Design of Structural Glued Laminated Timber Columns

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WOOD
The Natural Choice

Engineered wood products are a good choice for the environment. They are manufactured for years of trouble-free, dependable use. They help reduce waste by decreasing disposal costs and product damage. Wood is a renewable, recyclable, biodegradable resource that is easily manufactured into a variety of viable products.

A few facts about wood.

▪ ***We're growing more wood every day.*** Forests fully cover one-third of the United States' and one-half of Canada's land mass. American landowners plant more than two billion trees every year. In addition, millions of trees seed naturally. The forest products industry, which comprises about 15 percent of forestland ownership, is responsible for 41 percent of replanted forest acreage. That works out to more than one billion trees a year, or about three million trees planted every day. This high rate of replanting accounts for the fact that each year, 27 percent more timber is grown than is harvested. Canada's replanting record shows a fourfold increase in the number of trees planted between 1975 and 1990.

▪ ***Life Cycle Assessment shows wood is the greenest building product.*** A 2004 Consortium for Research on Renewable Industrial Materials (CORRIM) study gave scientific validation to the strength of wood as a green building product. In examining building products' life cycles – from extraction of the raw material to demolition of the building at the end of its long lifespan – CORRIM found that wood was better for the environment than steel or concrete in terms of embodied energy, global warming potential, air emissions, water emissions and solid waste production. For the complete details of the report, visit www.CORRIM.org.

▪ ***Manufacturing wood is energy efficient.*** Wood products made up 47 percent of all industrial raw materials manufactured in the United States, yet consumed only 4 percent of the energy needed to manufacture all industrial raw materials, according to a 1987 study.

Material	Percent of Production	Percent of Energy Use
Wood	47	4
Steel	23	48
Aluminum	2	8

▪ ***Good news for a healthy planet.*** For every ton of wood grown, a young forest produces 1.07 tons of oxygen and absorbs 1.47 tons of carbon dioxide.

Wood: It's the natural choice for the environment, for design and for strong, lasting construction.

DESIGN OF STRUCTURAL GLUED LAMINATED TIMBER COLUMNS

Introduction

While glued laminated timbers (glulam) are typically used as some type of bending member, they are also ideally suited for use as columns. Because glulam is manufactured with "dry" lumber having a maximum moisture content at the time of fabrication of 16 percent, it has excellent dimensional stability. Thus, a glulam column will not undergo the dimensional changes normally associated with larger, solid-sawn sections which are typically supplied as "green" timbers. Glulam will remain straight and true in cross-section. Since glulam is manufactured with dry lumber, it is also less susceptible to checking and splitting which often occur with green timbers, and it has better fastener holding capacities.

Member Sizes

Like other glulam shapes, columns can be manufactured in virtually any cross-sectional size and length required. Since they are manufactured using dimension lumber, however, specifying glulam column in the typical widths, as shown by Table 1, will ensure maximum efficiency of the resource and product availability.

The depths of glulam columns are normally specified in multiples of 1-1/2 inches for Western species and 1-3/8 inches for southern pine. Examples of column sizes are given in Table 2 to show the use of typical glulam width and depth size multiples.

Another advantage of glulam is that any length can be supplied, eliminating the need for costly splices to create long-length columns for multi-story applications or high open areas. Availability of specific cross-section dimensions and lengths should be verified with the supplier or manufacturer.

Member Layup and Design Stresses

Since compression parallel-to-grain stresses are distributed uniformly over the cross-section of an axially loaded member, glulam columns are typically manufactured using a single grade of lumber throughout the depth of the member. Examples of layup combinations and some of the associated design stresses for single-grade glulam members are shown in Table 3.

Two distinct values are provided for F_b and F_v depending on which axis the load is applied to (i.e., parallel to the wide or to the narrow face of the member). If a column is going to be loaded as a combined axial and bending member,

TABLE 1

TYPICAL GLULAM COLUMN WIDTHS

National Width (inches)	4*	6*	8	10	12
Western species	3-1/8	5-1/8	6-3/4	8-3/4	10-3/4
Southern pine	3	5	6-3/4	8-1/2	10-1/2

*For the 4-inch and 6-inch nominal widths, glulam may also be available in 3-1/2" and 5-1/2" widths respectively. These "full-width" members correspond to the dimensions of 2x4 and 2x6 framing lumber and are supplied with "hit or miss" surfacing which is only acceptable for concealed applications or when appearance is not a design consideration. For additional information on the appearance characteristics of glulam, see EWS Technical Note: *Appearance Classifications for Glued Laminated Timber*, Form Y110.

TABLE 2

TYPICAL GLULAM COLUMN SIZES*

Nominal Size (inches)	6 x 6	8 x 8	8 x 10	10 x 10	10 x 12
Western species	5-1/8 x 6	6-3/4 x 7-1/2	6-3/4 x 9	8-3/4 x 9	8-3/4 x 12
Southern pine	5 x 5-1/2	6-3/4 x 6-7/8	6-3/4 x 9-5/8	8-1/2 x 9-5/8	8-1/2 x 11

*Other sizes are available. Contact the local supplier or manufacturer for additional information.

TABLE 3

COLUMN LAYUP DESIGNATIONS AND DESIGN STRESSES*

Species and Layup Combination	Lam Grade	F_c	E	F_{bx}	F_{by}	F_{vx}	F_{vy}
DF – No. 2	L2	1,950	1.6×10^6	1,700	1,800	265	230
SP – No. 47	N2M14	1,900	1.4×10^6	1,400	1,750	300	260

*All stress values are in psi and assume 4 or more laminations (up to 15 inches) without special tension laminations. Numerous other species and layup combinations are available. See *Glulam Design Properties*, Form Y117, for more information.

it may be preferable to specify a bending member layup, such as a 24F-V8/DF or 24F-V5/SP combination. Such members use a graded lumber layup throughout the depth of the member and are more efficient for resisting high bending stresses.

For a complete listing of available glulam layup combinations for both members primarily loaded axially or as bending members, refer to EWS Data File, *Glulam Design Properties and Layup Combinations,* Form Y117, or the Supplement to the 2005 National Design Specification (NDS) (available from the American Forest and Paper Association).

Column Design Equations

Equation 1 is for a member subjected to **concentric axial loads** only.

Equation 1:

$$C_p = \frac{1 + (F_{cE}/F^*_c)}{2c} - \sqrt{\left[\frac{1 + (F_{cE}/F^*_c)}{2c}\right]^2 - \frac{F_{cE}/F^*_c}{c}}$$

Where:

C_p = column stability factor – adjustment to compression-parallel-to-grain design value

F^*_c = tabulated compression parallel-to-grain design value adjusted for service conditions (moisture, temperature, load duration)

c = 0.9 for glued laminated timber

F_{cE} = critical buckling design value

$$= \frac{0.822\, E'_{min}}{(L_e/d)^2}$$

E'_{min} = $E'(1 - 1.645\, COV_E)(1.05)/1.66$

E' = tabulated modulus of elasticity adjusted for service conditions (moisture and temperature)

d = least unbraced dimension of column

L_e = effective column length based on unbraced length and end fixity conditions

COV_E = 0.10 for glued laminated timber of five or more lams or 0.15 for less than five lams

The solution of this equation which determines the allowable compression parallel-to-grain stress is based on the physical dimensions of the column, the published material properties, such as E and F_c and several constants. The two constants, c and COV_E, are material dependent resulting in higher column capacities for glulam, than a similar size solid-sawn column.

Through the laminating process, naturally occurring strength reducing characteristics in the lumber are randomly distributed throughout the member, resulting in lower variability in mechanical properties for glulam as compared to sawn lumber products. For example, the typical coefficient of variation for the modulus of elasticity of glulam is about 10 percent which is equal to or lower than other comparable wood products.

Column Design Tables

Tables 4–17 have been generated to provide column capacities for two typical glulam layup combinations for an **eccentric axial loads** condition. These tables are summarized as follows:

- No. 2 Douglas-fir (DF) Tables 4–10 (**eccentric** loading)
- No. 47 southern pine (SP) Tables 11–17 (**eccentric** loading)

All tables have been truncated at an L/d ratio of 50.

For most applications, the No. 2 DF and No. 47 SP combinations will result in the most cost-efficient columns. These permit the use of all L2 laminations for the No. 2 DF and all No. 2 medium grain laminations for the No. 47 SP combinations.

For those applications requiring greater capacities, the use of a No. 5 DF (all L1 laminations) or a No. 50 SP (all No. 1 dense laminations) are recommended. Any of the column layup combinations can be finished to meet any appearance classification. (See EWS Technical Note: *Appearance Classifications for Glued Laminated Timber,* Form Y110, for a more detailed discussion of glulam appearance classifications.)

Since wood columns are typically not loaded concentrically, Tables 4–17 are provided based on the assumption that the load is applied with an eccentricity of 1/6 of the least dimension of the column. This degree of eccentricity is considered to be representative of many actual in-service column installations, such as an end column supporting a beam. As such, it provides a conservative solution based on an allowance for some degree of field framing inaccuracies. It is recommended that these tables be used for those applications where it is desirable to use a simple tabular solution for preliminary design sizing.

For applications with greater degrees of eccentricities or side loads, the designer is referred to the NDS for equations that account for these conditions of loading.

As with the use of all design tables, it is recommended that the advice of a design professional be obtained to verify the capacity and applicability of any column size provided in Tables 4–17.

Where higher capacities are required and it can be assured that the loads will be applied concentrically, the column may be designed in accordance with equation 1, as shown in the following example.

Design Example

Determine the size of a glulam column required to support a 45-kip axial floor load (DOL = 1.0) applied concentrically. Assume the length of the column is 15 feet and that it is in a dry-use service condition. Use a Douglas-fir combination No. 2. Assume the column is unbraced and that the end conditions are pinned.

Tabulated allowable stresses (see Table 3):

F_c = 1,950 psi
E = 1,600,000 psi

Adjusted allowable stresses:

$F^*_c = F'_c$ = 1,950 x 1.0 = 1,950 psi
E' = 1,600,000 x 1.0 = 1,600,000 psi
$E'_{min} = E'[1 - 1.645\ COV_E](1.05)/1.66$ = 1,600,000[1 – 1.645(0.10)](1.05)/1.66 = 845,566 psi

Try a 6-3/4" x 7-1/2" section: Net area = 6.75 x 7.5 = 50.62 $in.^2$

Determine effective length (L_e) = 15(12) x 1.0 = 180 in.

Determine maximum slenderness ratio = L_e/d = 180/6.75 = 26.67 < 50

Determine allowable compression parallel to grain design value using equation 1:

$$F_{cE} = \frac{0.822\ E'_{min}}{(L_e/d)^2} = \frac{(0.822 \times 845{,}566)}{(26.67)^2} = 977 \text{ psi}$$

$$F_{cE}/F^*_c = \frac{977}{1{,}950} = 0.501$$

$$C_p = \frac{1 + 0.501}{2 \times 0.9} - \sqrt{\left[\frac{1 + 0.501}{2 \times 0.9}\right]^2 - \frac{0.501}{0.9}} = 0.462$$

Determine allowable axial load capacity = $C_p\ F'_c\ A$ = 0.462(1,950)(50.62)/1,000 = 45.6 kips > 45 kips

Use a 6-3/4" x 7-1/2" No. 2 Douglas-fir glulam combination.

Note that if the column is designed to a maximum eccentricity of either 1/6 column width or depth, whichever is greatest, the column capacity for 6-3/4" x 7-1/2" No. 2 DF is only 24,768 lbf (see Table 8), which would not be sufficient to carry the design load of 45,000 lbf. In this case, a 8-3/4" x 9" No. 2 DF may be needed (see Table 9).

Further Information

For more complex design situations, such as members subjected to combined bending and axial forces or columns subjected to side loads, the designer is referred to the NDS for the applicable design equations. Another recommended reference is the *Wood Engineering and Construction Handbook,* published by McGraw-Hill, which provides guidance for virtually any wood design situation including the design of wood columns.

For information on recommended connection details for the installation of glulam columns, refer to EWS Technical Note: *Glulam Connection Details,* Form T300. For more information on the design of glulam columns or any other aspects of designing with glued laminated timber, visit **www.apawood.org.**

TABLE 4

ALLOWABLE AXIAL LOADS (POUNDS) FOR COMBINATION NO. 2 DOUGLAS-FIR GLULAM COLUMNS
Side loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or depth, whichever is worse.

Effective Column Length (ft)	Lamination Net Width = 3-1/8 in.								
	Net Depth = 4-1/2 in. (3 lams)			Net Depth = 6 in. (4 lams)			Net Depth = 7-1/2 in. (5 lams)		
	Load Duration Factor			Load Duration Factor			Load Duration Factor		
	1.00	1.15	1.25	1.00	1.15	1.25	1.00	1.15	1.25
8	5,557	5,773	5,897	7,668	7,942	8,100	9,584	9,928	10,125
9	4,674	4,832	4,922	6,419	6,619	6,734	8,023	8,274	8,418
10	3,976	4,095	4,163	5,441	5,592	5,678	6,801	6,990	7,098
11	3,419	3,510	3,562	4,665	4,781	4,848	5,831	5,976	6,059
12	2,968	3,040	3,081	4,041	4,132	4,184	5,051	5,165	5,230
13	2,599	2,656	2,689	3,532	3,605	3,646	4,415	4,506	4,558

Notes:

1. The tabulated allowable loads apply only to one-piece glulam members made with all L2 laminations (Combination 2) without special tension laminations.
2. Applicable service conditions = dry.
3. The tabulated allowable loads are based on axially loaded columns subjected to a maximum eccentricity of either 1/6 column width or 1/6 column depth, whichever is worse. For side loads, other eccentric end loads, or other combined axial and flexural loads, see NDS.
4. The column is assumed to be unbraced, except at the column ends, and the effective column length is equal to the actual column length.
5. Design properties for normal load duration and dry-use service conditions:
   Compression parallel to grain (F_c) = 1,950 psi for 4 or more lams, or 1,600 psi for 2 or 3 lams.
   Modulus of elasticity (E) = 1.6 x 10^6 psi.
   Flexural stress when loaded parallel to wide faces of lamination (F_{by}) = 1,800 psi for 4 or more lams, or 1,600 psi for 3 lams.
   Flexural stress when loaded perpendicular to wide faces of lamination (F_{bx}) = 1,700 psi for 2 lams to 15 in. deep without special tension laminations.
   Volume factor for F_{bx} is in accordance with NDS. Size factor for F_{by} is $(12/d)^{1/9}$, where d is equal to the lamination width in inches.
6. These values are for preliminary design use only. Final design should include a complete analysis, including bearing capacity of the foundation supporting the column.

TABLE 5

ALLOWABLE AXIAL LOADS (POUNDS) FOR COMBINATION NO. 2 DOUGLAS-FIR GLULAM COLUMNS
Side loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or depth, whichever is worse.

Effective Column Length (ft)	Lamination Net Width = 3-1/2 in.								
	Net Depth = 4-1/2 in. (3 lams)			Net Depth = 6 in. (4 lams)			Net Depth = 7-1/2 in. (5 lams)		
	Load Duration Factor			Load Duration Factor			Load Duration Factor		
	1.00	1.15	1.25	1.00	1.15	1.25	1.00	1.15	1.25
8	7,283	7,611	7,799	10,108	10,523	10,762	12,635	13,154	13,453
9	6,184	6,424	6,561	8,531	8,836	9,010	10,664	11,044	11,263
10	5,298	5,479	5,582	7,278	7,507	7,639	9,097	9,384	9,548
11	4,580	4,720	4,800	6,271	6,448	6,550	7,839	8,060	8,187
12	3,994	4,104	4,167	5,454	5,594	5,673	6,817	6,992	7,092
13	3,510	3,598	3,649	4,783	4,895	4,959	5,979	6,119	6,199
14	3,107	3,179	3,220	4,226	4,318	4,370	5,283	5,397	5,462

Notes:

1. The tabulated allowable loads apply only to one-piece glulam members made with all L2 laminations (Combination 2) without special tension laminations.
2. Applicable service conditions = dry.
3. The tabulated allowable loads are based on axially loaded columns subjected to a maximum eccentricity of either 1/6 column width or 1/6 column depth, whichever is worse. For side loads, other eccentric end loads, or other combined axial and flexural loads, see NDS.
4. The column is assumed to be unbraced, except at the column ends, and the effective column length is equal to the actual column length.
5. Design properties for normal load duration and dry-use service conditions:
   Compression parallel to grain (F_c) = 1,950 psi for 4 or more lams, or 1,600 psi for 2 or 3 lams.
   Modulus of elasticity (E) = 1.6 x 10^6 psi.
   Flexural stress when loaded parallel to wide faces of lamination (F_{by}) = 1,800 psi for 4 or more lams, or 1,600 psi for 3 lams.
   Flexural stress when loaded perpendicular to wide faces of lamination (F_{bx}) = 1,700 psi for 2 lams to 15 in. deep without special tension laminations.
   Volume factor for F_{bx} is in accordance with NDS. Size factor for F_{by} is $(12/d)^{1/9}$, where d is equal to the lamination width in inches.
6. These values are for preliminary design use only. Final design should include a complete analysis, including bearing capacity of the foundation supporting the column.

TABLE 6

ALLOWABLE AXIAL LOADS (POUNDS) FOR COMBINATION NO. 2 DOUGLAS-FIR GLULAM COLUMNS
Side loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or depth, whichever is worse.

Effective Column Length (ft)	Lamination Net Width = 5-1/8 in.								
	Net Depth = 6 in. (4 lams)			Net Depth = 7-1/2 in. (5 lams)			Net Depth = 9 in. (6 lams)		
	Load Duration Factor			Load Duration Factor			Load Duration Factor		
	1.00	1.15	1.25	1.00	1.15	1.25	1.00	1.15	1.25
8	23,078	24,712	25,660	28,848	30,890	32,075	36,328	39,108	40,728
9	20,384	21,597	22,297	25,480	26,996	27,872	32,368	34,444	35,645
10	17,977	18,902	19,436	22,471	23,627	24,295	28,729	30,314	31,229
11	15,892	16,615	17,032	19,865	20,768	21,290	25,516	26,756	27,472
12	14,106	14,683	15,015	17,633	18,354	18,769	22,732	23,722	24,293
13	12,581	13,048	13,317	15,726	16,310	16,646	20,332	21,136	21,599
14	11,274	11,659	11,880	14,093	14,573	14,849	18,265	18,926	19,307
15	10,152	10,471	10,655	12,690	13,089	13,319	16,480	17,030	17,347
16	9,182	9,451	9,605	11,478	11,814	12,006	14,932	15,395	15,661
17	8,341	8,569	8,699	10,426	10,711	10,874	13,584	13,978	14,203
18	7,607	7,802	7,913	9,509	9,752	9,892	12,405	12,742	12,935
19	6,963	7,131	7,227	8,704	8,914	9,034	11,369	11,659	11,826
20	6,397	6,542	6,626	7,996	8,178	8,282	10,454	10,706	10,851
21	5,895	6,022	6,095	7,369	7,528	7,619	9,643	9,864	9,990

Notes:

1. The tabulated allowable loads apply only to one-piece glulam members made with all L2 laminations (Combination 2) without special tension laminations.
2. Applicable service conditions = dry.
3. The tabulated allowable loads are based on axially loaded columns subjected to a maximum eccentricity of either 1/6 column width or 1/6 column depth, whichever is worse. For side loads, other eccentric end loads, or other combined axial and flexural loads, see NDS.
4. The column is assumed to be unbraced, except at the column ends, and the effective column length is equal to the actual column length.
5. Design properties for normal load duration and dry-use service conditions:
   Compression parallel to grain (F_c) = 1,950 psi for 4 or more lams, or 1,600 psi for 2 or 3 lams.
   Modulus of elasticity (E) = 1.6×10^6 psi.
   Flexural stress when loaded parallel to wide faces of lamination (F_{by}) = 1,800 psi for 4 or more lams, or 1,600 psi for 3 lams.
   Flexural stress when loaded perpendicular to wide faces of lamination (F_{bx}) = 1,700 psi for 2 lams to 15 in. deep without special tension laminations.
   Volume factor for F_{bx} is in accordance with NDS. Size factor for F_{by} is $(12/d)^{1/9}$, where d is equal to the lamination width in inches.
6. These values are for preliminary design use only. Final design should include a complete analysis, including bearing capacity of the foundation supporting the column.

TABLE 7

ALLOWABLE AXIAL LOADS (POUNDS) FOR COMBINATION NO. 2 DOUGLAS-FIR GLULAM COLUMNS
Side loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or depth, whichever is worse.

Effective Column Length (ft)	Lamination Net Width = 5-1/2 in.								
	Net Depth = 6 in. (4 lams)			Net Depth = 7-1/2 in. (5 lams)			Net Depth = 9 in. (6 lams)		
	Load Duration Factor			Load Duration Factor			Load Duration Factor		
	1.00	1.15	1.25	1.00	1.15	1.25	1.00	1.15	1.25
8	25,904	28,114	29,418	33,028	35,627	37,144	41,358	44,863	46,925
9	23,401	25,092	26,080	29,525	31,473	32,599	37,317	39,979	41,522
10	21,009	22,207	22,894	26,271	27,758	28,618	33,448	35,487	36,665
11	18,701	19,632	20,170	23,376	24,540	25,212	29,925	31,521	32,443
12	16,683	17,427	17,856	20,854	21,784	22,320	26,807	28,082	28,819
13	14,939	15,543	15,891	18,674	19,428	19,864	24,082	25,119	25,717
14	13,432	13,930	14,216	16,791	17,412	17,770	21,712	22,566	23,058
15	12,129	12,543	12,781	15,161	15,679	15,976	19,648	20,361	20,771
16	10,997	11,346	11,546	13,746	14,182	14,432	17,849	18,449	18,794
17	10,010	10,306	10,476	12,513	12,883	13,095	16,274	16,784	17,077
18	9,146	9,399	9,545	11,432	11,749	11,931	14,890	15,328	15,579
19	8,385	8,604	8,730	10,482	10,755	10,912	13,669	14,048	14,264
20	7,714	7,904	8,013	9,642	9,880	10,016	12,589	12,918	13,106
21	7,118	7,284	7,379	8,898	9,105	9,224	11,628	11,916	12,080
22	6,587	6,733	6,817	8,234	8,417	8,521	10,771	11,024	11,169

Notes:

1. The tabulated allowable loads apply only to one-piece glulam members made with all L2 laminations (Combination 2) without special tension laminations.
2. Applicable service conditions = dry.
3. The tabulated allowable loads are based on axially loaded columns subjected to a maximum eccentricity of either 1/6 column width or 1/6 column depth, whichever is worse. For side loads, other eccentric end loads, or other combined axial and flexural loads, see NDS.
4. The column is assumed to be unbraced, except at the column ends, and the effective column length is equal to the actual column length.
5. Design properties for normal load duration and dry-use service conditions:
   Compression parallel to grain (F_c) = 1,950 psi for 4 or more lams, or 1,600 psi for 2 or 3 lams.
   Modulus of elasticity (E) = 1.6 x 10^6 psi.
   Flexural stress when loaded parallel to wide faces of lamination (F_{by}) = 1,800 psi for 4 or more lams, or 1,600 psi for 3 lams.
   Flexural stress when loaded perpendicular to wide faces of lamination (F_{bx}) = 1,700 psi for 2 lams to 15 in. deep without special tension laminations.
   Volume factor for F_{bx} is in accordance with NDS. Size factor for F_{by} is $(12/d)^{1/9}$, where d is equal to the lamination width in inches.
6. These values are for preliminary design use only. Final design should include a complete analysis, including bearing capacity of the foundation supporting the column.

TABLE 8

ALLOWABLE AXIAL LOADS (POUNDS) FOR COMBINATION NO. 2 DOUGLAS-FIR GLULAM COLUMNS
Side loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or depth, whichever is worse.

Effective Column Length (ft)	Lamination Net Width = 6-3/4 in.								
	Net Depth = 7-1/2 in. (5 lams)			Net Depth = 9 in. (6 lams)			Net Depth = 10-1/2 in. (7 lams)		
	Load Duration Factor			Load Duration Factor			Load Duration Factor		
	1.00	1.15	1.25	1.00	1.15	1.25	1.00	1.15	1.25
8	45,476	50,400	53,431	57,147	63,250	67,005	66,672	73,791	78,173
9	42,587	46,682	49,039	53,389	58,464	61,509	62,287	68,208	71,760
10	39,449	42,491	44,265	49,455	53,563	55,977	57,697	62,491	65,306
11	36,014	38,425	39,822	45,487	48,777	50,688	53,069	56,906	59,136
12	32,774	34,708	35,828	41,650	44,298	45,831	48,592	51,681	53,469
13	29,809	31,386	32,299	38,066	40,227	41,477	44,410	46,932	48,390
14	27,143	28,448	29,202	34,796	36,584	37,618	40,595	42,682	43,888
15	24,768	25,860	26,491	31,850	33,348	34,214	37,158	38,906	39,916
16	22,657	23,581	24,114	29,211	30,480	31,212	34,079	35,560	36,414
17	20,782	21,571	22,026	26,853	27,937	28,563	31,329	32,594	33,323
18	19,115	19,794	20,185	24,746	25,680	26,218	28,871	29,960	30,588
19	17,630	18,218	18,556	22,862	23,672	24,138	26,672	27,617	28,161
20	16,303	16,816	17,111	21,173	21,880	22,286	24,701	25,526	26,000
21	15,115	15,565	15,823	19,655	20,276	20,632	22,931	23,655	24,071
22	14,047	14,444	14,671	18,288	18,836	19,150	21,336	21,975	22,342
23	13,085	13,437	13,638	17,054	17,540	17,818	19,897	20,463	20,788
24	12,216	12,529	12,708	15,937	16,370	16,618	18,593	19,098	19,387

Notes:

1. The tabulated allowable loads apply only to one-piece glulam members made with all L2 laminations (Combination 2) without special tension laminations.
2. Applicable service conditions = dry.
3. The tabulated allowable loads are based on axially loaded columns subjected to a maximum eccentricity of either 1/6 column width or 1/6 column depth, whichever is worse. For side loads, other eccentric end loads, or other combined axial and flexural loads, see NDS.
4. The column is assumed to be unbraced, except at the column ends, and the effective column length is equal to the actual column length.
5. Design properties for normal load duration and dry-use service conditions:
   Compression parallel to grain (F_c) = 1,950 psi for 4 or more lams, or 1,600 psi for 2 or 3 lams.
   Modulus of elasticity (E) = 1.6×10^6 psi.
   Flexural stress when loaded parallel to wide faces of lamination (F_{by}) = 1,800 psi for 4 or more lams, or 1,600 psi for 3 lams.
   Flexural stress when loaded perpendicular to wide faces of lamination (F_{bx}) = 1,700 psi for 2 lams to 15 in. deep without special tension laminations.
   Volume factor for F_{bx} is in accordance with NDS. Size factor for F_{by} is $(12/d)^{1/9}$, where d is equal to the lamination width in inches.
6. These values are for preliminary design use only. Final design should include a complete analysis, including bearing capacity of the foundation supporting the column.

TABLE 9

ALLOWABLE AXIAL LOADS (POUNDS) FOR COMBINATION NO. 2 DOUGLAS-FIR GLULAM COLUMNS
Side loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or depth, whichever is worse.

Effective Column Length (ft)	Lamination Net Width = 8-3/4 in.								
	Net Depth = 9 in. (6 lams)			Net Depth = 10-1/2 in. (7 lams)			Net Depth = 12 in. (8 lams)		
	Load Duration Factor			Load Duration Factor			Load Duration Factor		
	1.00	1.15	1.25	1.00	1.15	1.25	1.00	1.15	1.25
8	77,664	87,462	93,741	93,358	105,586	113,482	107,874	121,357	129,976
9	74,840	83,789	89,453	90,643	101,485	108,241	103,741	115,983	123,704
10	71,772	79,822	84,838	86,847	96,412	102,347	99,254	110,186	116,968
11	68,492	75,611	79,967	82,657	91,047	96,152	94,465	104,054	109,888
12	65,040	71,226	74,942	78,262	85,490	89,804	89,442	97,702	102,633
13	61,468	66,770	69,906	73,741	79,879	83,488	84,275	91,290	95,415
14	57,854	62,365	65,008	69,193	74,374	77,393	79,077	84,999	88,449
15	54,283	58,124	60,364	64,731	69,112	71,654	73,979	78,985	81,890
16	50,836	54,124	56,037	60,453	64,181	66,342	69,089	73,350	75,819
17	47,568	50,403	52,051	56,422	59,622	61,475	64,482	68,139	70,258
18	44,429	46,903	48,341	52,670	55,438	57,040	60,194	63,358	65,189
19	41,524	43,690	44,947	49,202	51,615	53,011	56,231	58,988	60,584
20	38,853	40,760	41,866	46,011	48,128	49,352	52,585	55,003	56,402
21	36,400	38,089	39,068	43,082	44,950	46,028	49,237	51,371	52,604
22	34,150	35,653	36,523	40,395	42,051	43,007	46,166	48,058	49,151
23	32,086	33,429	34,206	37,930	39,405	40,256	43,348	45,035	46,007
24	30,190	31,396	32,092	35,667	36,987	37,748	40,762	42,271	43,140

Notes:

1. The tabulated allowable loads apply only to one-piece glulam members made with all L2 laminations (Combination 2) without special tension laminations.
2. Applicable service conditions = dry.
3. The tabulated allowable loads are based on axially loaded columns subjected to a maximum eccentricity of either 1/6 column width or 1/6 column depth, whichever is worse. For side loads, other eccentric end loads, or other combined axial and flexural loads, see NDS.
4. The column is assumed to be unbraced, except at the column ends, and the effective column length is equal to the actual column length.
5. Design properties for normal load duration and dry-use service conditions:
   Compression parallel to grain (F_c) = 1,950 psi for 4 or more lams, or 1,600 psi for 2 or 3 lams.
   Modulus of elasticity (E) = 1.6×10^6 psi
   Flexural stress when loaded parallel to wide faces of lamination (F_{by}) = 1,800 psi for 4 or more lams, or 1,600 psi for 3 lams.
   Flexural stress when loaded perpendicular to wide faces of lamination (F_{bx}) = 1,700 psi for 2 lams to 15 in. deep without special tension laminations.
   Volume factor for F_{bx} is in accordance with NDS. Size factor for F_{by} is $(12/d)^{1/9}$, where d is equal to the lamination width in inches.
6. These values are for preliminary design use only. Final design should include a complete analysis, including bearing capacity of the foundation supporting the column.

TABLE 10

ALLOWABLE AXIAL LOADS (POUNDS) FOR COMBINATION NO. 2 DOUGLAS-FIR GLULAM COLUMNS
Side loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or depth, whichever is worse.

Effective Column Length (ft)	Lamination Net Width = 10-3/4 in.								
	Net Depth = 10-1/2 in. (7 lams)			Net Depth = 12 in. (8 lams)			Net Depth = 13-1/2 in. (9 lams)		
	Load Duration Factor			Load Duration Factor			Load Duration Factor		
	1.00	1.15	1.25	1.00	1.15	1.25	1.00	1.15	1.25
8	115,664	131,690	141,023	134,798	153,170	165,156	153,652	174,199	187,547
9	112,642	127,884	136,397	131,977	149,461	160,789	149,814	169,177	181,656
10	109,334	123,723	131,368	128,856	145,363	155,753	145,599	163,677	175,222
11	105,763	119,237	125,986	125,002	140,223	149,607	141,034	157,751	168,308
12	101,727	114,202	120,037	120,825	134,622	143,098	136,157	151,450	160,985
13	97,367	108,796	113,730	116,449	128,743	136,297	131,005	144,836	153,334
14	92,918	103,291	107,384	111,664	122,652	129,299	125,622	137,984	145,462
15	88,419	97,760	101,096	106,721	116,435	122,225	120,061	130,990	137,503
16	83,919	92,288	94,976	101,683	110,198	115,215	114,393	123,972	129,617
17	79,478	86,966	89,120	96,621	104,056	108,403	108,699	117,063	121,954
18	75,157	81,869	83,592	91,620	98,114	101,894	103,072	110,378	114,631
19	71,008	77,048	78,424	86,753	92,445	95,752	97,598	104,001	107,721
20	67,066	72,525	73,624	82,082	87,095	90,004	92,342	97,981	101,255
21	63,352	68,307	69,180	77,641	82,080	84,654	87,346	92,340	95,236
22	59,870	64,387	65,076	73,451	77,402	79,692	82,633	87,078	89,654
23	56,617	60,749	61,288	69,517	73,050	75,097	78,207	82,181	84,484
24	53,585	57,378	57,793	65,835	69,008	70,845	74,065	77,634	79,700

Notes:

1. The tabulated allowable loads apply only to one-piece glulam members made with all L2 laminations (Combination 2) without special tension laminations.
2. Applicable service conditions = dry.
3. The tabulated allowable loads are based on axially loaded columns subjected to a maximum eccentricity of either 1/6 column width or 1/6 column depth, whichever is worse. For side loads, other eccentric end loads, or other combined axial and flexural loads, see NDS.
4. The column is assumed to be unbraced, except at the column ends, and the effective column length is equal to the actual column length.
5. Design properties for normal load duration and dry-use service conditions:
   Compression parallel to grain (F_c) = 1,950 psi for 4 or more lams, or 1,600 psi for 2 or 3 lams.
   Modulus of elasticity (E) = 1.6 x 10^6 psi.
   Flexural stress when loaded parallel to wide faces of lamination (F_{by}) = 1,800 psi for 4 or more lams, or 1,600 psi for 3 lams.
   Flexural stress when loaded perpendicular to wide faces of lamination (F_{bx}) = 1,700 psi for 2 lams to 15 in. deep without special tension laminations.
   Volume factor for F_{bx} is in accordance with NDS. Size factor for F_{by} is $(12/d)^{1/9}$, where d is equal to the lamination width in inches.
6. These values are for preliminary design use only. Final design should include a complete analysis, including bearing capacity of the foundation supporting the column.

TABLE 11

ALLOWABLE AXIAL LOADS (POUNDS) FOR COMBINATION NO. 47 SOUTHERN PINE GLULAM COLUMNS
Side loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or depth, whichever is worse.

Effective Column Length (ft)	Lamination Net Width = 3 in.								
	Net Depth = 4-1/8 in. (3 lams)			Net Depth = 5-1/2 in. (4 lams)			Net Depth = 6-7/8 in. (5 lams)		
	Load Duration Factor			Load Duration Factor			Load Duration Factor		
	1.00	1.15	1.25	1.00	1.15	1.25	1.00	1.15	1.25
8	4,105	4,256	4,342	5,700	5,883	5,989	7,125	7,354	7,486
9	3,441	3,549	3,611	4,744	4,877	4,953	5,930	6,096	6,192
10	2,918	2,998	3,044	4,003	4,103	4,160	5,004	5,129	5,200
11	2,501	2,563	2,598	3,420	3,496	3,540	4,275	4,371	4,425
12	2,166	2,214	2,242	2,953	3,013	3,048	3,692	3,767	3,810

Notes:

1. The tabulated allowable loads apply only to one-piece glulam members made with all N2M laminations (Combination 47) without special tension laminations.
2. Applicable service conditions = dry.
3. The tabulated allowable loads are based on axially loaded columns subjected to a maximum eccentricity of either 1/6 column width or 1/6 column depth, whichever is worse. For side loads, other eccentric end loads, or other combined axial and flexural loads, see NDS.
4. The column is assumed to be unbraced, except at the column ends, and the effective column length is equal to the actual column length.
5. Design properties for normal load duration and dry-use service conditions:
   Compression parallel to grain (F_c) = 1,900 psi for 4 or more lams, or 1,150 psi for 2 or 3 lams.
   Modulus of elasticity (E) = 1.4 x 10^6 psi.
   Flexural stress when loaded parallel to wide faces of lamination (F_{by}) = 1,750 psi for 4 or more lams, or 1,550 psi for 3 lams.
   Flexural stress when loaded perpendicular to wide faces of lamination (F_{bx}) = 1,400 psi for 2 lams to 15 in. deep without special tension laminations.
   Volume factor for F_{bx} is in accordance with NDS. Size factor for F_{by} is $(12/d)^{1/9}$, where d is equal to the lamination width in inches.
6. These values are for preliminary design use only. Final design should include a complete analysis, including bearing capacity of the foundation supporting the column.

TABLE 12

ALLOWABLE AXIAL LOADS (POUNDS) FOR COMBINATION NO. 47 SOUTHERN PINE GLULAM COLUMNS
Side loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or depth, whichever is worse.

Effective Column Length (ft)	Lamination Net Width = 3-1/2 in.								
	Net Depth = 4-1/8 in. (3 lams)			Net Depth = 5-1/2 in. (4 lams)			Net Depth = 6-7/8 in. (5 lams)		
	Load Duration Factor			Load Duration Factor			Load Duration Factor		
	1.00	1.15	1.25	1.00	1.15	1.25	1.00	1.15	1.25
8	5,939	6,212	6,367	8,360	8,682	8,868	10,451	10,853	11,085
9	5,048	5,243	5,354	7,028	7,264	7,399	8,785	9,080	9,249
10	4,324	4,469	4,551	5,977	6,154	6,256	7,471	7,693	7,820
11	3,735	3,846	3,909	5,138	5,275	5,353	6,422	6,593	6,691
12	3,254	3,341	3,391	4,460	4,567	4,629	5,574	5,709	5,786
13	2,857	2,927	2,966	3,905	3,991	4,040	4,881	4,989	5,050
14	2,527	2,583	2,616	3,445	3,516	3,556	4,307	4,395	4,445

Notes:

1. The tabulated allowable loads apply only to one-piece glulam members made with all N2M laminations (Combination 47) without special tension laminations.
2. Applicable service conditions = dry.
3. The tabulated allowable loads are based on axially loaded columns subjected to a maximum eccentricity of either 1/6 column width or 1/6 column depth, whichever is worse. For side loads, other eccentric end loads, or other combined axial and flexural loads, see NDS.
4. The column is assumed to be unbraced, except at the column ends, and the effective column length is equal to the actual column length.
5. Design properties for normal load duration and dry-use service conditions:
   Compression parallel to grain (F_c) = 1,900 psi for 4 or more lams, or 1,150 psi for 2 or 3 lams.
   Modulus of elasticity (E) = 1.4 x 10^6 psi.
   Flexural stress when loaded parallel to wide faces of lamination (F_{by}) = 1,750 psi for 4 or more lams, or 1,550 psi for 3 lams.
   Flexural stress when loaded perpendicular to wide faces of lamination (F_{bx}) = 1,400 psi for 2 lams to 15 in. deep without special tension laminations.
   Volume factor for F_{bx} is in accordance with NDS. Size factor for F_{by} is $(12/d)^{1/9}$, where d is equal to the lamination width in inches.
6. These values are for preliminary design use only. Final design should include a complete analysis, including bearing capacity of the foundation supporting the column.

TABLE 13

ALLOWABLE AXIAL LOADS (POUNDS) FOR COMBINATION NO. 47 SOUTHERN PINE GLULAM COLUMNS
Side loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or depth, whichever is worse.

Effective Column Length (ft)	Lamination Net Width = 5 in.								
	Net Depth = 5-1/2 in. (4 lams)			Net Depth = 6-7/8 in. (5 lams)			Net Depth = 8-1/4 in. (6 lams)		
	Load Duration Factor			Load Duration Factor			Load Duration Factor		
	1.00	1.15	1.25	1.00	1.15	1.25	1.00	1.15	1.25
8	17,259	18,527	19,271	23,172	24,633	25,477	29,355	31,353	32,510
9	15,317	16,283	16,848	20,228	21,307	21,931	25,821	27,301	28,156
10	13,582	14,334	14,772	17,690	18,512	18,987	22,704	23,833	24,485
11	12,070	12,666	13,011	15,540	16,183	16,553	20,027	20,909	21,418
12	10,765	11,244	11,521	13,727	14,238	14,533	17,746	18,450	18,855
13	9,640	10,030	10,255	12,194	12,608	12,846	15,805	16,375	16,703
14	8,670	8,985	9,141	10,892	11,232	11,427	14,149	14,617	14,886
15	7,824	8,050	8,179	9,781	10,062	10,224	12,728	13,117	13,340
16	7,060	7,250	7,358	8,825	9,062	9,197	11,503	11,830	12,017
17	6,400	6,560	6,652	8,000	8,200	8,315	10,441	10,719	10,877
18	5,826	5,963	6,041	7,283	7,454	7,552	9,517	9,754	9,889
19	5,325	5,443	5,510	6,656	6,803	6,887	8,707	8,911	9,028
20	4,884	4,986	5,045	6,105	6,233	6,306	7,994	8,171	8,272

Notes:

1. The tabulated allowable loads apply only to one-piece glulam members made with all N2M laminations (Combination 47) without special tension laminations.
2. Applicable service conditions = dry.
3. The tabulated allowable loads are based on axially loaded columns subjected to a maximum eccentricity of either 1/6 column width or 1/6 column depth, whichever is worse. For side loads, other eccentric end loads, or other combined axial and flexural loads, see NDS.
4. The column is assumed to be unbraced, except at the column ends, and the effective column length is equal to the actual column length.
5. Design properties for normal load duration and dry-use service conditions:
   Compression parallel to grain (F_c) = 1,900 psi for 4 or more lams, or 1,150 psi for 2 or 3 lams.
   Modulus of elasticity (E) = 1.4 x 10^6 psi.
   Flexural stress when loaded parallel to wide faces of lamination (F_{by}) = 1,750 psi for 4 or more lams, or 1,550 psi for 3 lams.
   Flexural stress when loaded perpendicular to wide faces of lamination (F_{bx}) = 1,400 psi for 2 lams to 15 in. deep without special tension laminations.
   Volume factor for F_{bx} is in accordance with NDS. Size factor for F_{by} is $(12/d)^{1/9}$, where d is equal to the lamination width in inches.
6. These values are for preliminary design use only. Final design should include a complete analysis, including bearing capacity of the foundation supporting the column.

TABLE 14

ALLOWABLE AXIAL LOADS (POUNDS) FOR COMBINATION NO. 47 SOUTHERN PINE GLULAM COLUMNS
Side loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or depth, whichever is worse.

Effective Column Length (ft)	Lamination Net Width = 5-1/2 in.								
	Net Depth = 5-1/2 in. (4 lams)			Net Depth = 6-7/8 in. (5 lams)			Net Depth = 8-1/4 in. (6 lams)		
	Load Duration Factor			Load Duration Factor			Load Duration Factor		
	1.00	1.15	1.25	1.00	1.15	1.25	1.00	1.15	1.25
8	17,731	19,733	20,551	27,248	29,623	31,028	35,308	38,081	39,698
9	16,363	18,023	18,579	24,687	26,386	27,263	31,555	33,631	34,833
10	14,951	16,302	16,659	21,978	23,135	23,804	28,071	29,657	30,574
11	13,568	14,670	14,892	19,458	20,364	20,886	24,975	26,216	26,933
12	12,276	13,187	13,321	17,293	18,015	18,432	22,278	23,270	23,842
13	11,106	11,871	11,947	15,438	16,023	16,361	19,947	20,753	21,217
14	10,064	10,716	10,753	13,846	14,328	14,605	17,935	18,598	18,979
15	9,143	9,706	9,716	12,476	12,877	13,107	16,194	16,746	17,063
16	8,332	8,822	8,813	11,291	11,628	11,821	14,682	15,147	15,414
17	7,616	8,046	8,025	10,262	10,548	10,711	13,364	13,759	13,985
18	6,984	7,364	7,334	9,363	9,607	9,747	12,210	12,548	12,742
19	6,423	6,761	6,725	8,574	8,785	8,906	11,194	11,486	11,653
20	5,925	6,227	6,187	7,879	8,062	8,166	10,298	10,551	10,696
21	5,481	5,753	5,710	7,263	7,423	7,514	9,502	9,724	9,850
22	5,083	5,329	5,285	6,716	6,856	6,936	8,793	8,988	9,099

Notes:

1. The tabulated allowable loads apply only to one-piece glulam members made with all N2M laminations (Combination 47) without special tension laminations.
2. Applicable service conditions = dry.
3. The tabulated allowable loads are based on axially loaded columns subjected to a maximum eccentricity of either 1/6 column width or 1/6 column depth, whichever is worse. For side loads, other eccentric end loads, or other combined axial and flexural loads, see NDS.
4. The column is assumed to be unbraced, except at the column ends, and the effective column length is equal to the actual column length.
5. Design properties for normal load duration and dry-use service conditions:
   Compression parallel to grain (F_c) = 1,900 psi for 4 or more lams, or 1,150 psi for 2 or 3 lams.
   Modulus of elasticity (E) = 1.4 x 10^6 psi.
   Flexural stress when loaded parallel to wide faces of lamination (F_{by}) = 1,750 psi for 4 or more lams, or 1,550 psi for 3 lams.
   Flexural stress when loaded perpendicular to wide faces of lamination (F_{bx}) = 1,400 psi for 2 lams to 15 in. deep without special tension laminations.
   Volume factor for F_{bx} is in accordance with NDS. Size factor for F_{by} is $(12/d)^{1/9}$, where d is equal to the lamination width in inches.
6. These values are for preliminary design use only. Final design should include a complete analysis, including bearing capacity of the foundation supporting the column.

TABLE 15

ALLOWABLE AXIAL LOADS (POUNDS) FOR COMBINATION NO. 47 SOUTHERN PINE GLULAM COLUMNS
Side loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or depth, whichever is worse.

Effective Column Length (ft)	Lamination Net Width = 6-3/4 in.								
	Net Depth = 6-7/8 in. (5 lams)			Net Depth = 8-1/4 in. (6 lams)			Net Depth = 9-5/8 in. (7 lams)		
	Load Duration Factor			Load Duration Factor			Load Duration Factor		
	1.00	1.15	1.25	1.00	1.15	1.25	1.00	1.15	1.25
8	35,129	38,688	40,858	46,113	51,362	54,626	55,823	62,441	66,577
9	32,546	35,453	37,189	43,560	48,023	50,728	53,115	58,330	61,159
10	29,919	32,261	33,643	40,771	44,459	46,651	49,199	52,984	55,191
11	27,365	29,259	30,371	37,856	40,871	42,552	44,905	47,905	49,643
12	24,975	26,526	27,433	34,963	37,085	38,279	40,858	43,265	44,658
13	22,794	24,078	24,828	31,849	33,532	34,505	37,157	39,120	40,255
14	20,830	21,905	22,531	28,998	30,390	31,195	33,831	35,456	36,394
15	19,073	19,981	20,509	26,458	27,624	28,297	30,868	32,228	33,013
16	17,503	18,278	18,726	24,202	25,188	25,757	28,236	29,386	30,050
17	16,103	16,768	17,152	22,199	23,041	23,525	25,898	26,881	27,446
18	14,852	15,426	15,758	20,417	21,142	21,558	23,820	24,665	25,152
19	13,732	14,232	14,520	18,830	19,458	19,819	21,969	22,701	23,122
20	12,727	13,164	13,416	17,413	17,960	18,274	20,315	20,953	21,320
21	11,824	12,208	12,429	16,143	16,623	16,898	18,833	19,394	19,715
22	11,009	11,349	11,544	15,002	15,426	15,668	17,503	17,997	18,280
23	10,273	10,575	10,748	13,975	14,350	14,565	16,304	16,742	16,992
24	9,606	9,875	10,029	13,046	13,380	13,571	15,221	15,610	15,833

Notes:

1. The tabulated allowable loads apply only to one-piece glulam members made with all N2M laminations (Combination 47) without special tension laminations.
2. Applicable service conditions = dry.
3. The tabulated allowable loads are based on axially loaded columns subjected to a maximum eccentricity of either 1/6 column width or 1/6 column depth, whichever is worse. For side loads, other eccentric end loads, or other combined axial and flexural loads, see NDS.
4. The column is assumed to be unbraced, except at the column ends, and the effective column length is equal to the actual column length.
5. Design properties for normal load duration and dry-use service conditions:
   Compression parallel to grain (F_c) = 1,900 psi for 4 or more lams, or 1,150 psi for 2 or 3 lams.
   Modulus of elasticity (E) = 1.4×10^6 psi.
   Flexural stress when loaded parallel to wide faces of lamination (F_{by}) = 1,750 psi for 4 or more lams, or 1,550 psi for 3 lams.
   Flexural stress when loaded perpendicular to wide faces of lamination (F_{bx}) = 1,400 psi for 2 lams to 15 in. deep without special tension laminations.
   Volume factor for F_{bx} is in accordance with NDS. Size factor for F_{by} is $(12/d)^{1/9}$, where d is equal to the lamination width in inches.
6. These values are for preliminary design use only. Final design should include a complete analysis, including bearing capacity of the foundation supporting the column.

TABLE 16

ALLOWABLE AXIAL LOADS (POUNDS) FOR COMBINATION NO. 47 SOUTHERN PINE GLULAM COLUMNS
Side loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or depth, whichever is worse.

Effective Column Length (ft)	Lamination Net Width = 8-1/2 in.								
	Net Depth = 8-1/4 in. (6 lams)			Net Depth = 9-5/8 in. (7 lams)			Net Depth = 11 in. (8 lams)		
	Load Duration Factor			Load Duration Factor			Load Duration Factor		
	1.00	1.15	1.25	1.00	1.15	1.25	1.00	1.15	1.25
8	59,221	66,887	70,824	71,909	80,979	86,788	84,297	95,257	102,318
9	56,502	63,485	66,780	69,290	77,560	82,783	81,720	91,842	98,274
10	53,609	59,869	62,536	66,425	73,831	78,427	78,828	87,999	93,724
11	50,584	56,109	58,200	63,333	69,834	73,791	75,611	83,739	88,707
12	47,487	52,309	53,913	60,051	65,655	69,008	72,086	78,941	82,497
13	44,396	48,591	49,808	56,647	61,429	64,258	68,006	73,037	75,967
14	41,392	45,053	45,973	53,222	57,295	59,691	63,234	67,431	69,866
15	38,540	41,754	42,447	49,872	53,357	55,399	58,694	62,226	64,272
16	35,875	38,714	39,233	46,669	49,668	51,421	54,457	57,458	59,195
17	33,410	35,933	36,317	43,653	46,251	47,766	50,550	53,124	54,612
18	31,143	33,398	33,676	40,812	43,048	44,174	46,973	49,198	50,484
19	29,052	31,076	31,272	38,179	39,941	40,921	43,710	45,647	46,766
20	27,132	28,957	29,088	35,646	37,131	37,988	40,739	42,436	43,415
21	25,379	27,032	27,111	33,278	34,587	35,342	38,032	39,528	40,390
22	23,778	25,280	25,319	31,121	32,280	32,948	35,567	36,892	37,654
23	22,314	23,684	23,690	29,154	30,185	30,778	33,319	34,497	35,175
24	20,973	22,228	22,207	27,357	28,278	28,808	31,265	32,318	32,923

Notes:

1. The tabulated allowable loads apply only to one-piece glulam members made with all N2M laminations (Combination 47) without special tension laminations.
2. Applicable service conditions = dry.
3. The tabulated allowable loads are based on axially loaded columns subjected to a maximum eccentricity of either 1/6 column width or 1/6 column depth, whichever is worse. For side loads, other eccentric end loads, or other combined axial and flexural loads, see NDS.
4. The column is assumed to be unbraced, except at the column ends, and the effective column length is equal to the actual column length.
5. Design properties for normal load duration and dry-use service conditions:
   Compression parallel to grain (F_c) = 1,900 psi for 4 or more lams, or 1,150 psi for 2 or 3 lams.
   Modulus of elasticity (E) = 1.4×10^6 psi.
   Flexural stress when loaded parallel to wide faces of lamination (F_{by}) = 1,750 psi for 4 or more lams, or 1,550 psi for 3 lams.
   Flexural stress when loaded perpendicular to wide faces of lamination (F_{bx}) = 1,400 psi for 2 lams to 15 in. deep without special tension laminations.
   Volume factor for F_{bx} is in accordance with NDS. Size factor for F_{by} is $(12/d)^{1/9}$, where d is equal to the lamination width in inches.
6. These values are for preliminary design use only. Final design should include a complete analysis, including bearing capacity of the foundation supporting the column.

TABLE 17

ALLOWABLE AXIAL LOADS (POUNDS) FOR COMBINATION NO. 47 SOUTHERN PINE GLULAM COLUMNS
Side loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or depth, whichever is worse.

Effective Column Length (ft)	Lamination Net Width = 10-1/2 in.								
	Net Depth = 11 in. (8 lams)			Net Depth = 12-3/8 in. (9 lams)			Net Depth = 13-3/4 in. (10 lams)		
	Load Duration Factor			Load Duration Factor			Load Duration Factor		
	1.00	1.15	1.25	1.00	1.15	1.25	1.00	1.15	1.25
8	105,144	119,084	128,127	120,417	136,731	147,360	135,506	154,145	166,328
9	102,352	115,446	123,870	117,751	133,229	143,242	132,935	150,747	162,311
10	99,308	111,493	119,256	114,805	129,365	138,698	129,841	146,724	157,600
11	96,033	107,256	114,325	111,423	124,987	133,590	126,356	142,170	152,245
12	92,485	102,720	109,080	107,709	120,172	127,971	122,608	137,247	146,448
13	88,649	97,846	103,477	103,780	115,087	122,051	118,580	131,948	140,214
14	84,699	92,874	97,806	99,649	109,774	115,914	114,269	126,001	132,199
15	80,676	87,879	92,177	95,350	104,321	109,691	109,644	118,673	123,982
16	76,637	82,958	86,701	90,943	98,842	103,527	103,700	111,496	116,048
17	72,647	78,196	81,467	86,512	93,457	97,552	97,860	104,603	108,525
18	68,768	73,655	76,527	82,136	88,255	91,337	92,223	98,082	101,485
19	65,047	69,370	71,906	77,886	82,781	85,456	86,855	91,978	94,952
20	61,514	65,355	67,605	73,617	77,673	80,026	81,796	86,304	88,918
21	58,182	61,610	63,616	69,355	72,944	75,024	77,062	81,049	83,360
22	55,054	58,127	59,921	65,384	70,102	70,424	72,649	76,195	78,249
23	52,127	54,891	56,503	61,692	64,544	66,195	68,547	71,716	73,550
24	49,393	51,888	53,341	58,265	60,824	62,304	64,739	67,583	69,227

Notes:

1. The tabulated allowable loads apply only to one-piece glulam members made with all N2M laminations (Combination 47) without special tension laminations.
2. Applicable service conditions = dry.
3. The tabulated allowable loads are based on axially loaded columns subjected to a maximum eccentricity of either 1/6 column width or 1/6 column depth, whichever is worse. For side loads, other eccentric end loads, or other combined axial and flexural loads, see NDS.
4. The column is assumed to be unbraced, except at the column ends, and the effective column length is equal to the actual column length.
5. Design properties for normal load duration and dry-use service conditions:
   Compression parallel to grain (F_c) = 1,900 psi for 4 or more lams, or 1,150 psi for 2 or 3 lams.
   Modulus of elasticity (E) = 1.4×10^6 psi.
   Flexural stress when loaded parallel to wide faces of lamination (F_{by}) = 1,750 psi for 4 or more lams, or 1,550 psi for 3 lams.
   Flexural stress when loaded perpendicular to wide faces of lamination (F_{bx}) = 1,400 psi for 2 lams to 15 in. deep without special tension laminations.
   Volume factor for F_{bx} is in accordance with NDS. Size factor for F_{by} is $(12/d)^{1/9}$, where d is equal to the lamination width in inches.
6. These values are for preliminary design use only. Final design should include a complete analysis, including bearing capacity of the foundation supporting the column.

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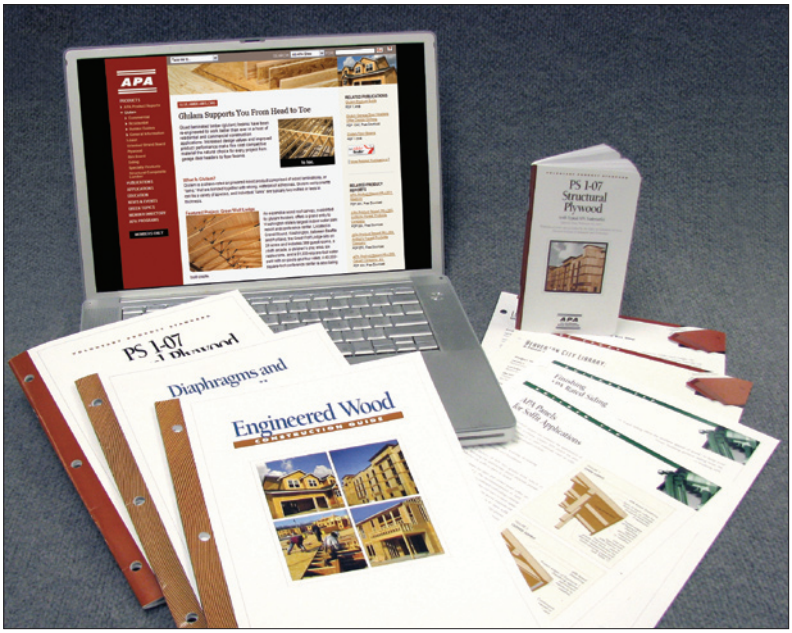

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Design of Structural Glued Laminated Timber Columns

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