



MADE FOR BUILDING
BUILT FOR LIVING

STRUCTURAL PRE-ANALYSIS TABLES



IMPRINT

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CONTENT

01	PRODUCT DESCRIPTION	03
02	STANDARD PANELS AND PANEL STRUCTURES	05
03	FLEXURAL (TT / TL) AND IN-PLANE SHEAR DESIGN CAPACITIES	07
04	PRE-ANALYSIS TABLES / KLH® FLOOR - LIGHT AND NORMAL FINISH.....	12
05	PRE-ANALYSIS TABLES / KLH® ROOF.....	16
06	ADDITIONAL DESIGN PROCEDURES	19
07	SAMPLE CLT GENERAL STRUCTURAL NOTES	21
08	SAMPLE CLT SPECIFICATION	22

INTRODUCTION

DESIGN GUIDE FOR USE IN THE U.S.

KLH® Cross Laminated Timber (CLT) panels are built up using layers of wood boards, with each successive layer arranged perpendicular to the adjacent ones. These layers are glued together with environmentally friendly PUR adhesive to form strong, solid wood panels which can be used for floor, roof, and wall construction. CLT, as a wood product, is naturally green and sustainable, and structures can often be built more quickly than structures using other materials.

In addition, the total carbon footprint, including shipment by container from Europe, compares favorably with panels delivered by rail or truck, and our prices are very competitive. Panels are delivered to the job site sequenced and numbered for easy erection, with all openings and other details having been precisely made in the factory using CNC technology. Panels can be easily placed and connected with a relatively small crew using simple tools and standard, readily available fasteners. KLH® - CLT is manufactured in Austria of European Spruce lumber. Our lumber supply is PEFC certified, with FSC® C119602 certified lumber available on request, and all products are manufactured to ANSI/APA PRG 320 standards.

KLH® was the first manufacturer in the world to produce CLT on a large-scale basis. At last count, KLH® - CLT has been used in over 45,000 projects over the world.

This brochure is designed for engineers who are considering CLT or are currently designing a structure with CLT. Therefore, you'll find numerous technical topics, including design aids, material properties, and more. Other brochures are available, both in print and online, that are more general in purpose and are intended to introduce CLT to potential clients, architects, contractors, and developers.

After you've read through this brochure, we invite you to turn to KLH®, the industry leader in CLT. Please call or email us to begin a conversation about the many benefits offered by KLH® - CLT. We stand ready to provide design assistance, 3D modeling, cost estimates, and any other information and services that your design/construction team requires.

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PRODUCT DESCRIPTION

01 PRODUCT DESCRIPTION

KLH® CROSS-LAMINATED TIMBER

KLH® cross-laminated timber is produced from layers of Austrian spruce lumber that are arranged crosswise on top of each other, with each layer glued to the adjacent layers under 12,500 psf pressure to form large, solid wood elements (panels). The cross-wise arrangement of the longitudinal and transverse layers reduces swelling and shrinkage of the wood in the plane of the panel. Also, the arrangement of the layers results in strong elements capable of significant load carrying capacity over relatively long spans. The lumber used to produce KLH® - CLT panels is dried to a moisture content of 12% (+/-2%) prior to producing the panels.

GLUING

Solvent- and formaldehyde-free PUR adhesive is used to glue the adjacent layers together. The glue is applied automatically and uniformly over the entire adhered surfaces, thus achieving a high level of adhesion under the high manufacturing pressure. All lumber comprising the laminations is carefully sorted prior to manufacturing of the built-up panels.

CNC CUTTING

Precise factory cutting according to specific design requirements takes place using state-of-the-art CNC technology. Cutting accuracy is generally +/-0.1 in. (2 mm), resulting in extremely precise finished panels with minimal waste. In addition to panel overall dimensions, window, door, and other openings can easily be prefabricated prior to delivery to the job site.

SURFACE QUALITY

KLH® - CLT panels are available in non-visible (NVQ), industrial visible (IVQ), and domestic visible (DVQ) surface qualities. The DVQ level includes gluing the sides of the boards together in the outer most, visible surface lamination. IVQ and DVQ surfaces are sanded.

ASSEMBLY

CLT panels can be erected quickly and efficiently by relatively small crews using simple tools and connectors. A crane is used to raise the panels into position. Holes, channels, or other surface features, such as those required for utility lines or electrical wiring, can be cut on site, or prefabricated. Erection consists of connecting wall, floor, and roof panels together to quickly build a fully enclosed structure. Of course, CLT panels also work particularly well in combination with wood post-and-beam frameworks.



Lifting of KLH® TL panel



The Children's Course Learning Center in Gladstone | Oregon

TECHNICAL DESCRIPTION

PRODUCT	Solid wood panels with crosswise glued laminations
PRODUCT NAME	KLH® Cross-Laminated Timber
USES	Structural elements for walls, floors, and roofs
WOOD TYPE	Austrian spruce (other wood species on request)
PANEL BUILD-UPS	3-, 5-, 7-, and 8-laminations
LAMINATIONS	Lamination thicknesses 0.79 in. - 1.57 in. Sorted for quality and finger-jointed
PANEL GRADE	CV1M1
GLUE	Formaldehyde-free PUR adhesive
LAMINATION PRESSURE	12,500 psf, minimum
MOISTURE CONTENT	12% (+/-2%) at delivery
MAXIMUM DIMENSIONS	Length 54'-2" / width 11'-5" / thickness 1'-½"
AVAILABLE WIDTHS	from 7'-5" to 11'-5"
SURFACE QUALITIES	Non-visible (NVQ) / Industrial visible (IVQ) / Domestic visible (DVQ)
WEIGHT	For structural calculations, 35 pcf Shipping weight, 31 pcf
DIMENSIONAL CHANGE WITH MOISTURE CONTENT	In-plane: 0.02% per 1% change in moisture content Out-of-plane: 0.24% per 1% change in moisture content
NOMINAL CHAR RATE	1.5 in./hr.
EFFECTIVE CHAR DEPTH	1.9 in. after 1 hour All lamination thicknesses = 1.38 in.
FIRE DESIGN	According to NDS 2024 and CSA O86
FLAME SPREAD INDEX	Classification B
CERTIFICATION	ANSI/APA PRG 320-2019

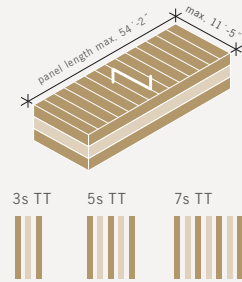
STANDARD PANELS AND STRUCTURES

02 STANDARD PANEL TYPES AND STRUCTURES

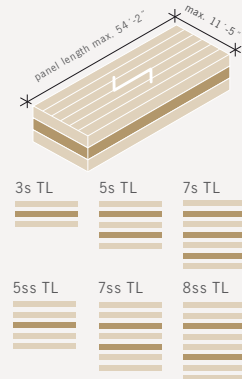
AVAILABLE WIDTHS: FROM 7'-5" TO 11'-5"

MAXIMUM DIMENSIONS: LENGTH 54'-2" / WIDTH 11'-5" / THICKNESS 1'-1/2"

	Panel Type	Thickness (in.)	Lamination Thickness in CLT Layup				(in.)	(in.)	(in.)	(in.)
			(in.)	(in.)	(in.)	(in.)				
Covering layer in the transverse panel direction TT	60 3s TT	2.36	0.79	0.79	0.79					
	70 3s TT	2.76	0.79	1.18	0.79					
	80 3s TT	3.15	1.18	0.79	1.18					
	80 3s TT (V2)	3.15	0.79	1.57	0.79					
	90 3s TT	3.54	1.18	1.18	1.18					
	100 3s TT	3.94	1.18	1.57	1.18					
	100 3s TT (V2)	3.94	1.57	0.79	1.57					
	105 3s TT *	4.13	1.38	1.38	1.38					
	110 3s TT	4.33	1.57	1.18	1.57					
	120 3s TT	4.72	1.57	1.57	1.57					
	100 5s TT	3.94	0.79	0.79	0.79	0.79	0.79			
	110 5s TT	4.33	0.79	0.79	1.18	0.79	0.79			
	120 5s TT	4.72	1.18	0.79	0.79	0.79	1.18			
	120 5s TT (V2)	4.72	0.79	1.18	0.79	1.18	0.79			
	130 5s TT	5.12	1.18	0.79	1.18	0.79	1.18			
	140 5s TT	5.51	1.18	0.79	1.57	0.79	1.18			
	140 5s TT (V2)	5.51	0.79	1.57	0.79	1.57	0.79			
	140 5s TT (V3)	5.51	1.57	0.79	0.79	0.79	1.57			
	150 5s TT	5.91	1.18	1.18	1.18	1.18	1.18			
	150 5s TT (V2)	5.91	1.57	0.79	1.18	0.79	1.57			
	160 5s TT	6.30	1.57	0.79	1.57	0.79	1.57			
	175 5s TT *	6.89	1.38	1.38	1.38	1.38	1.38			
	180 5s TT	7.09	1.57	1.18	1.57	1.18	1.57			
	200 5s TT	7.87	1.57	1.57	1.57	1.57	1.57			
	180 7s TT	7.09	1.18	0.79	1.18	0.79	1.18	0.79	1.18	



Covering layer in the longitudinal panel direction TL	60 3s TL	2.36	0.79	0.79	0.79					
	70 3s TL	2.76	0.79	1.18	0.79					
	80 3s TL	3.15	1.18	0.79	1.18					
	80 3s TL (V2)	3.15	0.79	1.57	0.79					
	90 3s TL	3.54	1.18	1.18	1.18					
	100 3s TL	3.94	1.57	0.79	1.57					
	100 3s TL (V2)	3.94	1.18	1.57	1.18					
	105 3s TL *	4.13	1.38	1.38	1.38					
	110 3s TL	4.33	1.57	1.18	1.57					
	120 3s TL	4.72	1.57	1.57	1.57					



*not available in DVQ

STANDARD PANELS AND STRUCTURES

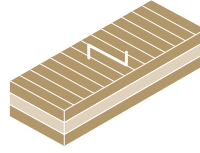
Covering layer in the longitudinal panel direction TL	Panel Type		Thickness	Lamination Thickness in CLT Layup					(in.)	(in.)	(in.)	(in.)
			(in.)	(in.)	(in.)	(in.)	(in.)	(in.)				
	100	5s TL	3.94	0.79	0.79	0.79	0.79	0.79				
	110	5s TL	4.33	0.79	0.79	1.18	0.79	0.79				
	120	5s TL	4.72	1.18	0.79	0.79	0.79	1.18				
	120	5s TL (V2)	4.72	0.79	1.18	0.79	1.18	0.79				
	130	5s TL	5.12	1.18	0.79	1.18	0.79	1.18				
	130	5s TL (V2)	5.12	0.79	1.18	1.18	1.18	0.79				
	140	5s TL	5.51	1.57	0.79	0.79	0.79	1.57				
	140	5s TL (V2)	5.51	0.79	1.57	0.79	1.57	0.79				
	150	5s TL	5.91	1.57	0.79	1.18	0.79	1.57				
	150	5s TL (V2)	5.91	1.18	1.18	1.18	1.18	1.18				
	150	5s TL (V3)	5.91	0.79	1.57	1.18	1.57	0.79				
	160	5s TL	6.30	1.57	0.79	1.57	0.79	1.57				
	160	5s TL (V2)	6.30	0.79	1.57	1.57	1.57	0.79				
	170	5s TL	6.69	1.57	1.18	1.18	1.18	1.57				
	170	5s TL (V2)	6.69	1.18	1.57	1.18	1.57	1.18				
	175	5s TL *	6.89	1.38	1.38	1.38	1.38	1.38				
	180	5s TL	7.09	1.57	1.18	1.57	1.18	1.57				
	180	5s TL (V2)	7.09	1.18	1.57	1.57	1.57	1.18				
	190	5s TL	7.48	1.57	1.57	1.18	1.57	1.57				
	200	5s TL	7.87	1.57	1.57	1.57	1.57	1.57				
	160	5ss TL	6.30	1.18+1.18	1.57	1.18+1.18						
	140	7s TL	5.51	0.79	0.79	0.79	0.79	0.79	0.79	0.79		
	160	7s TL	6.30	0.79	1.18	0.79	0.79	0.79	1.18	0.79		
	180	7s TL	7.09	0.79	1.57	0.79	0.79	0.79	1.57	0.79		
	180	7s TL (V2)	7.09	1.18	0.79	1.18	0.79	1.18	0.79	1.18		
	200	7s TL	7.87	0.79	1.57	0.79	1.57	0.79	1.57	0.79		
	210	7s TL	8.27	1.18	1.18	1.18	1.18	1.18	1.18	1.18		
	220	7s TL	8.66	1.18	1.57	1.18	0.79	1.18	1.57	1.18		
	220	7s TL (V2)	8.66	1.57	0.79	1.57	0.79	1.57	0.79	1.57		
	230	7s TL	9.06	1.18	1.57	1.18	1.18	1.18	1.57	1.18		
	240	7s TL	9.45	1.18	1.57	1.18	1.57	1.18	1.57	1.18		
	245	7s TL *	9.65	1.38	1.38	1.38	1.38	1.38	1.38	1.38		
	260	7s TL	10.24	1.57	1.57	1.18	1.57	1.18	1.57	1.57		
	180	7ss TL	7.09	1.18+1.18	0.79	0.79	0.79	1.18+1.18				
	200	7ss TL	7.87	1.18+1.18	0.79	1.57	0.79	1.18+1.18				
	210	7ss TL	8.27	1.18+1.18	1.18	1.18	1.18	1.18+1.18				
	220	7ss TL	8.66	1.57+1.57	0.79	0.79	0.79	1.57+1.57				
	220	7ss TL (V2)	8.66	1.18+1.18	1.18	1.57	1.18	1.18+1.18				
	230	7ss TL	9.06	1.57+1.57	0.79	1.18	0.79	1.57+1.57				
	240	7ss TL	9.45	1.57+1.57	0.79	1.57	0.79	1.57+1.57				
	250	7ss TL	9.84	1.57+1.57	1.18	1.18	1.18	1.57+1.57				
	260	7ss TL	10.24	1.57+1.57	1.18	1.57	1.18	1.57+1.57				
	280	7ss TL	11.02	1.57+1.57	1.57	1.57	1.57	1.57+1.57				
	300	8ss TL	11.81	1.57+1.57	1.18	1.57+1.57	1.18	1.57+1.57				
	320	8ss TL	12.60	1.57+1.57	1.57	1.57+1.57	1.57	1.57+1.57				

*not available in DVQ

FLEXURAL DESIGN CAPACITIES

03 DESIGN CAPACITIES

3.1 FOR TT PANELS



according to NDS 2024

Table 1. Allowable Design Properties^(a) for lumber laminations used in KLH® - CLT (for use in the U.S.)

CLT Grade	Major strength direction						Minor strength direction					
	$F_{b,0}$ (psi)	E_0 (10^6 psi)	$F_{t,0}$ (psi)	$F_{c,0}$ (psi)	$F_{v,0}$ (psi)	$F_{s,0}$ (psi)	$F_{b,90}$ (psi)	E_{90} (10^6 psi)	$F_{t,90}$ (psi)	$F_{c,90}$ (psi)	$F_{v,90}$ (psi)	$F_{s,90}$ (psi)
CV1M1	1340	1.6	550	1450	175	55	1340	1.6	550	1450	175	55

For SI: 1 psi = 0.006895 Mpa

^(a) Tabulated values are allowable design values and not permitted to be increased for the lumber size adjustment factor in accordance with the NDS. The design values shall be used in conjunction with the section properties provided by KLH® based on the actual layout used in manufacturing the CLT panel (see Table 2).

Table 2. Allowable Design Capacities^(a) for KLH® - CLT (for use in the U.S.)

CLT Grade	Layup #	Thickness (in.)	Lamination thickness (in.) in CLT layup							Major strength direction				Minor strength direction			
			=	⊥	=	⊥	=	⊥	=	F _b S _{eff,0} (lbf-ft/ft)	EI _{eff,0} (10 ⁶ lbf- in. ² /ft)	GA _{eff,0} (10 ⁶ lbf/ft)	V _{s,0} ^(c) (lbf/ft)	F _b S _{eff,90} (lbf-ft/ft)	EI _{eff,90} (10 ⁶ lbf- in. ² /ft)	GA _{eff,90} (10 ⁶ lbf/ft)	V _{s,90} ^(c) (lbf/ft)
CV1M1	60 3s TT	2.36	0.79	0.79	0.79					1021	20.3	0.26	1039	138	0.78	0.26	346
CV1M1	70 3s TT	2.76	0.79	1.18	0.79					1332	30.9	0.27	1213	312	2.64	0.39	520
CV1M1	80 3s TT	3.15	1.18	0.79	1.18					1855	49.2	0.39	1386	138	0.78	0.27	346
CV1M1	80 3s TT V2	3.15	0.79	1.57	0.79					1656	43.9	0.30	1386	554	6.25	0.54	693
CV1M1	90 3s TT	3.54	1.18	1.18	1.18					2298	68.6	0.38	1559	312	2.64	0.38	520
CV1M1	100 3s TT	3.94	1.18	1.57	1.18					2760	91.6	0.40	1732	554	6.25	0.51	693
CV1M1	100 3s TT V2	3.94	1.57	0.79	1.57					2920	96.9	0.54	1732	138	0.78	0.30	346
CV1M1	105 3s TT	4.13	1.38	1.38	1.38					3128	109	0.45	1819	424	4.19	0.45	606
CV1M1	110 3s TT	4.33	1.57	1.18	1.57					3491	127	0.51	1906	312	2.64	0.40	520
CV1M1	120 3s TT	4.72	1.57	1.57	1.57					4085	163	0.51	2079	554	6.25	0.51	693
CV1M1	100 5s TT	3.94	0.79	0.79	0.79	0.79	0.79			2351	78	0.51	1732	1202	20	0.51	1039
CV1M1	110 5s TT	4.33	0.79	0.79	1.18	0.79	0.79			2743	100	0.64	1906	1567	31	0.52	1213
CV1M1	120 5s TT	4.72	1.18	0.79	0.79	0.79	1.18			3744	149	0.64	2079	1202	20	0.52	1039
CV1M1	120 5s TT V2	4.72	0.79	1.18	0.79	1.18	0.79			3042	121	0.54	2079	2182	49	0.77	1386
CV1M1	130 5s TT	5.12	1.18	0.79	1.18	0.79	1.18			4281	185	0.77	2252	1567	31	0.54	1213
CV1M1	140 5s TT	5.51	1.18	0.79	1.57	0.79	1.18			4857	226	0.92	2425	1948	44	0.57	1386
CV1M1	140 5s TT V2	5.51	0.79	1.57	0.79	1.57	0.79			3752	174	0.60	2425	3435	97	1.08	1732
CV1M1	140 5s TT V3	5.51	1.57	0.79	0.79	0.79	1.57			5345	248	0.77	2425	1202	20	0.54	1039
CV1M1	150 5s TT	5.91	1.18	1.18	1.18	1.18	1.18			5289	263	0.77	2598	2704	69	0.77	1559
CV1M1	150 5s TT V2	5.91	1.57	0.79	1.18	0.79	1.57			6021	300	0.92	2589	1567	31	0.57	1213
CV1M1	160 5s TT	6.30	1.57	0.79	1.57	0.79	1.57	6736	358	1.08	2772	1948	44	0.60	1386		
CV1M1	175 5s TT	6.89	1.38	1.38	1.38	1.38	1.38	7200	418	0.89	3032	3680	109	0.89	1819		
CV1M1	180 5s TT	7.09	1.57	1.18	1.57	1.18	1.57	8054	481	1.02	3118	3247	92	0.80	1732		
CV1M1	200 5s TT	7.87	1.57	1.57	1.57	1.57	1.57	9403	624	1.02	3465	4806	163	1.02	2079		
CV1M1	180 7s TT	7.09	1.18	0.79	1.18	0.79	1.18	0.79	1.18	7599	454	1.16	3118	3579	121	0.82	2079

For SI: 1 in. = 25.4 mm; 1 ft = 304.8 mm; 1 lbf = 4.448 N

^(a) Tabulated values are allowable design values and not permitted to be increased for the lumber size adjustment factor in accordance with the NDS.

^(b) The CV1M1 grade uses Austrian spruce lumber in both major and minor strength directions.

FLEXURAL DESIGN CAPACITIES

3.2 FOR TL PANELS

according to NDS 2024

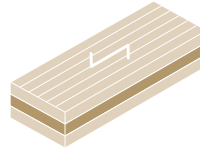


Table 1. Allowable Design Properties^(a) for lumber laminations used in KLH® - CLT (for use in the U.S.)

CLT Grade	Major strength direction						Minor strength direction					
	$F_{b,0}$ (psi)	E_0 (10 ⁶ psi)	$F_{t,0}$ (psi)	$F_{c,0}$ (psi)	$F_{v,0}$ (psi)	$F_{s,0}$ (psi)	$F_{b,90}$ (psi)	E_{90} (10 ⁶ psi)	$F_{t,90}$ (psi)	$F_{c,90}$ (psi)	$F_{v,90}$ (psi)	$F_{s,90}$ (psi)
CV1M1	1340	1.6	550	1450	175	55	1340	1.6	550	1450	175	55

For SI: 1 psi = 0.006895 Mpa

^(a) Tabulated values are allowable design values and not permitted to be increased for the lumber size adjustment factor in accordance with the NDS. The design values shall be used in conjunction with the section properties provided by KLH® based on the actual layup used in manufacturing the CLT panel (see Table 2).

Table 2. Allowable Design Capacities^(a) for KLH® - CLT (for use in the U.S.)

CLT Grade	Layup #	Thickness (in.)	Lamination thickness (in.) in CLT layup						Major strength direction				Minor strength direction					
			=	⊥	=	⊥	=	⊥	=	$F_b S_{eff,0}$ (lbf-ft/ft)	$EI_{eff,0}$ (10 ⁶ lbf- in. ² /ft)	$GA_{eff,0}$ (10 ⁶ lbf/ft)	$V_{s,0}^{(c)}$ (lbf/ft)	$F_b S_{eff,90}$ (lbf-ft/ft)	$EI_{eff,90}$ (10 ⁶ lbf- in. ² /ft)	$GA_{eff,90}$ (10 ⁶ lbf/ft)	$V_{s,90}^{(c)}$ (lbf/ft)	
CV1M1	60 3s TL	2.36	0.79	0.79	0.79						1021	20.3	0.26	1039	138	0.78	0.26	346
CV1M1	70 3s TL	2.76	0.79	1.18	0.79						1332	30.9	0.27	1213	312	2.64	0.39	520
CV1M1	80 3s TL	3.15	1.18	0.79	1.18						1855	49.2	0.39	1386	138	0.78	0.27	346
CV1M1	80 3s TL V2	3.15	0.79	1.57	0.79						1656	43.9	0.30	1386	554	6.25	0.54	693
CV1M1	90 3s TL	3.54	1.18	1.18	1.18						2298	68.6	0.38	1559	312	2.64	0.38	520
CV1M1	100 3s TL	3.94	1.57	0.79	1.57						2920	96.9	0.54	1732	138	0.78	0.30	346
CV1M1	100 3s TL V2	3.94	1.18	1.57	1.18						2760	91.6	0.40	1732	554	6.25	0.51	693
CV1M1	105 3s TL	4.13	1.38	1.38	1.38						3128	109	0.45	1819	424	4.19	0.45	606
CV1M1	110 3s TL	4.33	1.57	1.18	1.57						3491	127	0.51	1906	312	2.64	0.40	520
CV1M1	120 3s TL	4.72	1.57	1.57	1.57						4085	163	0.51	2079	554	6.25	0.51	693

For SI: 1 in. = 25.4 mm; 1 ft = 304.8 mm; 1 lbf = 4.448 N

^(a) Tabulated values are allowable design values and not permitted to be increased for the lumber size adjustment factor in accordance with the NDS.

^(b) The CV1M1 grade uses Austrian spruce lumber in both major and minor strength directions.

FLEXURAL DESIGN CAPACITIES

Table 2. Allowable Design Capacities^(a) for KLH® - CLT (for use in the U.S.) (continued)

CLT Grade	Layup #	Thickness (in.)	Lamination thickness (in.) in CLT layout							Major strength direction				Minor strength direction			
			=	⊥	=	⊥	=	⊥	=	$F_b S_{b\text{ eff},0}$ (lb-ft/ft)	$EI_{\text{eff},0}$ (10 ⁶ lb-ft-in. ² /ft)	$GA_{\text{eff},0}$ (10 ⁶ lb/ft)	$V_{s,0}^{(c)}$ (lb/ft)	$F_b S_{b\text{ eff},90}$ (lb-ft/ft)	$EI_{\text{eff},90}$ (10 ⁶ lb-ft-in. ² /ft)	$GA_{\text{eff},90}$ (10 ⁶ lb/ft)	$V_{s,90}^{(c)}$ (lb/ft)
CV1M1	100 5s TL	3.94	0.79	0.79	0.79	0.79	0.79		2351	78	0.51	1732	1202	20	0.51	1039	
CV1M1	110 5s TL	4.33	0.79	0.79	1.18	0.79	0.79		2743	100	0.64	1906	1567	31	0.52	1213	
CV1M1	120 5s TL	4.72	1.18	0.79	0.79	0.79	1.18		3744	149	0.64	2079	1202	20	0.52	1039	
CV1M1	120 5s TL V2	4.72	0.79	1.18	0.79	1.18	0.79		3042	121	0.54	2079	2182	49	0.77	1386	
CV1M1	130 5s TL	5.12	1.18	0.79	1.18	0.79	1.18		4281	185	0.77	2252	1567	31	0.54	1213	
CV1M1	130 5s TL V2	5.12	0.79	1.18	1.18	1.18	0.79		3437	148	0.65	2252	2704	69	0.76	1559	
CV1M1	140 5s TL	5.51	1.57	0.79	0.79	0.79	1.57		5345	248	0.77	2425	1202	20	0.54	1039	
CV1M1	140 5s TL V2	5.51	0.79	1.57	0.79	1.57	0.79		3752	174	0.60	2425	3435	97	1.08	1732	
CV1M1	150 5s TL	5.91	1.57	0.79	1.18	0.79	1.57		6021	300	0.92	2598	1567	31	0.57	1213	
CV1M1	150 5s TL V2	5.91	1.18	1.18	1.18	1.18	1.18		5289	263	0.77	2598	2704	69	0.77	1559	
CV1M1	150 5s TL V3	5.91	0.79	1.57	1.18	1.57	0.79		4148	206	0.69	2598	4106	127	1.04	1906	
CV1M1	160 5s TL	6.30	1.57	0.79	1.57	0.79	1.57		6736	358	1.08	2772	1948	44	0.60	1386	
CV1M1	160 5s TL V2	6.30	0.79	1.57	1.57	1.57	0.79		4574	243	0.80	2772	4806	163	1.02	2079	
CV1M1	170 5s TL	6.69	1.57	1.18	1.18	1.18	1.57		7329	413	0.89	2945	2704	69	0.78	1559	
CV1M1	170 5s TL V2	6.69	1.18	1.57	1.18	1.57	1.18		6322	357	0.80	2945	4106	127	1.02	1906	
CV1M1	175 5s TL	6.89	1.38	1.38	1.38	1.38	1.38		7200	418	0.89	3032	3680	109	0.89	1819	
CV1M1	180 5s TL	7.09	1.57	1.18	1.57	1.18	1.57		8054	481	1.02	3118	3247	92	0.80	1732	
CV1M1	180 5s TL V2	7.09	1.18	1.57	1.57	1.57	1.18		6904	412	0.91	3118	4806	163	1.02	2079	
CV1M1	190 5s TL	7.48	1.57	1.57	1.18	1.57	1.57		8670	547	0.91	3291	4106	127	1.02	1906	
CV1M1	200 5s TL	7.87	1.57	1.57	1.57	1.57	1.57		9403	624	1.02	3465	4806	163	1.02	2079	
CV1M1	160 5ss TL	6.30	1.18 x 2	1.57	1.18 x 2				7419	394	0.77	2772	554	6	0.54	693	
CV1M1	140 7s TL	5.51	0.79	0.79	0.79	0.79	0.79	0.79	0.79	4158	193	0.77	2425	2766	78	0.77	1732
CV1M1	160 7s TL	6.30	0.79	1.18	0.79	0.79	0.79	1.18	0.79	4830	256	0.80	2772	4405	149	1.02	2079
CV1M1	180 7s TL	7.09	0.79	1.57	0.79	0.79	0.79	1.57	0.79	5526	330	0.84	3118	6288	248	1.30	2425
CV1M1	180 7s TL V2	7.09	1.18	0.79	1.18	0.79	1.18	0.79	1.18	7599	454	1.16	3118	3579	121	0.82	2079
CV1M1	200 7s TL	7.87	0.79	1.57	0.79	1.57	0.79	1.57	0.79	6582	437	0.89	3465	7925	358	1.62	2772
CV1M1	210 7s TL	8.27	1.18	1.18	1.18	1.18	1.18	1.18	1.18	9356	652	1.15	3638	6223	263	1.15	2598
CV1M1	220 7s TL	8.66	1.18	1.57	1.18	0.79	1.18	1.57	1.18	9597	701	1.16	3811	7808	352	1.27	2772
CV1M1	220 7s TL V2	8.66	1.57	0.79	1.57	0.79	1.57	0.79	1.57	11976	874	1.62	3811	4414	174	0.89	2425
CV1M1	230 7s TL	9.06	1.18	1.57	1.18	1.18	1.18	1.57	1.18	10358	791	1.18	3984	8622	413	1.40	2945
CV1M1	240 7s TL	9.45	1.18	1.57	1.18	1.57	1.18	1.57	1.18	11146	888	1.19	4158	9476	481	1.53	3118
CV1M1	245 7s TL	9.65	1.38	1.38	1.38	1.38	1.38	1.38	1.38	12735	1035	1.34	4244	8470	418	1.34	3032
CV1M1	260 7s TL	10.24	1.57	1.57	1.18	1.57	1.18	1.57	1.57	14535	1254	1.30	4504	9476	481	1.53	3118

FLEXURAL DESIGN CAPACITIES

Table 2. Allowable Design Capacities^(a) for KLH® - CLT
(for use in the U.S.) (continued)

CLT Grade	Layup #	Thickness (in.)	Lamination thickness (in.) in CLT layup						Major strength direction				Minor strength direction			
			=	⊥	=	⊥	=	⊥	$F_b S_{eff,0}$ (lbf-ft/ft)	$EI_{eff,0}$ (10 ⁶ lbf-in. ² /ft)	$GA_{eff,0}$ (10 ⁶ lbf/ft)	$V_{s,0}^{(c)}$ (lbf/ft)	$F_b S_{eff,90}$ (lbf-ft/ft)	$EI_{eff,90}$ (10 ⁶ lbf-in. ² /ft)	$GA_{eff,90}$ (10 ⁶ lbf/ft)	$V_{s,90}^{(c)}$ (lbf/ft)
CV1M1	180 7ss TL	7.09	1.18 x 2	0.79	0.79	0.79	1.18 x 2		9205	550	1.08	3118	1202	20	0.60	1039
CV1M1	200 7ss TL	7.87	1.18 x 2	0.79	1.57	0.79	1.18 x 2		11133	739	1.42	3465	1948	44	0.65	1386
CV1M1	210 7ss TL	8.27	1.18 x 2	1.18	1.18	1.18	1.18 x 2		12025	838	1.16	3638	2704	69	0.82	1559
CV1M1	220 7ss TL	8.66	1.57 x 2	0.79	0.79	0.79	1.57 x 2		13972	1020	1.42	3811	1202	20	0.65	1039
CV1M1	220 7ss TL V2	8.66	1.18 x 2	1.18	1.57	1.18	1.18 x 2		13031	951	1.30	3811	3247	92	0.84	1732
CV1M1	230 7ss TL	9.06	1.57 x 2	0.79	1.18	0.79	1.57 x 2		15175	1158	1.61	3984	1567	31	0.68	1213
CV1M1	240 7ss TL	9.45	1.57 x 2	0.79	1.57	0.79	1.57 x 2		16417	1307	1.80	4157	1948	44	0.71	1386
CV1M1	250 7ss TL	9.84	1.57 x 2	1.18	1.18	1.18	1.57 x 2		17591	1459	1.46	4331	2704	69	0.87	1559
CV1M1	260 7ss TL	10.24	1.57 x 2	1.18	1.57	1.18	1.57 x 2		18867	1628	1.62	4504	3247	92	0.89	1732
CV1M1	280 7ss TL	11.02	1.57 x 2	1.57	1.57	1.57	1.57 x 2		21378	1986	1.54	4850	4806	163	1.09	2079
CV1M1	300 8ss TL	11.81	1.57 x 2	1.18	1.57 x 2	1.18	1.57 x 2		24366	2426	2.32	5197	5561	220	1.01	2425
CV1M1	320 8ss TL	12.60	1.57 x 2	1.57	1.57 x 2	1.57	1.57 x 2		26945	2861	2.15	5543	7791	352	1.19	2772

For SI: 1 in. = 25.4 mm; 1 ft = 304.8 mm; 1 lbf = 4.448 N

^(a) Tabulated values are allowable design values and not permitted to be increased for the lumber size adjustment factor in accordance with the NDS.

^(b) The CV1M1 grade uses Austrian spruce lumber in both major and minor strength directions.

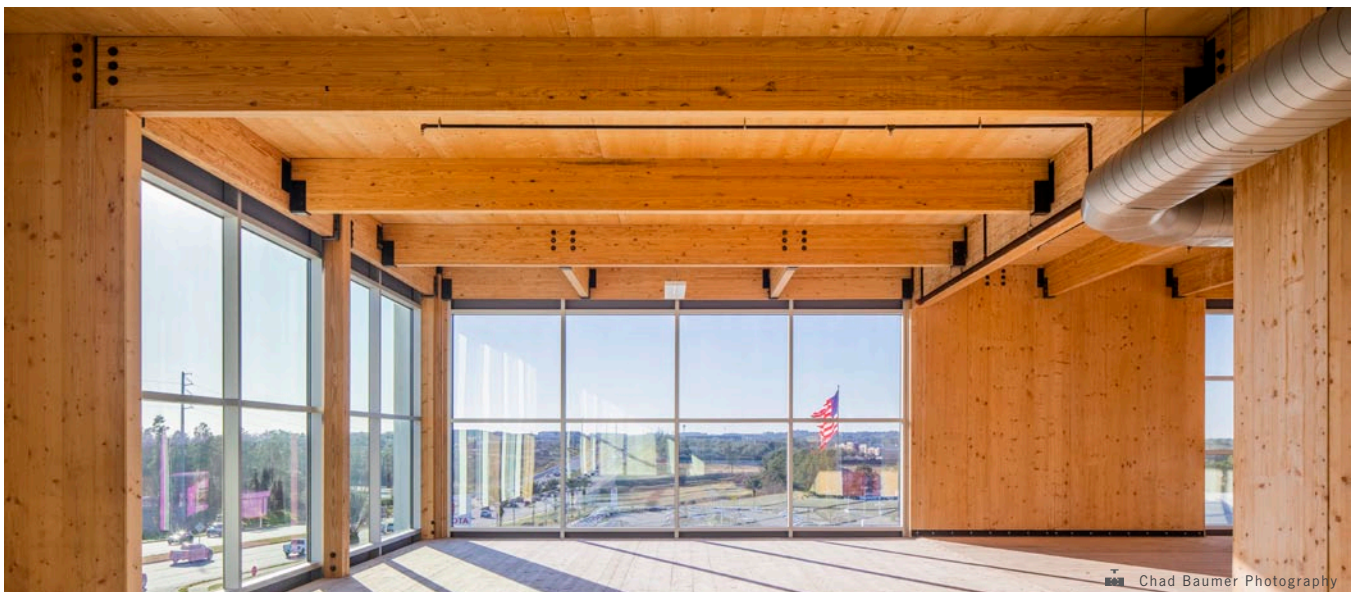
IN-PLANE SHEAR DESIGN CAPACITIES

3.3 IN-PLANE SHEAR CAPACITY

Table 3. Allowable In-Plane Shear Stress for KLH® - CLT
(For Use in the U.S.)

Grade	Layup (lams.)	Thickness, t_p (in.)	$F_{v,e,0}$ (psi)	$F_{v,e,90}$ (psi)
CV1M1	3	2.36 – 4.72	254	254
CV1M1	5	3.94 – 7.87	254	179
CV1M1	7	5.51 – 11.02	254	179
CV1M1	8	11.81 – 12.60	254	179

- $F_{v,e,0}$ is allowable stress in the major strength direction.
- $F_{v,e,90}$ is allowable stress in the minor strength direction.
- Allowable stress values shall be applied to the CLT thickness, t_p .
- 3 lamination values based on test results from 100 3s TL V2 panels.
- 5, 7, and 8 lamination values based on test results from 160 5s TL panels.
- Testing performed at Holzforschung Austria - Österreichische Gesellschaft für Holzforschung, Vienna, Austria, an Accredited Testing Laboratory (ID-number: 0055) according to EN ISO/IEC 17025:2017
- Research report satisfies IBC Section 1703.4 for determining the characteristic strength.
- Characteristic strength obtained from testing is divided by 2.1 to obtain allowable stress values.



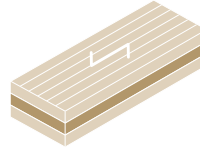
Fifty West Building in Clearmont | Florida

STRUCTURAL PRE-ANALYSIS TABLES

04 KLH® FLOOR PANELS

4.1 FLOORS WITH LIGHT FINISHES, L = 40 PSF

according to NDS 2024



Preliminary Sizing of CLT Floor Panels with light finishes
D = 15 psf + panel self weight
L = 40 psf, $C_D = 1.0$
Allowable spans for KLH® - CLT in major strength direction
Single span = L and two equal spans each = L
Governing span in bold font

Panel Type	Thickness (in)	Both span conditions		Single span		Two equal spans	
		Vibration	Allowable	Long term	Live load Δ_L	Long term	Live load Δ_L
		Control	Moment	$\Delta_T = L/240$	@ Allowable	$\Delta_T = L/240$	@ Allowable
		(ft)	(ft)	(ft)	Moment span	(ft)	Moment span
60 3s TL	2.36	8.15	11.49	7.84	168	10.66	405
70 3s TL	2.76	9.05	13.00	8.96	178	12.20	430
80 3s TL	3.15	10.22	15.21	10.41	178	14.14	429
90 3s TL	3.54	11.08	16.77	11.51	185	15.67	447
100 3s TL	3.94	12.15	18.74	12.87	189	17.47	454
105 3s TL	4.13	12.40	19.32	13.23	192	18.02	462
120 3s TL	4.72	13.69	21.80	14.94	199	20.35	480
100 5s TL	3.94	11.41	16.82	11.98	210	16.25	505
120 5s TL	4.72	13.46	20.87	14.62	210	19.84	505
130 5s TL	5.12	14.23	22.13	15.63	219	21.19	528
140 5s TL	5.51	15.30	24.53	17.05	215	23.15	518
150 5s TL	5.91	16.08	25.82	18.08	224	24.52	538
160 5s TL	6.30	16.84	27.10	19.08	231	25.85	558
160 5ss TL	6.30	17.11	28.44	19.49	217	26.53	524
170 5s TL	6.69	17.29	28.05	19.73	238	26.81	574
175 5s TL	6.89	17.28	27.70	19.74	250	26.82	603
180 5s TL	7.09	17.99	29.18	20.66	247	28.05	595
180 7s TL	7.09	16.09	24.17	18.19	296	24.71	712
200 7s TL	7.87	17.19	25.99	19.67	314	26.74	756
220 7s TL	8.66	19.55	30.93	22.78	301	30.95	724
240 7s TL	9.45	20.66	32.86	24.29	316	33.03	762
245 7s TL	9.65	21.59	35.01	25.53	306	34.69	738
210 7ss TL	8.27	20.67	34.87	24.30	252	33.03	606
240 7ss TL	9.45	23.34	39.88	27.85	265	37.73	638
280 7ss TL	11.02	25.55	44.30	30.96	289	42.14	697
320 8ss TL	12.60	28.14	48.47	34.38	320	46.69	772

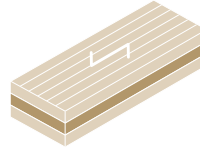
Notes:

- (1) Spans controlled by allowable moment include panel self weight
- (2) Vibration control calculation as per Chapter 7, CLT Handbook, US Ed.
- (3) Deflections based on EI_{app} as per NDS 2024 Section 10.4.1
- (4) Long term loading deflection Δ_L based on $K_{cr} = 2.0$ as per NDS 2024 Section 3.5.2
- (5) Vibration controlled span is assumed the same for single and two span conditions where all spans = L
- (6) Allowable moment controlled span based on $M_{max} = +wL^2/8$ for single span condition and $M_{max} = -wL^2/8$ over interior support for two span condition
- (7) E.O.R. must verify structural adequacy of CLT panel chosen for actual project load and span conditions and deflection limits

STRUCTURAL PRE-ANALYSIS TABLES

4.2 FLOORS WITH 2 IN. N.W. CONCRETE, L = 40 PSF

according to NDS 2024



Preliminary Sizing of CLT Floor Panels with 2" n.w. concrete
D = 40 psf + panel self weight
L = 40 psf, $C_D = 1.0$
Allowable spans for KLH® - CLT in major strength direction
Single span = L and two equal spans each = L
Governing span in bold font

Panel Type	Thickness (in)	Both span conditions		Single span		Two equal spans	
		Vibration	Allowable	Long term	Live load Δ_L	Long term	Live load Δ_L
		Control	Moment	$\Delta_T = L/240$	@ Allowable	$\Delta_T = L/240$	@ Allowable
		(ft)	(ft)	(ft)	Moment span	(ft)	Moment span
60 3s TL	2.36	8.15	9.70	6.63	275	9.06	662
70 3s TL	2.76	9.05	11.00	7.59	289	10.40	695
80 3s TL	3.15	10.22	12.90	8.87	287	12.11	692
90 3s TL	3.54	11.08	14.27	9.82	296	13.45	713
100 3s TL	3.94	12.15	15.98	11.05	300	15.06	723
105 3s TL	4.13	12.40	16.49	11.35	303	15.53	729
120 3s TL	4.72	13.69	18.67	12.86	311	17.61	750
100 5s TL	3.94	11.41	14.34	10.28	333	14.01	802
120 5s TL	4.72	13.46	17.87	12.62	329	17.20	792
130 5s TL	5.12	14.23	18.99	13.54	342	18.42	823
140 5s TL	5.51	15.30	21.10	14.80	333	20.17	802
150 5s TL	5.91	16.08	22.26	15.75	345	21.43	830
160 5s TL	6.30	16.84	23.41	16.67	355	22.65	855
160 5ss TL	6.30	17.11	24.56	16.98	332	23.21	800
170 5s TL	6.69	17.29	24.27	17.25	362	23.53	873
175 5s TL	6.89	17.28	23.99	17.27	379	23.56	913
180 5s TL	7.09	17.99	25.30	18.11	374	24.68	901
180 7s TL	7.09	16.09	20.96	15.93	446	21.73	1075
200 7s TL	7.87	17.19	22.61	17.30	468	23.62	1127
220 7s TL	8.66	19.55	27.01	20.14	445	27.45	1072
240 7s TL	9.45	20.66	28.79	21.53	463	29.39	1115
245 7s TL	9.65	21.59	30.69	22.67	448	30.91	1079
210 7ss TL	8.27	20.67	30.40	21.42	374	29.23	902
240 7ss TL	9.45	23.34	34.94	24.74	390	33.62	939
280 7ss TL	11.02	25.55	39.05	27.63	417	37.75	1003
320 8ss TL	12.60	28.14	42.97	30.92	455	42.11	1095

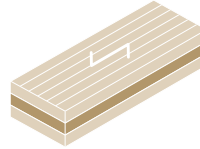
Notes:

- (1) Spans controlled by allowable moment include panel self weight
- (2) Vibration control calculation as per Chapter 7, CLT Handbook, US Ed.
- (3) Deflections based on EI_{app} as per NDS 2024 Section 10.4.1
- (4) Long term loading deflection Δ_L based on $K_{cr} = 2.0$ as per NDS 2024 Section 3.5.2
- (5) Vibration controlled span is assumed the same for single and two span conditions where all spans = L
- (6) Allowable moment controlled span based on $M_{max} = +wL^2/8$ for single span condition and $M_{max} = -wL^2/8$ over interior support for two span condition
- (7) E.O.R. must verify structural adequacy of CLT panel chosen for actual project load and span conditions and deflection limits

STRUCTURAL PRE-ANALYSIS TABLES

4.3 FLOORS WITH 2 IN. N.W. CONCRETE, L = 65 PSF

according to NDS 2024



Preliminary Sizing of CLT Floor Panels with 2" n.w. concrete
D = 40 psf + panel self weight
L = 50 psf + 15 psf (partitions), $C_D = 1.0$
Allowable spans for KLH® - CLT in major strength direction
Single span = L and two equal spans each = L
Governing span in bold font

Panel Type	Thickness (in)	Both span conditions		Single span		Two equal spans	
		Vibration	Allowable	Long term	Live load Δ_L	Long term	Live load Δ_L
		Control	Moment	$\Delta_T = L/240$	@ Allowable	$\Delta_T = L/240$	@ Allowable
		(ft)	(ft)	(ft)	Moment span	(ft)	Moment span
60 3s TL	2.36	8.29	8.54	6.23	243	8.54	585
70 3s TL	2.76	9.21	9.71	7.13	253	9.80	610
80 3s TL	3.15	10.34	11.40	8.35	252	11.42	607
90 3s TL	3.54	11.20	12.63	9.25	258	12.69	621
100 3s TL	3.94	12.22	14.16	10.43	262	14.24	630
105 3s TL	4.13	12.48	14.62	10.70	262	14.68	632
120 3s TL	4.72	13.69	16.59	12.14	268	16.67	646
100 5s TL	3.94	11.60	12.71	9.70	290	13.25	699
120 5s TL	4.72	13.65	15.88	11.93	284	16.29	685
130 5s TL	5.12	14.39	16.90	12.82	295	17.47	710
140 5s TL	5.51	15.46	18.79	14.01	286	19.13	688
150 5s TL	5.91	16.21	19.85	14.93	295	20.34	711
160 5s TL	6.30	16.93	20.90	15.82	303	21.53	731
160 5ss TL	6.30	17.52	21.93	16.08	282	22.04	680
170 5s TL	6.69	17.39	21.70	16.36	307	22.36	741
175 5s TL	6.89	17.38	21.46	16.39	321	22.40	773
180 5s TL	7.09	18.05	22.64	17.20	317	23.47	763
180 7s TL	7.09	16.35	18.76	15.13	377	20.67	908
200 7s TL	7.87	17.45	20.29	16.44	392	22.49	945
220 7s TL	8.66	19.71	24.28	19.17	372	26.17	895
240 7s TL	9.45	20.78	25.94	20.52	384	28.05	924
245 7s TL	9.65	21.66	27.66	21.61	371	29.51	894
210 7ss TL	8.27	21.01	27.30	20.38	314	27.85	756
240 7ss TL	9.45	23.55	31.48	23.60	325	32.11	783
280 7ss TL	11.02	25.73	35.31	26.38	342	36.11	823
320 8ss TL	12.60	28.14	39.00	29.61	370	40.37	891

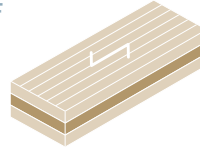
Notes:

- (1) Spans controlled by allowable moment include panel self weight
- (2) Vibration control calculation as per Chapter 7, CLT Handbook, US Ed.
- (3) Deflections based on EI_{app} as per NDS 2024 Section 10.4.1
- (4) Long term loading deflection Δ_L based on $K_{cr} = 2.0$ as per NDS 2024 Section 3.5.2
- (5) Vibration controlled span is assumed the same for single and two span conditions where all spans = L
- (6) Allowable moment controlled span based on $M_{max} = +wL^2/8$ for single span condition and $M_{max} = -wL^2/8$ over interior support for two span condition
- (7) E.O.R. must verify structural adequacy of CLT panel chosen for actual project load and span conditions and deflection limits

STRUCTURAL PRE-ANALYSIS TABLES

4.4 FLOORS WITH 2 IN. N.W. CONCRETE, L = 100 PSF

according to NDS 2024



Preliminary Sizing of CLT Floor Panels with 2" n.w. concrete
D = 40 psf + panel self weight
L = 100 psf, $C_D = 1.0$
Allowable spans for KLH® - CLT in major strength direction
Single span = L and two equal spans each = L
Governing span in bold font

Panel Type	Thickness (in)	Both span conditions		Single span		Two equal spans	
		Vibration	Allowable	Long term	Live load Δ_L	Long term	Live load Δ_L
		Control	Moment	$\Delta_T = L/240$	@ Allowable	$\Delta_T = L/240$	@ Allowable
		(ft)	(ft)	(ft)	Moment span	(ft)	Moment span
60 3s TL	2.36	8.29	7.46	5.79	232	7.96	558
70 3s TL	2.76	9.21	8.48	6.62	240	9.14	578
80 3s TL	3.15	10.34	9.97	7.78	239	10.67	576
90 3s TL	3.54	11.20	11.06	8.61	243	11.86	586
100 3s TL	3.94	12.22	12.42	9.73	247	13.33	595
105 3s TL	4.13	12.48	12.83	9.98	246	13.74	594
120 3s TL	4.72	13.69	14.58	11.33	251	15.61	603
100 5s TL	3.94	11.60	11.14	9.06	274	12.40	659
120 5s TL	4.72	13.65	13.96	11.15	267	15.27	643
130 5s TL	5.12	14.39	14.87	12.00	276	16.39	665
140 5s TL	5.51	15.46	16.55	13.12	267	17.96	642
150 5s TL	5.91	16.21	17.50	14.00	275	19.12	662
160 5s TL	6.30	16.93	18.45	14.85	282	20.25	680
160 5ss TL	6.30	17.52	19.36	15.07	261	20.71	629
170 5s TL	6.69	17.39	19.17	15.36	284	21.04	684
175 5s TL	6.89	17.38	18.97	15.38	296	21.08	713
180 5s TL	7.09	18.05	20.03	16.16	292	22.10	703
180 7s TL	7.09	16.35	16.59	14.21	346	19.46	834
200 7s TL	7.87	17.45	17.98	15.46	358	21.20	862
220 7s TL	8.66	19.71	21.55	18.06	338	24.71	815
240 7s TL	9.45	20.78	23.07	19.35	347	26.51	836
245 7s TL	9.65	21.66	24.62	20.39	336	27.90	809
210 7ss TL	8.27	21.01	24.21	19.18	287	26.27	691
240 7ss TL	9.45	23.55	28.00	22.28	296	30.36	712
280 7ss TL	11.02	25.73	31.52	24.93	306	34.20	738
320 8ss TL	12.60	28.14	34.92	28.06	330	38.34	794

Notes:

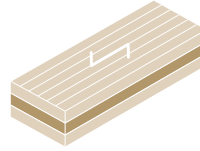
- (1) Spans controlled by allowable moment include panel self weight
- (2) Vibration control calculation as per Chapter 7, CLT Handbook, US Ed.
- (3) Deflections based on EI_{app} as per NDS 2024 Section 10.4.1
- (4) Long term loading deflection Δ_L based on $K_{cr} = 2.0$ as per NDS 2024 Section 3.5.2
- (5) Vibration controlled span is assumed the same for single and two span conditions where all spans = L
- (6) Allowable moment controlled span based on $M_{max} = +wL^2/8$ for single span condition and $M_{max} = -wL^2/8$ over interior support for two span condition
- (7) E.O.R. must verify structural adequacy of CLT panel chosen for actual project load and span conditions and deflection limits

STRUCTURAL PRE-ANALYSIS TABLES

05 KLH® ROOF PANELS

5.1 ROOFS WITH $L = 20$ PSF

according to NDS 2024

**Preliminary** Sizing of CLT Roof Panels

D = 10 psf + panel self weight

L = 20 psf, $C_D = 1.25$

Allowable spans for KLH® - CLT in major strength direction

Single span = L and two equal spans each = L

Governing span in **bold** font

Panel Type	Thickness (in)	Both span conditions	Single span		Two equal spans	
				Live load Δ_L		Live load Δ_L
		Allowable	Long term	@ Allowable	Long term	@ Allowable
		Moment	$\Delta_T = L/180$	Moment span	$\Delta_T = L/180$	Moment span
		(ft)	(ft)		(ft)	
60 3s TL	2.36	16.64	10.13	113	13.70	273
70 3s TL	2.76	18.71	11.53	123	15.61	296
80 3s TL	3.15	21.76	13.30	124	17.98	299
90 3s TL	3.54	23.87	14.67	132	19.86	318
100 3s TL	3.94	26.53	16.30	136	22.02	327
105 3s TL	4.13	27.27	16.77	140	22.70	336
120 3s TL	4.72	30.55	18.82	148	25.49	358
100 5s TL	3.94	23.81	15.16	151	20.48	364
120 5s TL	4.72	29.24	18.36	155	24.81	375
130 5s TL	5.12	30.87	19.55	164	26.40	396
140 5s TL	5.51	34.06	21.28	164	28.76	394
150 5s TL	5.91	35.71	22.48	172	30.35	415
160 5s TL	6.30	37.32	23.63	180	31.89	434
160 5ss TL	6.30	39.16	24.23	170	32.80	410
170 5s TL	6.69	38.47	24.43	189	33.04	455
175 5s TL	6.89	37.91	24.40	199	33.01	480
180 5s TL	7.09	39.87	25.49	198	34.45	476
180 7s TL	7.09	33.02	22.45	238	30.36	572
200 7s TL	7.87	35.25	24.17	258	32.71	621
220 7s TL	8.66	41.67	27.85	251	37.67	605
240 7s TL	9.45	44.01	29.59	270	40.05	649
245 7s TL	9.65	46.80	31.05	262	42.01	631
210 7ss TL	8.27	47.14	29.79	208	40.30	501
240 7ss TL	9.45	53.41	33.84	224	45.69	540
280 7ss TL	11.02	58.65	37.46	255	50.74	614
320 8ss TL	12.60	63.54	41.27	290	55.82	698

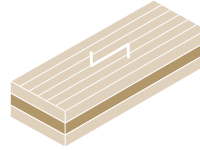
Notes:

- (1) Spans controlled by allowable moment include panel self weight
- (2) Deflections based on EI_{app} as per NDS 2024 Section 10.4.1
- (3) Long term loading deflection Δ_T based on $K_{cr} = 2.0$ as per NDS 2024 Section 3.5.2
- (4) Allowable moment controlled span based on $M_{max} = +wL^2/8$ for single span condition and $M_{max} = -wL^2/8$ over interior support for two span condition
- (5) E.O.R. must verify structural adequacy of CLT panel chosen for actual project load and span conditions and deflection limits

STRUCTURAL PRE-ANALYSIS TABLES

5.2 ROOFS WITH S = 25 PSF

according to NDS 2024

**Preliminary** Sizing of CLT Roof Panels

D = 20 psf + panel self weight

S = 25 psf, $C_D = 1.15$

Allowable spans for KLH® - CLT in major strength direction

Single span = L and two equal spans each = L

Governing span in **bold** font

Panel Type	Thickness (in)	Both span conditions	Single span		Two equal spans	
		Allowable	Long term	Snow load Δ_s @ Allowable	Long term	Snow load Δ_s @ Allowable
		Moment	$\Delta_T = L/180$	Moment span	$\Delta_T = L/180$	Moment span
		(ft)	(ft)		(ft)	
60 3s TL	2.36	13.45	8.87	169	12.02	408
70 3s TL	2.76	15.20	10.13	181	13.75	436
80 3s TL	3.15	17.75	11.75	181	15.92	437
90 3s TL	3.54	19.55	13.00	190	17.64	457
100 3s TL	3.94	21.81	14.52	194	19.65	467
105 3s TL	4.13	22.46	14.94	198	20.28	476
120 3s TL	4.72	25.29	16.85	207	22.88	498
100 5s TL	3.94	19.57	13.50	215	18.28	518
120 5s TL	4.72	24.21	16.47	217	22.29	523
130 5s TL	5.12	25.64	17.59	228	23.79	548
140 5s TL	5.51	28.37	19.19	224	25.99	541
150 5s TL	5.91	29.84	20.33	234	27.51	564
160 5s TL	6.30	31.27	21.44	243	28.98	586
160 5ss TL	6.30	32.82	21.95	229	29.78	552
170 5s TL	6.69	32.33	22.20	252	30.08	607
175 5s TL	6.89	31.90	22.20	265	30.08	638
180 5s TL	7.09	33.59	23.23	262	31.44	631
180 7s TL	7.09	27.82	20.45	314	27.71	757
200 7s TL	7.87	29.85	22.11	336	29.98	809
220 7s TL	8.66	35.45	25.58	323	34.66	779
240 7s TL	9.45	37.59	27.27	342	36.97	824
245 7s TL	9.65	40.03	28.65	332	38.82	799
210 7ss TL	8.27	40.01	27.30	269	37.01	649
240 7ss TL	9.45	45.62	31.22	286	42.21	688
280 7ss TL	11.02	50.49	34.74	316	47.14	762
320 8ss TL	12.60	55.07	38.51	353	52.15	851

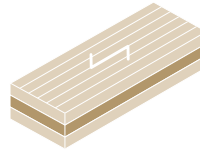
Notes:

- (1) Spans controlled by allowable moment include panel self weight
- (2) Deflections based on EI_{app} as per NDS 2024 Section 10.4.1
- (3) Long term loading deflection Δ_T based on $K_{cr} = 2.0$ as per NDS 2024 Section 3.5.2
- (4) Allowable moment controlled span based on $M_{max} = +wL^2/8$ for single span condition and $M_{max} = -wL^2/8$ over interior support for two span condition
- (5) E.O.R. must verify structural adequacy of CLT panel chosen for actual project load and span conditions and deflection limits

STRUCTURAL PRE-ANALYSIS TABLES

5.3 ROOFS WITH S = 40 PSF

according to NDS 2024

**Preliminary** Sizing of CLT Roof Panels

D = 20 psf + panel self weight

S = 40 psf, $C_D = 1.15$

Allowable spans for KLH® - CLT in major strength direction

Single span = L and two equal spans each = L

Governing span in **bold** font

Panel Type	Thickness (in)	Both span conditions	Single span		Two equal spans	
				Snow load Δ_s		Snow load Δ_s
		Allowable	Long term	@ Allowable	Long term	@ Allowable
		Moment	$\Delta_T = L/180$	Moment span	$\Delta_T = L/180$	Moment span
		(ft)	(ft)		(ft)	
60 3s TL	2.36	11.85	8.34	154	11.32	370
70 3s TL	2.76	13.42	9.54	163	12.97	392
80 3s TL	3.15	15.71	11.09	162	15.04	390
90 3s TL	3.54	17.34	12.28	168	16.69	406
100 3s TL	3.94	19.39	13.74	171	18.62	412
105 3s TL	4.13	19.98	14.14	174	19.22	418
120 3s TL	4.72	22.57	15.98	180	21.73	434
100 5s TL	3.94	17.39	12.78	190	17.32	458
120 5s TL	4.72	21.61	15.62	189	21.17	456
130 5s TL	5.12	22.93	16.71	197	22.63	476
140 5s TL	5.51	25.42	18.25	194	24.74	466
150 5s TL	5.91	26.78	19.37	201	26.22	484
160 5s TL	6.30	28.12	20.44	208	27.65	500
160 5ss TL	6.30	29.51	20.91	195	28.41	470
170 5s TL	6.69	29.12	21.18	214	28.72	515
175 5s TL	6.89	28.76	21.19	224	28.74	540
180 5s TL	7.09	30.31	22.18	221	30.06	533
180 7s TL	7.09	25.10	19.53	265	26.48	638
200 7s TL	7.87	27.02	21.14	280	28.70	676
220 7s TL	8.66	32.18	24.51	268	33.24	646
240 7s TL	9.45	34.22	26.17	281	35.51	677
245 7s TL	9.65	36.46	27.51	272	37.30	655
210 7ss TL	8.27	36.27	26.14	224	35.46	541
240 7ss TL	9.45	41.53	29.97	235	40.55	567
280 7ss TL	11.02	46.20	33.42	256	45.39	617
320 8ss TL	12.60	50.62	37.15	282	50.35	680

Notes:

- (1) Spans controlled by allowable moment include panel self weight
- (2) Deflections based on EI_{app} as per NDS 2024 Section 10.4.1
- (3) Long term loading deflection Δ_T based on $K_{cr} = 2.0$ as per NDS 2024 Section 3.5.2
- (4) Allowable moment controlled span based on $M_{max} = +wL^2/8$ for single span condition and $M_{max} = -wL^2/8$ over interior support for two span condition
- (5) E.O.R. must verify structural adequacy of CLT panel chosen for actual project load and span conditions and deflection limits

 ADDITIONAL DESIGN PROCEDURES

06 ADDITIONAL DESIGN PROCEDURES

6.1 FIRE DESIGN PROCEDURE FOR CLT PANELS

Step 1:

Determine the effective char depth for a given fire duration using the procedures illustrated in Chapter 16 of the National Design Specification for Wood Construction (NDS), 2024 Ed. For all laminations of equal thicknesses, see Table 16.2.1B for a summary of effective char depth based on lamination thicknesses and fire duration. For CLT panels of unequal lamination thicknesses, refer to the CLT Handbook, U.S. Ed., for modified procedures for calculating the effective char depth.

Step 2:

Calculate the reduced section properties of remaining unburned wood using principles of engineering mechanics. Worked examples are provided in the CLT Handbook, U.S. Ed.

Step 3:

Calculate the member strength after charring using the procedure described in NDS Section 16.2.2. Adjustment factors applied to the various strength properties are given in Table 16.2.2.

Step 4:

Verify that the member strengths are greater than the load effects due to service loads.

Step 5:

Verify the integrity of CLT joints using the procedure specified in Chapter 8 of the CLT Handbook, U.S. Ed.

6.2 DEFLECTION OF HORIZONTAL CLT PANELS DUE TO OUT-OF-PLANE LOADS

Deflection shall be calculated according to NDS 3.5, including time-dependent deformation (creep). Deflection calculations shall be performed using the apparent bending stiffness $(EI)_{app}$, which reduces the effective bending stiffness $(EI)_{eff}$ to account for the effects of shear deformation, as per NDS 10.4.

6.3 VIBRATION ANALYSIS OF CLT PANELS DUE TO OUT-OF-PLANE LOADS

Vibration limit states may be calculated using the simplified equation in the CLT Handbook, U.S. Ed., or any rational procedure approved by the engineer.

6.4 CLT AS COMPRESSION MEMBERS WITH OR WITHOUT SIMULTANEOUS OUT-OF-PLANE LOADING

For CLT loaded in plane as a compression member, such as a bearing wall, the column stability factor CP shall be calculated as per NDS 3.7 using $(EI)_{app-min} = 0.5184(EI)_{app}$ and applied to the reference compression design value parallel to grain, $F_c(A_{parallel})$, as per NDS 10.3.7, along with all other applicable adjustment factors as per NDS Table 10.3.1. For cases involving simultaneous out-of-plane loading, such as wind load, refer to the procedures specified in NDS 3.9.

6.5 CLT IN-PLANE BENDING

The engineer should use a rational method to calculate the bending capacity of CLT members used for in-plane loading situations, such as lintels or cantilevered walls. For example, only horizontal laminations might be considered as effective for bending resistance, with shear checked using the values for in-plane shear reported in section 3.3.

6.6 FASTENERS

The procedures specified in NDS Chapters 11-12 for fastener design may be used for CLT construction, giving attention to how the fasteners are oriented relative to the direction of grain of the laminations involved in the connection.

FIRE RESISTANCE TESTING

6.7 FIRE PERFORMANCE TESTING AT SOUTHWEST RESEARCH INSTITUTE (SWRI ®)

ASTM E119-16 STANDARD TEST METHODS FOR FIRE TESTS OF BUILDING CONSTRUCTION AND MATERIALS

60-minute Fire Resistance Rating

5-ply 130 mm thick CLT, load bearing roof assembly,
SwRI Project No. 01.23472.01.001, June 6, 2018

5-ply 160 mm thick CLT, load bearing floor assembly,
SwRI Project No. 01.23472.01.004, June 29, 2018

ASTM E119-19 STANDARD TEST METHODS FOR FIRE TESTS OF BUILDING CONSTRUCTION AND MATERIALS

120-minute Fire Resistance Rating

5-ply 175 mm thick CLT, load bearing wall assembly,
SwRI Project No. 01.25700.01.001, April 24, 2020

5-ply 175 mm thick CLT, load bearing floor assembly,
SwRI Project No. 01.25700.01.002, April 24, 2020

5-ply 180 mm thick CLT, load bearing floor assembly,
SwRI Project No. 01.25700.01.003, October 2, 2020

ASTM E84-16 STANDARD TEST METHOD FOR SURFACE BURNING CHARACTERISTICS OF BUILDING MATERIALS

Flame Spread Index and Smoke Developed Index, Classification B

5-ply 130 mm thick CLT, SwRI Project No.
01.23472.02.001, April 17, 2018

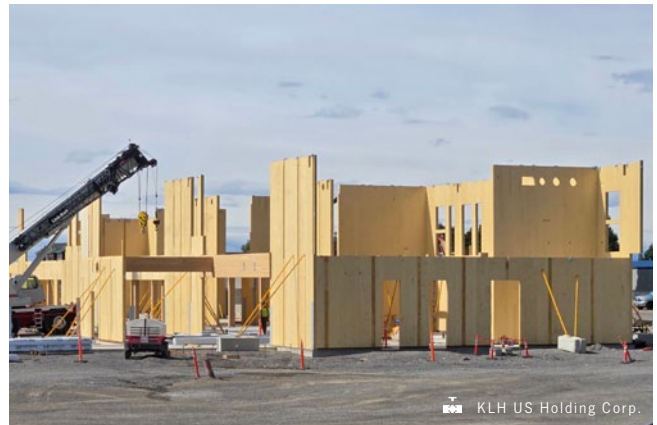
ASTM E2768-11 STANDARD TEST METHOD FOR EXTENDED DURATION SURFACE BURNING CHARACTERISTICS OF BUILDING MATERIALS (30 MIN TUNNEL TEST)

Flame Spread Index and Smoke Developed Index, Classification B

5-ply 130 mm thick CLT, SwRI Project No.
01.23472.02.001a



Hidden Creek Community Center in Hillsboro | Portland



Redmond Public Safety Facility in Redmond | Oregon



Timber Lofts in Milwaukee | Wisconsin

SAMPLE CLT GENERAL STRUCTURAL NOTES

07 GENERAL STRUCTURAL NOTES

- 01 Cross-Laminated Timber panels shall be manufactured in conformance with the latest edition of ANSI/APA PRG 320, Standard for Performance-Rated Cross-Laminated Timber.
- 02 Minimum allowable design properties for the lumber laminations used in the panels shall be grade CV1M1.
- 03 Exposed panel surfaces shall be finished as per the Architectural drawings.
- 04 Contractor to confirm all dimensions and details with Architectural drawings.
- 05 CLT panels shall consist of 3, 5, 7, or 8 layers of crosswise stacked spruce boards and glued together with approved adhesives. Lamination thickness may vary from 20 mm to 40 mm (25/32" to 1-9/16").
- 06 Panels shall not be fabricated until approval of the shop drawings by the E.O.R.
- 07 Panels shall be manufactured with lumber of maximum moisture content of 12% (+/-) 2%.
- 08 The Contractor shall cut no holes, slots, notches, grooves, etc. in the panels without written approval by the E.O.R.
- 09 CLT panels shall be installed in strict conformance with manufacturer's requirements
- 10 Store all panels off the ground and stacked using spacers to separate individual panels. Contractor is responsible for taking appropriate measures to minimize the likelihood of staining, cracking, distortion, warping or other types of damage to the panels.
- 11 Lift and support panels during construction only at designated points shown in the shop drawings.
- 12 Handle panels consistent with their shape to minimize damage.
- 13 Panels shall fit together properly, without trimming or cutting in the field. The Contractor shall report any problems with fit-up to the E.O.R.
- 14 CLT panels shall be adequately braced until all structural diaphragms and permanent bracing systems are installed and connected.
- 15 Floor and roof panels shall be oriented with the exterior layers perpendicular to the supports, u.o.n.
- 16 Structural steel components used to connect the panels to each other or the structural framework and, if supplied by the manufacturer, test fitted in the manufacturing facility prior to shipment.
- 17 The manufacturer shall provide instructions and prepare the panels for shipment in such a way as to facilitate erection.
- 18 Manufacturer shall affix labels to all panels.
- 19 Panel labels will include information on the surface qualities of each face.
- 20 Manufacturer shall submit product certificates to the A.O.R. and E.O.R. for review and written approval prior to fabrication.

SAMPLE CLT SPECIFICATIONS

08 SECTION 06130 HEAVY TIMBER CONSTRUCTION

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A Labor, materials, equipment, services, and transportation required to complete the work as shown on the Drawings and as specified herein.
- 1 Cross Laminated Timber (CLT) panels as indicated in the drawings.
 - 2 Connectors, fasteners, and other installation accessories.
 - 3 Erection.

1.3 REFERENCES

- A ANSI/APA PRG 320 Standard for Performance-Rated Cross-Laminated Timber.
- B NDS 2015 National Design Specification for Wood Construction.
- C AITC 108: Standard for Heavy Timber Construction
- D ANSI 405: Standard for Adhesives for Use in Structural Glued Laminated Timber

1.4 SUBMITTALS

- A Product Data for each type of product indicated.
- B Shop Drawings, including panel location plans, dimensions, shapes and sections, openings, support conditions, and connections.
- 1 Indicate lifting connections.
 - 2 Indicate locations, tolerances, and details of anchorage to supporting structure.
 - 3 Include and locate openings.
 - 4 Indicate location of CLT panel by identification mark placed on panel.
 - 5 Indicate relationship of CLT panels to adjacent materials.
 - 6 Clearly indicate stress grade, service grade, and appearance grade of surfaces.
 - 7 Provide three dimensional models of all interfaces and CLT panels, including all connections.
 - 8 CLT supplier shall provide a fully accurate three-dimensional (3D) model of the interfaces (supports, abutments, etc.), CLT panels, and all connections prior to submission of shop drawings. Model to be generated using hsbcad (compatible with AutoCAD 2011).

C Sustainable Design Submittals

- 1 Manufacturer's product data for adhesives, sealants, paints, and coatings, including printed manufacturer's statement of VOC content.
- 2 Provide certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material to Project, by rail, by inland waterway, by sea and by all other means. Include statement indicating cost for each regional material, and fraction by weight that is considered regional.
- 3 For non-recycled wood and wood based materials, provide itemized list of materials including manufacturer and vendor chain-of-custody certificates.
- 4 Certified Wood: Lamination stock shall be produced from wood obtained from forests certified by a PEFC- or FSC®-accredited certification body.

1.5 QUALITY ASSURANCE

- A Material Standard: Certify CLT panels to APA/ANSI PRG 320.
- B Manufacturer's Qualifications: Manufacturer shall comply with the National Design Specification for Wood Construction- NDS 2015, applicable to types of CLT panels indicated.

1.6 DELIVERY, STORAGE, AND HANDLING

- A Support panels during shipment on non-staining material in same position as during storage.
- B Store panels with adequate bracing and protect panels to prevent contact with soil. Separate panels with blocking so that air may circulate around all faces. Take all reasonable steps to prevent cracking, distortion, warping or other physical damage.
- 1 Place stored panels so that identification labels are clearly visible.
 - 2 Handle and transport units in a position consistent with their shape and design in order to avoid excessive stresses that would cause cracking or damage.
 - 3 Lift and support panels only at designated points shown on the Shop Drawings.
 - 4 Cover top and sides with opaque moisture resistant membrane.
 - 5 Maintain protection of panels at all times during construction.

SAMPLE CLT SPECIFICATIONS

PART 2 PRODUCTS

2.1 PRODUCT REQUIREMENTS

- A Provide PEFC- or FSC® C119602-certified wood products.

2.2 MANUFACTURER

- A Basis-of-Design manufacturer:
- 1 KLH. Contact Sebastian Popp, 30 Wall Street | 8th floor
New York, NY 10005-2205, (971) 804-3794,
sebastian.popp@klhusa.com

2.3 MATERIALS

- A Wood Species: PEFC- or FSC® C119602-certified Austrian Spruce for lamination stock for panels.
- B Adhesives: Provide adhesive products in compliance with ANSI A190.1, DIN 68141, and EN301 and EN302.
- 1 Acceptable Product: Purbond HB X172 by Henkel Corp.:
na.henkel-adhesives.com.

2.4 FABRICATION

- A Fabricate panels in accordance with ANSI/APA PRG 320. Use multiple layers of 20 mm minimum to 40 mm maximum thick laminations.
- B Manufacturer to be ISO 9001, 14001 certified.
- C CLT Layup shall be Stress Grade CV1M1 as per Product listing.
- D Joints: CLT panels shall be joined at panel edges using connections as indicated on the Drawings.
- E Panels shall satisfy one of the following appearance classifications, as indicated on the Drawings.
See www.klh.at/en/product/surface/ for a complete description of these classifications.
- 1 NSI (NVQ): Non-Visual Quality (very low surface quality, planed)
 - 2 ISI (IVQ): Industrial Visual Quality (medium surface quality, sanded)
 - 3 WSI (DVQ): Domestic Visual Quality (high surface quality, sanded, surface edges glued)
- F Tolerances: +/- 2 mm for panels >1 m² @ 12% moisture content.

PART 3 EXECUTION

3.1 EXAMINATION

- A Prior to fabrication, check all dimensions relating to this section of work. Report any discrepancies to the EOR.
- B Prior to site erection, examine all site conditions and ensure an acceptable condition.

3.2 INSTALLATION

- A Erect panels in accordance with final approved shop drawings.
- B Make adequate provision for possible erection stresses.
Set panels level and plumb to correct positions. Securely brace panels and anchor in place to maintain plumb until permanently secured by finished structure.
- C Fit panels closely and accurately, without trimming, cutting, or other modifications, unless approved in writing by the EOR.
- D Site cutting or boring of panels, other than shown on the shop drawings, is not permitted without the written consent of the EOR.

3.3 CLEANING

- A Clean exposed surface of panels after erection and completion of field touch up.
- 1 Perform cleaning procedures, if necessary, according to Manufacturer's written recommendations. Protect other work from staining or damage due to cleaning operations.
 - 2 Do not use cleaning materials or processes that could damage the appearance of the panels or damage adjacent materials.

END OF SECTION 06130





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