ENGINEERED WOOD SYSTEMS
APA EWS

ENGINEERED WOOD DATA FILE

DESIGN OF STRUCTURAL GLUED LAMINATED TIMBER COLUMNS

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APA EWS

WOOD, THE NATURAL CHOICE

Wood is good. It is the earth's natural, energy efficient and renewable building material.

Engineered wood is a better use of wood. It uses less wood to make more wood products.

That's why using APA trademarked plywood, oriented strand board and *APA EWS* glued laminated timbers is the right thing to do.

A few facts about wood.

- *We're not running out of trees.* One-third of the United States land base – 731 million acres – is covered by forests. About two-thirds of that 731 million acres is suitable for repeated planting and harvesting of timber. But only about half of the land suitable for growing timber is open to logging. Most of that harvestable acreage also is open to other uses, such as camping, hiking, hunting, etc.

- *We're growing more wood every day.* 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.

- *Manufacturing wood products 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 right product for the environment.

NOTICE:
The recommendations in this data file apply only to glulam that bears the APA EWS trademark. Only glulam bearing the APA EWS trademark is subject to the Association's quality auditing program.

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%, 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. However, since they are manufactured using dimension lumber, 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" for Western species and 1-3/8" 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

TABLE 1

TYPICAL GLULAM COLUMN WIDTHS

Nominal Width	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. For additional information on the appearance characteristics of glulam, see EWS Technical Note Y110, "Appearance Classifications for Glued Laminated Timber."

TABLE 2

TYPICAL GLULAM COLUMN SIZES*

Nominal Size	6x6	8x8	8x10	10x10	10x12
Western species	5-1/8x6	6-3/4x7-1/2	6-3/4x9	8-3/4x9	8-3/4x12
Southern pine	5x5-1/2	6-3/4x6-7/8	6-3/4x9-5/8	8-1/2x9-5/8	8-1/2x11

*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	$F_{bx\text{-}x}$	$F_{by\text{-}y}$	$F_{vx\text{-}x}$	$F_{vy\text{-}y}$
DF – No. 2	L2	1900	$1.7x10^6$	1700	1800	240	210
SP – No. 47	N2M	1900	$1.4x10^6$	1400	1750	270	235

*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 EWS Data File Y117 for more information.

column is going to be loaded as a combined axial and bending member, 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 1997 National Design Specification (NDS) (available from the American Forest and Paper Association).

Column Design Equations

Until the promulgation of the 1991 NDS, wood columns were designed based on a methodology that required classifying the member as a short, intermediate or long column. This required a trial and error solution when it was not obvious which classification applied for a specific design situation and many designers considered it to be a cumbersome procedure.

Based on extensive research conducted at the USDA Forest Products Laboratory and at other research institutions, the 1991 NDS was revised to reflect the use of a single column design formula regardless of the length to depth (l/d) ratio previously used to classify columns as short, intermediate or long. This is shown as Equation 1 for a member subjected to concentric axial loads only.

Equation 1:

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

Where F'_c = allowable compression parallel to grain design value

F^*_c = tabulated compression parallel to grain design value adjusted for service conditions (moisture, temperature, load duration) and size effect when applicable

F_{cE} = critical buckling design value

c = 0.8 for sawn lumber, 0.85 for round timber poles and piles, 0.9 for glued laminated timber and structural composite lumber.

The critical buckling design value is determined by the well-known Euler column formula:

$$F_{cE} = \frac{K_{cE} E'}{(L_e/d)^2}$$

Where E' = allowable modulus of elasticity adjusted for service conditions (moisture, temperature)

d = least unbraced dimension of column

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

K_{cE} = 0.300 for products with COV_E = 0.25, such as visually graded lumber and round timber poles and piles; 0.384 for products with COV_E = 0.15, such as machine evaluated lumber (MEL); 0.418 for products with $COV_E \leq 0.11$, such as glued laminated timber, machine stress-rated (MSR) lumber, and structural composite lumber.

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 K_{cE}, are material dependent with higher values assigned to wood products with lower variability such as glulam thus resulting in higher column capacities.

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% which is equal to or lower than other comparable wood products. Based on the relative homogeneity of glulam and its low variability, the values of c and K_{cE} for glulam have been established as 0.9 and 0.418 respectively.

Column Design Tables

Tables 4-17 have been generated to provide column capacities for two typical glulam layup combinations for an eccentric condition of load application. These tables are summarized as follows:

No.2 DF Tables 4-10 (eccentric loading)

No.47 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 Y110 *Appearance Classifications for Glued Laminated Timber* 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 inconsistencies. 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 ft. 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 = 1900 *psi*

E = 1,700,000 *psi*

Adjusted allowable stresses:

F^*_c = 1900 x 1.0 = 1900 *psi*

E' = E = 1,700,000 *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 slenderness ratio = L_e/d = 180/6.75 = 26.67 < 50

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

$$F_{cE} = \frac{(K_{cE} E')}{(L_e/d)^2} = \frac{(0.418 \times 1{,}700{,}000)}{(26.67)^2} = 999 \text{ psi}$$

$$F_{cE}/F^*_c = \frac{999}{1900} = 0.526$$

$$F'_c = 1900 \left\{ \frac{1 + 0.526}{2 \times 0.9} - \sqrt{\left[\frac{1 + 0.526}{2 \times 0.9}\right]^2 - \frac{0.526}{0.9}} \right\} = 914.5 \text{ psi}$$

Determine allowable axial load = Fc' x A = 914.5 x 50.62 = 46.3 kips > 45 kips

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

Further Information

For more complex design situations such as members subjected to combined bending and axial forces or columns subjected to non-concentric 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 has a comprehensive chapter on the design of wood columns in addition to providing guidance for virtually any wood design situation.

APA has also sponsored the development of a computer software program to design and analyze wood columns up to five stories in height with any degree of load eccentricity. This software, *WOODCAD Column*, is available from Eagle Point Software. Or contact *APA EWS* for more information.

For information on recommended connection details for the installation of glulam columns, the reader is referred to EWS Technical Note T300B *Glulam Connection Details.* For further information on the design of glulam columns or any other aspect of designing with glued laminated timber, contact:

APA EWS
P.O. Box 11700
Tacoma, WA 98411
Tel: 253-565-6600
Fax: 253-565-7265

TABLE 4

ECCENTRIC END LOADS FOR DOUGLAS-FIR COMBINATION NO. 2 GLULAM COLUMNS
Allowable axial loads (pounds). Side loads and bracket loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or 1/6 column depth.

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	6,071	6,327	6,474	8,396	8,722	8,909	10,495	10,902	11,137
9	5,132	5,319	5,426	7,061	7,299	7,436	8,826	9,124	9,295
10	4,382	4,523	4,604	6,007	6,186	6,288	7,508	7,732	7,860
11	3,779	3,887	3,950	5,164	5,302	5,381	6,455	6,628	6,727
12	3,288	3,374	3,423	4,483	4,592	4,654	5,604	5,740	5,817
13	2,885	2,953	2,993	3,926	4,013	4,062	4,907	5,016	5,078

Notes:

(1) The tabulated allowable loads apply to 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 1997 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 1,600 psi for 2 or 3 lams.
Modulus of elasticity (E) = 1.7 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 1997 NDS. Size factor for F_{by} is $(12/d)^{0.111}$, where d is equal to the lamination width in inches.

(6) This table is for preliminary design use only. Final design should include a complete analysis, including the bearing capability of the foundation supporting the column.

TABLE 5

ECCENTRIC END LOADS FOR DOUGLAS-FIR COMBINATION NO. 2 GLULAM COLUMNS
Allowable axial loads (pounds). Side loads and bracket loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or 1/6 column depth.

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	7,910	8,297	8,520	11,009	11,501	11,784	13,762	14,377	14,731
9	6,758	7,041	7,203	9,344	9,704	9,912	11,680	12,130	12,390
10	5,815	6,029	6,152	8,004	8,276	8,432	10,005	10,345	10,540
11	5,045	5,210	5,305	6,919	7,130	7,250	8,649	8,912	9,063
12	4,411	4,542	4,617	6,033	6,199	6,294	7,541	7,749	7,868
13	3,886	3,991	4,051	5,302	5,436	5,512	6,628	6,795	6,890
14	3,446	3,532	3,581	4,694	4,802	4,865	5,867	6,003	6,081

Notes:

(1) The tabulated allowable loads apply to 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 1997 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 1,600 psi for 2 or 3 lams.
Modulus of elasticity (E) = 1.7×10^6 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 1997 NDS. Size factor for F_{by} is $(12/d)^{0.111}$, where d is equal to the lamination width in inches.

(6) This table is for preliminary design use only. Final design should include a complete analysis, including the bearing capability of the foundation supporting the column.

TABLE 6

ECCENTRIC END LOADS FOR DOUGLAS-FIR COMBINATION NO. 2 GLULAM COLUMNS
Allowable axial loads (pounds). Side loads and bracket loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or 1/6 column depth.

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	24,349	26,269	27,389	30,437	32,837	34,236	36,524	39,404	41,084
9	21,771	23,206	24,036	27,214	29,008	30,045	32,657	34,810	36,054
10	19,370	20,464	21,096	24,213	25,580	26,370	29,055	30,696	31,644
11	17,232	18,087	18,580	21,541	22,609	23,225	25,849	27,130	27,870
12	15,370	16,051	16,444	19,212	20,064	20,555	23,054	24,077	24,666
13	13,759	14,312	14,631	17,199	17,890	18,288	20,639	21,468	21,946
14	12,369	12,824	13,086	15,461	16,030	16,357	18,553	19,236	19,628
15	11,166	11,545	11,763	13,958	14,431	14,703	16,749	17,317	17,644
16	10,122	10,441	10,624	12,652	13,051	13,280	15,183	15,661	15,935
17	9,212	9,483	9,638	11,515	11,853	12,047	13,818	14,224	14,457
18	8,415	8,647	8,780	10,519	10,809	10,974	12,623	12,970	13,169
19	7,714	7,914	8,029	9,643	9,893	10,036	11,572	11,872	12,043
20	7,096	7,269	7,369	8,870	9,087	9,211	10,643	10,904	11,053
21	6,547	6,699	6,785	8,184	8,373	8,481	9,820	10,048	10,178

Notes:

(1) The tabulated allowable loads apply to 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 1997 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 1,600 psi for 2 or 3 lams.
Modulus of elasticity (E) = 1.7×10^6 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 1997 NDS. Size factor for F_{by} is $(12/d)^{0.111}$, where d is equal to the lamination width in inches.

(6) This table is for preliminary design use only. Final design should include a complete analysis, including the bearing capability of the foundation supporting the column.

TABLE 7

ECCENTRIC END LOADS FOR DOUGLAS-FIR COMBINATION NO. 2 GLULAM COLUMNS
Allowable axial loads (pounds). Side loads and bracket loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or 1/6 column depth.

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	26,966	29,492	31,001	34,574	37,587	39,366	41,489	45,105	47,239
9	24,676	26,650	27,806	31,312	33,612	34,945	37,574	40,334	41,935
10	22,388	23,926	24,740	28,146	29,908	30,925	33,776	35,889	37,110
11	20,186	21,287	21,923	25,233	26,609	27,404	30,279	31,931	32,884
12	18,108	18,987	19,494	22,635	23,734	24,368	27,162	28,481	29,241
13	16,285	16,999	17,410	20,356	21,248	21,763	24,427	25,498	26,115
14	14,693	15,281	15,620	18,367	19,102	19,525	22,040	22,922	23,430
15	13,305	13,796	14,078	16,632	17,245	17,597	19,958	20,694	21,117
16	12,093	12,506	12,744	15,116	15,633	15,929	18,139	18,759	19,115
17	11,031	11,382	11,584	13,788	14,227	14,480	16,546	17,073	17,375
18	10,097	10,398	10,570	12,621	12,997	13,213	15,145	15,597	15,856
19	9,272	9,532	9,681	11,590	11,915	12,102	13,908	14,298	14,522
20	8,542	8,768	8,897	10,677	10,960	11,121	12,812	13,152	13,346
21	7,892	8,090	8,203	9,865	10,112	10,253	11,838	12,134	12,304
22	7,312	7,486	7,585	9,140	9,357	9,481	10,968	11,229	11,378

Notes:

(1) The tabulated allowable loads apply to 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 1997 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 1,600 psi for 2 or 3 lams.
Modulus of elasticity (E) = 1.7×10^6 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 1997 NDS. Size factor for F_{by} is $(12/d)^{0.111}$, where d is equal to the lamination width in inches.

(6) This table is for preliminary design use only. Final design should include a complete analysis, including the bearing capability of the foundation supporting the column.

TABLE 8

ECCENTRIC END LOADS FOR DOUGLAS-FIR COMBINATION NO. 2 GLULAM COLUMNS
Allowable axial loads (pounds). Side loads and bracket loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or 1/6 column depth.

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	46,419	51,735	55,055	57,007	63,204	67,033	66,509	73,738	78,206
9	43,906	48,470	51,252	53,421	58,620	61,752	62,324	68,390	72,044
10	41,184	44,902	46,984	49,641	53,883	56,381	57,915	62,863	65,778
11	38,162	41,002	42,653	45,794	49,203	51,184	53,426	57,403	59,714
12	35,027	37,314	38,637	42,032	44,777	46,365	49,037	52,240	54,092
13	32,072	33,936	35,013	38,486	40,723	42,016	44,900	47,510	49,019
14	29,356	30,897	31,788	35,228	37,077	38,145	41,099	43,256	44,503
15	26,898	28,188	28,933	32,278	33,826	34,720	37,658	39,464	40,507
16	24,690	25,782	26,412	29,628	30,938	31,694	34,566	36,094	36,976
17	22,712	23,644	24,182	27,254	28,373	29,019	31,797	33,102	33,855
18	20,942	21,745	22,207	25,130	26,094	26,648	29,318	30,442	31,090
19	19,356	20,052	20,453	23,227	24,062	24,543	27,098	28,073	28,634
20	17,933	18,541	18,890	21,519	22,249	22,668	25,106	25,957	26,446
21	16,653	17,187	17,493	19,984	20,624	20,992	23,314	24,061	24,490
22	15,500	15,971	16,241	18,600	19,165	19,489	21,700	22,359	22,737
23	14,458	14,876	15,115	17,349	17,851	18,138	20,241	20,826	21,161
24	13,514	13,886	14,099	16,217	16,663	16,919	18,920	19,441	19,739

Notes:

(1) The tabulated allowable loads apply to 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 1997 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 1,600 psi for 2 or 3 lams.
Modulus of elasticity (E) = 1.7×10^6 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 1997 NDS. Size factor for F_{by} is $(12/d)^{0.111}$, where d is equal to the lamination width in inches.

(6) This table is for preliminary design use only. Final design should include a complete analysis, including the bearing capability of the foundation supporting the column.

TABLE 9

ECCENTRIC END LOADS FOR DOUGLAS-FIR COMBINATION NO. 2 GLULAM COLUMNS
Allowable axial loads (pounds). Side loads and bracket loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or 1/6 column depth.

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	77,152	86,969	93,273	92,611	104,825	112,726	107,117	120,632	129,293
9	74,473	83,480	89,193	90,045	101,094	107,917	103,206	115,536	123,334
10	71,555	79,699	84,789	86,575	96,266	102,297	98,943	110,018	116,911
11	68,426	75,672	80,122	82,582	91,135	96,363	94,379	104,155	110,129
12	65,121	71,458	75,279	78,377	85,795	90,240	89,573	98,051	103,132
13	61,687	67,146	70,385	74,027	80,361	84,096	84,602	91,841	96,110
14	58,187	62,847	65,581	69,620	74,983	78,112	79,565	85,695	89,271
15	54,702	58,674	60,991	65,261	69,799	72,433	74,583	79,770	82,780
16	51,311	54,711	56,689	61,047	64,908	67,144	69,767	74,181	76,736
17	48,075	51,005	52,707	57,051	60,361	62,277	65,201	68,984	71,174
18	44,948	47,502	48,986	53,312	56,174	57,829	60,928	64,198	66,091
19	42,045	44,279	45,576	49,844	52,336	53,777	56,964	59,813	61,460
20	39,367	41,334	42,475	46,644	48,830	50,092	53,307	55,805	57,248
21	36,904	38,645	39,654	43,700	45,627	46,740	49,942	52,146	53,418
22	34,640	36,189	37,086	40,994	42,703	43,689	46,851	48,804	49,931
23	32,560	33,945	34,745	38,509	40,032	40,909	44,011	45,751	46,754
24	30,648	31,891	32,609	36,226	37,588	38,372	41,401	42,958	43,854

Notes:

(1) The tabulated allowable loads apply to 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 1997 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 1,600 psi for 2 or 3 lams.
Modulus of elasticity (E) = 1.7×10^6 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 1997 NDS. Size factor for F_{by} is $(12/d)^{0.111}$, where d is equal to the lamination width in inches.

(6) This table is for preliminary design use only. Final design should include a complete analysis, including the bearing capability of the foundation supporting the column.

TABLE 10

ECCENTRIC END LOADS FOR DOUGLAS-FIR COMBINATION NO. 2 GLULAM COLUMNS
Allowable axial loads (pounds). Side loads and bracket loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or 1/6 column depth.

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	117,027	132,314	142,232	133,540	151,828	163,770	152,143	173,303	186,943
9	113,589	127,978	137,284	130,879	148,323	159,645	149,341	168,786	181,341
10	110,048	123,628	132,414	127,928	144,449	155,087	145,333	163,549	175,205
11	106,547	119,467	127,863	124,264	139,751	149,637	140,984	157,889	168,592
12	103,229	115,656	123,749	120,286	134,645	143,612	136,321	151,851	161,563
13	100,187	112,183	119,923	116,135	129,316	137,059	131,381	145,491	154,191
14	97,390	108,819	116,004	111,816	123,444	130,284	126,202	138,875	146,569
15	94,663	105,225	111,630	107,351	117,411	123,394	120,833	132,088	138,819
16	91,763	101,180	106,689	102,520	111,322	116,518	115,335	125,237	131,083
17	88,528	96,675	101,317	97,581	105,284	109,789	109,779	118,445	123,512
18	84,935	91,863	95,752	92,671	99,402	103,317	104,254	111,827	116,232
19	81,079	86,941	90,212	87,862	93,758	97,179	98,845	105,478	109,327
20	77,099	82,075	84,849	83,219	88,407	91,413	93,621	99,457	102,840
21	73,123	77,377	79,755	78,785	83,373	86,032	88,633	93,795	96,786
22	69,243	72,913	74,970	74,586	78,665	81,028	83,909	88,498	91,156
23	65,520	68,714	70,509	70,631	74,276	76,386	79,460	83,561	85,934
24	61,987	64,789	66,368	66,922	70,193	72,086	75,287	78,967	81,096

Notes:

(1) The tabulated allowable loads apply to 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 1997 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 1,600 psi for 2 or 3 lams.
Modulus of elasticity (E) = 1.7×10^6 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 1997 NDS. Size factor for F_{by} is $(12/d)^{0.111}$, where d is equal to the lamination width in inches.

(6) This table is for preliminary design use only. Final design should include a complete analysis, including the bearing capability of the foundation supporting the column.

TABLE 11

ECCENTRIC END LOADS FOR SOUTHERN PINE COMBINATION NO. 47 GLULAM COLUMNS
Allowable axial loads (pounds). Side loads and bracket loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or 1/6 column depth.

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	4,304	4,469	4,563	5,990	6,189	6,304	7,487	7,737	7,880
9	3,616	3,735	3,803	4,994	5,140	5,223	6,243	6,425	6,529
10	3,072	3,161	3,211	4,221	4,330	4,393	5,276	5,413	5,491
11	2,638	2,705	2,744	3,610	3,694	3,742	4,513	4,618	4,678
12	2,287	2,340	2,370	3,121	3,187	3,224	3,901	3,983	4,030

Notes:

(1) The tabulated allowable loads apply to 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 1997 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 1997 NDS. Size factor for F_{by} is $(12/d)^{0.111}$, where d is equal to the lamination width in inches.

(6) This table is for preliminary design use only. Final design should include a complete analysis, including the bearing capability of the foundation supporting the column.

TABLE 12

ECCENTRIC END LOADS FOR SOUTHERN PINE COMBINATION NO. 47 GLULAM COLUMNS
Allowable axial loads (pounds). Side loads and bracket loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or 1/6 column depth.

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	6,196	6,496	6,666	8,758	9,109	9,310	10,947	11,386	11,638
9	5,287	5,501	5,622	7,380	7,637	7,784	9,225	9,546	9,731
10	4,540	4,698	4,789	6,288	6,482	6,593	7,860	8,102	8,241
11	3,929	4,050	4,120	5,413	5,563	5,648	6,766	6,953	7,060
12	3,428	3,523	3,577	4,704	4,822	4,889	5,880	6,027	6,111
13	3,013	3,090	3,133	4,123	4,217	4,271	5,153	5,271	5,339
14	2,668	2,730	2,765	3,641	3,718	3,762	4,551	4,647	4,702

Notes:

(1) The tabulated allowable loads apply to 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 1997 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 1997 NDS. Size factor for F_{by} is $(12/d)^{0.111}$, where d is equal to the lamination width in inches.

(6) This table is for preliminary design use only. Final design should include a complete analysis, including the bearing capability of the foundation supporting the column.

TABLE 13

ECCENTRIC END LOADS FOR SOUTHERN PINE COMBINATION NO. 47 GLULAM COLUMNS
Allowable axial loads (pounds). Side loads and bracket loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or 1/6 column depth.

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	17,783	19,146	19,948	23,985	25,571	26,489	28,782	30,685	31,787
9	15,858	16,901	17,512	21,036	22,210	22,888	25,243	26,652	27,466
10	14,114	14,927	15,401	18,458	19,353	19,870	22,150	23,224	23,844
11	12,579	13,224	13,599	16,256	16,956	17,359	19,508	20,347	20,831
12	11,244	11,764	12,066	14,388	14,945	15,266	17,265	17,934	18,319
13	10,089	10,513	10,758	12,802	13,253	13,513	15,362	15,904	16,215
14	9,088	9,438	9,627	11,450	11,821	12,034	13,740	14,185	14,440
15	8,219	8,481	8,622	10,293	10,601	10,778	12,352	12,721	12,933
16	7,438	7,645	7,763	9,297	9,556	9,704	11,157	11,467	11,645
17	6,748	6,923	7,023	8,435	8,654	8,779	10,122	10,385	10,535
18	6,147	6,297	6,383	7,684	7,872	7,979	9,221	9,446	9,574
19	5,622	5,751	5,825	7,028	7,189	7,281	8,433	8,627	8,737
20	5,160	5,272	5,336	6,450	6,590	6,670	7,740	7,908	8,004

Notes:

(1) The tabulated allowable loads apply to 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 1997 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 1997 NDS. Size factor for F_{by} is $(12/d)^{0.111}$, where d is equal to the lamination width in inches.

(6) This table is for preliminary design use only. Final design should include a complete analysis, including the bearing capability of the foundation supporting the column.

TABLE 14

ECCENTRIC END LOADS FOR SOUTHERN PINE COMBINATION NO. 47 GLULAM COLUMNS
Allowable axial loads (pounds). Side loads and bracket loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or 1/6 column depth.

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	20,172	21,844	22,835	27,898	30,437	31,945	34,715	37,365	38,907
9	18,158	19,452	20,213	25,424	27,397	28,368	30,921	32,898	34,042
10	16,281	17,297	17,893	22,864	24,123	24,850	27,437	28,947	29,820
11	14,596	15,408	15,883	20,304	21,289	21,857	24,365	25,546	26,229
12	13,112	13,771	14,155	18,086	18,872	19,326	21,703	22,647	23,191
13	11,814	12,356	12,670	16,176	16,814	17,181	19,411	20,176	20,618
14	10,681	11,132	11,392	14,530	15,055	15,357	17,436	18,066	18,429
15	9,692	10,070	10,288	13,109	13,546	13,798	15,731	16,256	16,557
16	8,826	9,146	9,331	11,877	12,245	12,456	14,253	14,694	14,947
17	8,065	8,338	8,496	10,805	11,117	11,296	12,966	13,340	13,555
18	7,394	7,629	7,764	9,866	10,134	10,287	11,840	12,161	12,344
19	6,800	7,004	7,121	9,042	9,273	9,405	10,850	11,127	11,286
20	6,273	6,451	6,553	8,314	8,515	8,629	9,977	10,217	10,355
21	5,803	5,959	6,048	7,669	7,844	7,944	9,203	9,413	9,533
22	5,383	5,520	5,599	7,095	7,249	7,337	8,514	8,699	8,804

Notes:

(1) The tabulated allowable loads apply to 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 1997 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 1997 NDS. Size factor for F_{by} is $(12/d)^{0.111}$, where d is equal to the lamination width in inches.

(6) This table is for preliminary design use only. Final design should include a complete analysis, including the bearing capability of the foundation supporting the column.

TABLE 15

ECCENTRIC END LOADS FOR SOUTHERN PINE COMBINATION NO. 47 GLULAM COLUMNS
Allowable axial loads (pounds). Side loads and bracket loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or 1/6 column depth.

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	35,774	39,505	41,796	45,733	50,861	54,038	55,427	61,905	65,938
9	33,301	36,391	38,245	43,086	47,409	50,018	52,597	57,387	60,096
10	30,759	33,271	34,757	40,208	43,755	45,857	48,352	51,969	54,074
11	28,251	30,291	31,489	37,230	40,118	41,595	44,014	46,872	48,528
12	25,872	27,544	28,524	34,253	36,217	37,354	39,961	42,254	43,580
13	23,677	25,065	25,875	31,098	32,700	33,627	36,281	38,150	39,231
14	21,686	22,849	23,527	28,277	29,602	30,368	32,990	34,536	35,429
15	19,893	20,878	21,450	25,773	26,882	27,522	30,068	31,362	32,109
16	18,286	19,126	19,613	23,553	24,491	25,032	27,479	28,573	29,204
17	16,847	17,569	17,987	21,587	22,387	22,848	25,185	26,119	26,656
18	15,557	16,182	16,543	19,841	20,530	20,926	23,148	23,951	24,413
19	14,399	14,943	15,257	18,288	18,884	19,227	21,336	22,032	22,431
20	13,359	13,835	14,110	16,903	17,422	17,721	19,720	20,326	20,674
21	12,422	12,841	13,082	15,663	16,118	16,380	18,273	18,805	19,110
22	11,575	11,946	12,159	14,550	14,952	15,182	16,975	17,444	17,712
23	10,809	11,138	11,327	13,548	13,904	14,108	15,806	16,221	16,459
24	10,114	10,408	10,576	12,644	12,961	13,142	14,751	15,121	15,332

Notes:

(1) The tabulated allowable loads apply to 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 1997 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 1997 NDS. Size factor for F_{by} is $(12/d)^{0.111}$, where d is equal to the lamination width in inches.

(6) This table is for preliminary design use only. Final design should include a complete analysis, including the bearing capability of the foundation supporting the column.

TABLE 16

ECCENTRIC END LOADS FOR SOUTHERN PINE COMBINATION NO. 47 GLULAM COLUMNS
Allowable axial loads (pounds). Side loads and bracket loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or 1/6 column depth.

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	58,811	65,794	70,212	71,516	80,466	86,187	83,914	94,750	101,717
9	56,008	62,197	66,050	68,804	76,927	82,043	81,234	91,197	97,510
10	53,030	58,411	61,697	65,839	73,070	77,541	78,224	87,198	92,778
11	49,925	54,519	57,274	62,644	68,949	72,772	74,878	82,775	87,580
12	46,763	50,638	52,935	59,262	64,666	67,889	71,222	77,545	80,942
13	43,626	46,890	48,811	55,778	60,369	63,080	66,784	71,587	74,380
14	40,599	43,362	44,983	52,297	56,199	58,490	61,972	65,972	68,292
15	37,742	40,099	41,478	48,919	52,252	54,203	57,426	60,790	62,739
16	35,086	37,112	38,295	45,708	48,574	50,248	53,207	56,064	57,718
17	32,639	34,393	35,415	42,700	45,180	46,550	49,332	51,782	53,200
18	30,396	31,923	32,813	39,880	41,926	42,997	45,797	47,915	49,139
19	28,331	29,670	30,448	37,258	38,871	39,802	42,580	44,424	45,488
20	26,439	27,619	28,303	34,699	36,112	36,927	39,656	41,271	42,203
21	24,715	25,760	26,365	32,374	33,618	34,335	36,998	38,421	39,240
22	23,142	24,071	24,609	30,258	31,360	31,994	34,580	35,840	36,564
23	21,705	22,536	23,015	28,330	29,310	29,874	32,377	33,498	34,142
24	20,391	21,136	21,566	26,571	27,447	27,950	30,367	31,368	31,943

Notes:

(1) The tabulated allowable loads apply to 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 1997 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 1997 NDS. Size factor for F_{by} is $(12/d)^{0.111}$, where d is equal to the lamination width in inches.

(6) This table is for preliminary design use only. Final design should include a complete analysis, including the bearing capability of the foundation supporting the column.

TABLE 17

ECCENTRIC END LOADS FOR SOUTHERN PINE COMBINATION NO. 47 GLULAM COLUMNS
Allowable axial loads (pounds). Side loads and bracket loads are not permitted. End loads are limited to a maximum eccentricity of either 1/6 column width or 1/6 column depth.

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	104,726	118,538	127,487	120,018	136,206	146,743	135,122	153,637	165,727
9	101,835	114,772	123,084	117,253	132,576	142,472	132,450	150,105	161,553
10	98,686	110,687	118,316	114,199	128,569	137,762	129,252	145,942	156,673
11	95,301	106,313	113,229	110,704	124,046	132,483	125,643	141,222	151,120
12	91,648	101,646	107,835	106,866	119,069	126,676	121,756	136,113	145,102
13	87,703	96,642	102,094	102,806	113,818	120,574	117,576	130,615	138,419
14	83,650	91,555	96,308	98,541	108,350	114,275	113,105	124,000	129,946
15	79,534	86,471	90,598	94,117	102,768	107,928	107,907	116,558	121,632
16	75,421	81,491	85,079	89,604	97,194	101,687	101,868	109,317	113,659
17	71,380	76,700	79,831	85,092	91,751	95,529	95,971	102,404	106,143
18	67,474	72,153	74,902	80,665	86,308	89,228	90,311	95,898	99,142
19	63,744	67,881	70,305	76,389	80,849	83,399	84,949	89,832	92,665
20	60,217	63,890	66,040	71,925	75,791	78,032	79,917	84,212	86,702
21	56,901	60,178	62,093	67,699	71,119	73,100	75,221	79,021	81,222
22	53,797	56,732	58,445	63,771	66,812	68,572	70,857	74,236	76,191
23	50,898	53,537	55,075	60,128	62,844	64,415	66,809	69,827	71,572
24	48,196	50,577	51,962	56,752	59,188	60,596	63,058	65,765	67,329

Notes:

(1) The tabulated allowable loads apply to 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 1997 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 1997 NDS. Size factor for F_{by} is $(12/d)^{0.111}$, where d is equal to the lamination width in inches.

(6) This table is for preliminary design use only. Final design should include a complete analysis, including the bearing capability of the foundation supporting the column.

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Other publications from APA and EWS:

Data File: *Glued Laminated Beam Design Tables,* EWS S475

Data File: *Substitution of Glulam Beams for Steel and Solid-Sawn Lumber,* EWS S570

APA Design/Construction Guide: Residential and Commercial, E30

Source List: Publications Index, EWS S400

Residential Pocket Guides, EWS X445 (Southern Edition) and EWS X450 (Western Edition)

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