 2.3.2 of ANSI/AWC NDS-2012.
Creep	The current factor specified in ANSI/AWC NDS-2012 does not account for creep that may occur in CLT. Therefore, the time dependent deformation (creep) factor K_{cr} = 2.0 is recommended for dry service conditions. A creep factor K_{cr} = 2.5 is suggested for wet service conditions, although it is strongly recommended to consult with Nordic before using any CLT product in conditions other than dry service.
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 (Table 1604.3 of the 2012 IBC).
Vibration design	The designer is advised to check the maximum floor vibrations 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, U.S. Edition.

CHARACTERISTICS

Material design properties

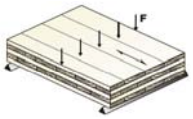
Stress grade	E1	
Orientation	Longitudinal	Transversal
Species group	S-P-F	S-P-F
Stress class	1950f MSR	No. 3
Bending at extreme fibre, F_b (psi)	1950	500
Shear parallel to grain, F_v (psi)	135	135
Rolling shear, F_s (psi)	45	45
Compression parallel to grain, F_c (psi)	1800	650
Compression perp. to grain, F_{cp} (psi)	425	425
Tension parallel to grain, F_t (psi)	1375	250
Modulus of elasticity, E_0 (psi)	1700000	1200000
Shear modulus, G_0 (psi)	106250	75000
Rolling shear modulus, G_s (psi)	10625	7500

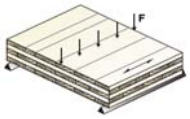
[1] Bogensperger T., Moosbrugger T., Silly G., Verification of CLT-plates under loads in plane. WCTE 2010
[2] Hamm P.,Richter A., Winter S. Floor vibrations - new results. WCTE 2010

Design Properties, Nordic X-Lam

DESIGN PROPERTIES - 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_0 (lbf-ft/ft)	2525	4525	5800	10400	15975	18375	23700	36700
Shear, V_0 (lbf/ft)	1070	1430	1470	1970	2400	2490	3200	3875
Bending rigidity, $EI_{eff,0}$ (10^6 lbf-in.^{2}/ft)	48	115	184	440	853	1089	1404	2794
Shear rigidity, $GA_{eff,0}$ (10^6 lbf/ft)	0,34	0,46	0,69	0,92	1,4	1,4	2,0	2,4
Bending about the minor strength axis								
Bending moment, M_{90} (lbf-ft/ft)	95	160	785	1370	2160	5200	1370	3125
Shear, V_{90} (lbf/ft)	380	495	1090	1430	1580	5450	1430	1960
Bending rigidity, $EI_{eff,90}$ (10^6 lbf-in.^{2}/ft)	1,4	3,1	35	81	184	309	81	309
Shear rigidity, $GA_{eff,90}$ (10^6 lbf/ft)	0,47	0,61	0,94	1,2	1,5	1,9	1,9	2,5





(1) The tabulated design values are for dry conditions of use and normal duration of loading.
(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 lumber (f_{cp} = 425 psi).
(4) The capacities were derived analytically using the shear analogy model[3] and validated by testing (the calculated moment capacities 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 NDS-2012 and the CLT Handbook, U.S. Edition.
(5) The specific gravity for dowel-type fastener design is 0.41. Member weight shall be based on density of 32 pcf.
* Nordic X-Lam products are certified by APA (Product Report PR-L306), per the ANSI/APA PRG 320 Standard.

PANEL LAYUPS

Product	Composition (L = longitudinal, T = transversal)	Number of plies	Thickness (mm)	Thickness (in.)	Weight (psf)
78-3s	26L - 27T - 26L	3	78	3 1/8	8,33
105-3s	35L - 35T - 35L	3	105	4 1/8	11,0
131-5s	26L - 27T - 26L - 27T - 26L	5	131	5 1/8	13,7
175-5s	35L - 35T - 35L - 35T - 35L	5	175	6 7/8	18,3
220-7s	35L - 27T - 35L - 27T - 35L - 27T - 35L	7	220	8 5/8	23,0
244-7l	35L - 35L - 35T - 35L - 35T - 35L - 35L	7	244	9 5/8	25,7
314-9l	35L - 35L - 35T - 35L - 35T - 35L - 35T - 35L - 35L	9	314	12 3/8	33,0

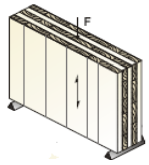
Note: The grade designation refers to the panel thickness (in mm), the number of layers, and the layup combination ("s" for standard perpendicular layers, and "l" for doubled outermost parallel

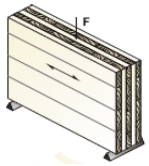
[3] Karacabeyli, E. and B. Douglas. 2013. CLT Handbook, U.S. Edition. FPInnovations, Canada. Chapter 3.

Design Properties, Nordic X-Lam (continued)

DESIGN PROPERTIES - 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 direction								
Compression, P_0 (10^3 lbf/ft)	44	59	66	89	119	119	149	178
Tension, T_0 (10^3 lbf/ft)	34	45	50	68	91	91	113	136
Effective area, A_{eff} (in.^{2}/ft)	24	33	37	50	66	66	83	99
Effective inertia, I_{eff} (in.^{4}/ft)	28	68	108	257	498	634	824	1638
Radius of gyration, r_{eff} (in./ft)	1,1	1,4	1,7	2,3	2,7	3,1	3,2	4,1
In-plane shear, V_0 (lbf/in.)	304	396	597	792	912	1188	1188	1584
Loaded to minor strength direction								
Compression, P_{90} (10^3 lbf/ft)	8,2	11	16	21	25	32	21	32
Tension, T_{90} (10^3 lbf/ft)	3,2	4,1	6,3	8,3	9,5	12,0	8,3	12
Effective area, A_{eff} (in.^{2}/ft)	13	17	25	33	38	50	33	50
Effective inertia, I_{eff} (in.^{4}/ft)	1,2	2,6	30	68	153	257	68	257
Radius of gyration, r_{eff} (in./ft)	0,3	0,4	1,1	1,4	2,0	2,3	1,4	2,3
In-plane shear, V_{90} (lbf/in.)	304	396	597	792	912	1188	1188	1584





(1) The tabulated design values are for dry conditions of use and normal duration of loading.
(2) Nordic X-Lam bending panels are symmetrical throughout the thickness of the member (balanced layups).
(3) The compression parallel to grain capacity values, P, shall be adjusted by the column stability factor, C_P, as defined in NDS-2012.
(4) The compression perpendicular to grain values shall be based on S-P-F No. 3 lumber (f_{cp} = 425 psi).
(5) The bending moment capacity and stiffness shall be based on S-P-F No. 3 (fb = 500 psi, E = 1,200,000 psi) or S-P-F MSR 1950f (f_b = 1950 psi, E = 1,700,000 psi) 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 capacities, V_r, are given in lbf/in. of member height. These values are based on the TUGraz study with the specified strengths fv,clt,k = 5.0 MPa and ft,clt,k = 2.5 MPa, adjusted with the following factors: kmod = 0.8, γM = 1.25. *(Ref. BSPhandbuch, TUGraz)*
(7) The design of cross-laminated timber members shall be in accordance to NDS-2012 and the CLT Handbook, U.S. Edition.
(8) The specific gravity for dowel-type fastener design is 0.41. Member weight shall be based on density of 32 pcf.
* Nordic X-Lam products are certified by APA (Product Report PR-L306), per the ANSI/APA PRG 320 Standard.