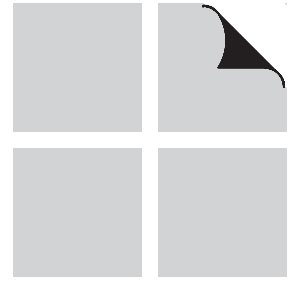


SUPPLEMENT
Structural Lumber



A S D

ALLOWABLE | STRESS | DESIGN

**MANUAL FOR ENGINEERED
WOOD CONSTRUCTION**

**Canadian Wood Council
Southern Forest Products Association
Southern Pine Inspection Bureau
West Coast Lumber Inspection Bureau
Western Wood Products Association**



May 2013

Codes and Standards Addenda and Amendments Related to Design Value Changes

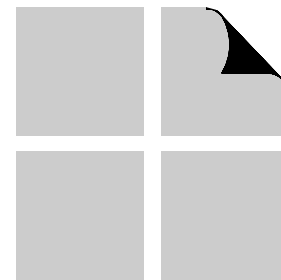
The American Lumber Standard Committee (ALSC) Board of Review has approved changes to design values for all grades and all sizes of visually-graded Southern Pine and Mixed Southern Pine lumber, 2"- 4" thick, with a recommended effective date of June 1, 2013. For more information, visit www.spib.org and www.southernpine.com.

AWC has developed [addenda and other updates](#) to use with new construction designed in accordance with many of its standards and design tools. However, this document has not been updated to include changes to design values. Designers are urged to download the addendum to the [2012 NDS Supplement](#), which contains the new design values, and use them accordingly with this document.

For additional information or questions, visit the AWC website at www.awc.org or email your request to info@awc.org.

Thank you.

SUPPLEMENT
Structural Lumber



A S D

ALLOWABLE STRESS DESIGN

**MANUAL FOR ENGINEERED
WOOD CONSTRUCTION**

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West Coast Lumber Inspection Bureau, Western Wood Products Association

Preface

This Supplement contains adjustment factors, dimensions, member design capacities and other properties required to design structural lumber in the ASD format.

The member design capacity values tabulated in this Supplement are to be used in conjunction with the design methodologies provided in *ANSI/AF&PA NDS-2001, National Design Specification® (NDS®) for Wood Construction*.

The tabulated design values are provided in the *NDS-2001 Supplement: Design Values for Wood Construction* and were derived according to ASTM Standards D1990, D245, and D2555.

The reference member design capacity values are to be used within the reference end-use conditions defined herein. When the end-use conditions fall outside the range of the reference conditions, the capacity values shall be determined by calculations according to the *NDS*. For unusual end-use conditions, the designer should consult additional literature for possible further adjustments.

The development and future maintenance of this Supplement is a cooperative effort between AF&PA and the lumber industry. The lumber organizations involved in the development and review are as follows:

Canadian Wood Council (CWC)
Southern Forest Products Association (SFPA)
Southern Pine Inspection Bureau (SPIB)
West Coast Lumber Inspection Bureau (WCLIB)
Western Wood Products Association (WWPA)

Every effort has been made to ensure the accuracy of the information presented. Member selection tables are provided for materials widely used in wood construction. The purpose of this Supplement is to provide convenient reference and design aids to design professionals.

Suggestions for improvement of this Supplement are welcomed and will be considered for future editions. All suggestions and comments should be directed to AF&PA or one of the organizations listed above.

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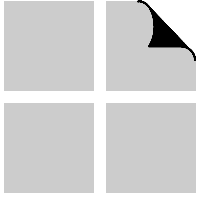
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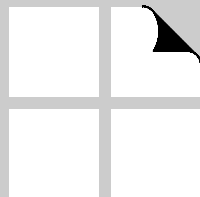
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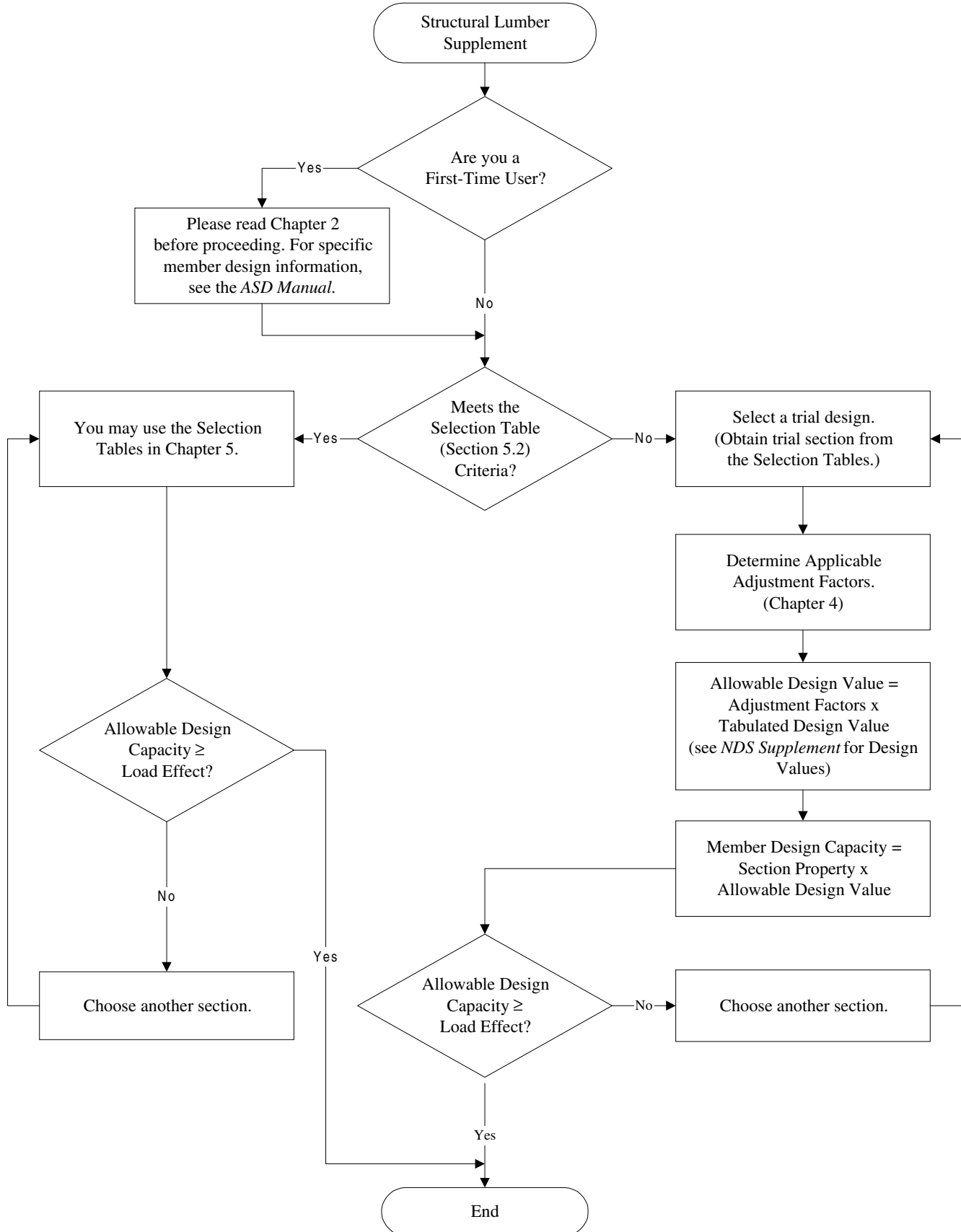
DESIGNER FLOWCHART

1.1 Flowchart

L-2

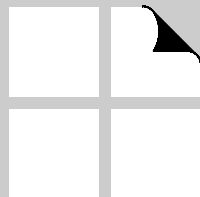


1.1 Flowchart



INTRODUCTION TO STRUCTURAL LUMBER

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2.2	Common Uses	L-4
2.3	Availability	L-4



2.1 Product Information

Structural lumber products are well-known throughout the construction industry. The economic advantages of lumber often dictate its choice as a preferred building material.

Lumber is available in a wide range of species, grades, sizes, and moisture contents. Structural lumber products are typically specified by either the stress level required, or by the species, grade, and size required.

This Supplement provides information for designing structural lumber products in accordance with the *National Design Specification (NDS) for Wood Construction*.

2.2 Common Uses

Structural lumber and timbers have been a primary construction material throughout the world for many centuries. They are the most widely used framing material for housing in North America.

In addition to use in housing, structural lumber finds broad use in commercial and industrial construction. Its high strength, universal availability, and cost saving attributes make it a viable option in most low- and mid-rise construction projects.

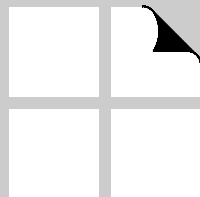
Structural lumber is used as beams, columns, headers, joists, rafters, studs and plates in conventional construction. In addition to its use in lumber form, structural lumber is used to manufacture glued-laminated beams, trusses, and wood I-joists.

2.3 Availability

Structural lumber is a widely available construction material in the U.S. However, to efficiently specify structural lumber for individual construction projects, the specifier should be aware of the species, grades, and sizes available locally. The best source of this information is your local lumber supplier.

DESIGN VALUES

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3.1 General

The *NDS Supplement* provides ASD tabulated design values for design of structural lumber members. These design values are used when manual calculation of member capacity is required, and shall be used in conjunction with the adjustment factors specified in Chapter 4.

3.2 Design Values

Design values are provided in the *NDS Supplement*, with values expressed in psi (pounds per square inch).

NDS

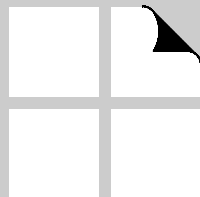
Supplement

Table Number

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4.1 General

Two approaches may be used to generate member design capacities. With the calculation method, tabulated design values are multiplied by adjustment factors and section properties to obtain member capacities. With the tabulation method, values for a given set of conditions are presented in the tables.

The member selection tables in Chapter 5 include pre-calculated ASD capacity values for reference conditions of use. For other conditions, the calculation method is used requiring the use of tabulated design values (from *NDS*

Supplement), modified appropriately by the adjustment factors discussed in this Chapter.

The adjustment factors provided in this Chapter are for applications outside the reference end-use conditions or for member configuration effects (i.e., flat use). Adjustment factors for the effects of load duration, moisture, temperature, size, flat use, and incising are provided in this Supplement.

4.2 Use of Adjustment Factors

Tension

The design capacities for tension members can be computed by the following equation:

$$T' = F_t' A$$

where:

T' is the allowable tension design capacity, F_t' is the allowable tension design value and A is the cross sectional area.

The allowable tension design value is computed by multiplying the tabulated design value by a series of adjustment factors.

The tabulated design values for F_t are provided in the *NDS Supplement*.

$$F_t' = F_t C_D C_M C_t C_i C_F$$

and:

C_D is 1.0 for normal (ten years) load duration, or as shown in Table 4.1 otherwise

C_M is 1.0 for 19% MC and less, or as shown in Table 4.2 otherwise

C_t is 1.0 unless temperatures exceed 100°F for extended periods of time, or as shown in Table 4.3 otherwise

C_i is 1.0 for members that are not incised, or as shown in Table 4.6 otherwise

C_F is as shown in Table 4.4

Compression

The design capacity for compression members can be computed by the following equation:

$$P' = F_c' A$$

where:

P' is the allowable compression design capacity, F_c' is the allowable compression design value and A is the cross sectional area.

The allowable compression design value is computed by multiplying the tabulated design value by a series of adjustment factors.

The tabulated design values for F_c are provided in the *NDS Supplement*.

$$F_c' = F_c C_D C_M C_t C_i C_P$$

and:

C_D is 1.0 for normal (ten years) load duration, or as shown in Table 4.1 otherwise

C_M is 1.0 for 19% MC and less, or as shown in Table 4.2 otherwise

C_t is 1.0 unless temperatures exceed 100°F for extended periods of time, or as shown in Table 4.3 otherwise

C_i is 1.0 for members that are not incised, or as shown in Table 4.6 otherwise

C_P is as shown in Table 4.4

C_p is 1.0 for fully supported or “zero length” columns, or as given in *NDS* Section 3.7 otherwise

Bending (Moment and Shear)

The capacities for bending members can be computed by the following equations:

For moment:

$$M' = F_b' S$$

For shear:

For a rectangular bending member of breadth, b , and depth, d ,

$$V' = \frac{2F_v' bd}{3}$$

where:

M' and V' are the allowable moment and shear capacities, F_b' and F_v' are the allowable bending and shear design values, S is the section modulus.

The allowable bending and shear design values are computed by multiplying the tabulated design values by a series of adjustment factors.

The tabulated design values for F_b and F_v are provided in the *NDS Supplement*.

$$F_b' = F_b C_D C_M C_t C_i C_L C_F C_{fu} C_r C_f$$

$$F_v' = F_v C_D C_M C_i$$

and:

C_D is 1.0 for normal (ten years) load duration, or as shown in Table 4.1 otherwise

C_M is 1.0 for 19% MC and less, or as shown in Table 4.2 otherwise

C_t is 1.0 unless temperatures exceed 100°F for extended periods of time, or as shown in Table 4.3 otherwise

C_i is 1.0 for members that are not incised, or as shown in Table 4.6 otherwise

C_r is 1.15 for members used in repetitive member applications as defined in *NDS* Section 4.3.9, or 1.00 otherwise

C_F is as shown in Table 4.4

C_L is 1.0 for fully laterally supported beams, or as given in *NDS* Section 3.3.3 otherwise

C_f is 1.0 for rectangular members loaded along a principal axis, or as given in *NDS* Section 4.3.10 otherwise

C_{fu} is 1.0 for members loaded edgewise, or as shown in Table 4.5 for members loaded flatwise

Combined Axial & Flexural

The design capacities for members under combined axial and flexural loading are based upon the equations in *NDS* Section 3.9. Users are directed to that section and to the discussion of tension, compression, and bending above.

Bearing

The required bearing areas of members are computed based upon the following equations:

For end bearing:

$$P_g' = F_c'$$

where:

$$F_c' = F_c C_D C_t$$

and:

C_D is 1.0 for normal (ten years) load duration, or as shown in Table 4.1 otherwise

C_t is 1.0 unless temperatures exceed 100°F for extended periods of time, or as shown in Table 4.3 otherwise

For side bearing:

$$P'_\perp = F'_{c\perp} A_n$$

where:

$$F'_{c\perp} = F_{c\perp} C_M C_t C_b$$

and:

C_M is 1.0 for 19% MC and less, or as shown in Table 4.2 otherwise

C_t is 1.0 unless temperatures exceed 100°F for extended periods of time, or as shown in Table 4.3 otherwise

C_i is 1.0 for members that are not incised, or as shown in Table 4.6 otherwise

C_b is 1.0 for all members, with an increase permitted as given in *NDS* Section 4.3.13.

Table 4.1 Frequently Used Load Duration Factors, C_D ¹

Load Duration	C_D	Typical Design Loads
Permanent	0.9	Dead Load
10 years	1.0	Occupancy Live Load
2 months	1.15	Snow Load
7 days	1.25	Construction Load
10 minutes	1.6	Wind/Earthquake Load
Impact ²	2.0	Impact Load

¹ Load duration factors shall not apply to modulus of elasticity, E , nor to compression perpendicular to grain design values, $F_{c\perp}$, based on a deformation limit.

² Load duration factors greater than 1.6 shall not apply to structural members pressure-treated with water-borne preservatives, or fire retardant chemicals. The impact load duration factor shall not apply to connections.

Table 4.2 Wet Service Factor, C_M

Nominal Thickness	End-Use Moisture Condition ²		F_t	F _c C _F		F_v	$F_{c\perp}$	E
	$F_b C_F \leq 1150$ psi	$F_b C_F > 1150$ psi		≤ 750 psi	> 750 psi			
4 in. or less	1.00	0.85	1.00	1.00	0.80	0.97	0.67	0.90
over 4 in.	1.00	1.00	1.00	0.91	0.91	1.00	0.67	1.00

Table 4.3 Temperature Factor, C_t ¹

Property	End-Use Moisture Condition ²	Sustained Temperature, °F	
		100 < T ≤ 125	125 < T ≤ 150
F_t, E	Dry	0.9	0.9
	Wet	0.9	0.9
$F_b, F_v, F_{c\perp}$ and $F_{c\perp}$	Dry	0.8	0.7
	Wet	0.7	0.5

¹ No adjustment is needed ($C_t = 1.0$) unless temperatures exceed 100°F for extended periods of time. The adjustments are not required in applications where diurnal temperatures may exceed 100°F from time to time.

² Wet and dry service conditions for sawn lumber are specified in *NDS* Section 4.1.4.

Table 4.4 Size Factor, $C_F^{1,2,3}$

Grades	Width	F_b Nominal Thickness		F_t	F_c
		2" & 3"	4"		
Sel. Struct., No. 1 & Better, No. 1, No. 2, No. 3	4" & less	1.5	1.5	1.5	1.15
	5"	1.4	1.4	1.4	1.10
	6"	1.3	1.3	1.3	1.10
	8"	1.2	1.3	1.2	1.05
	10"	1.1	1.2	1.1	1.00
	12" ≥ 14"	1.0 0.9	1.1 1.0	1.0 0.9	1.00 0.90
Stud	4" & less	1.1	1.1	1.1	1.05
	5" & 6"	1.0	1.0	1.0	1.00
	8" & wider	Use No. 3 grade base values and size factors			
Const., Stand.	4" & less	1.0	1.0	1.0	1.00
Utility	4"	1.0	1.0	1.0	1.00
	2" & 3"	0.4	—	0.4	0.60

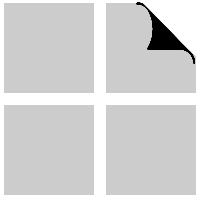
¹ For Southern Pine and Mixed Southern Pine dimension lumber (tabulated design values in Table 4B of *NDS Supplement*), the value of C_F is 1.0 for all properties and all sizes 12" in width and less, except for material 4" in thickness and 8" and wider, where C_F is 1.1 for F_b . See *NDS Supplement* for additional requirements.
² For mechanically graded dimension lumber (both MSR and MEL, tabulated design values in Table 4C of *NDS Supplement*), the value of C_F is 1.0 for all properties and all sizes.
³ For members with tabulated design values listed in Table 4D of *NDS Supplement*, C_F for F_b is computed as $(12/d)^{1/9} \leq 1.0$, where d is the depth of the member. C_F for other properties is 1.0. See *NDS Supplement* for additional requirements.

Table 4.5 Flat Use Factor, C_{fu}

Width	Thickness	
	2" and 3"	4"
2" & 3"	1.00	—
4"	1.10	1.00
5"	1.10	1.05
6"	1.15	1.05
8"	1.15	1.05
10" & wider	1.20	1.10

Table 4.6 Incising Factor, C_i

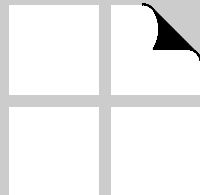
Design Value	C_i
E	0.95
F_b, F_t, F_c	0.80
$F_v, F_{c\perp}$	1.00



MEMBER SELECTION TABLES

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5.1 General

Member selection tables provide allowable design capacities for many common designs. Before using the selection tables, please refer to the checklist to be certain that the tables are appropriate for your application.

The tables in this Chapter provide design capacity values for structural lumber and timbers. Moment capacity, M' , shear capacity, V' , and bending stiffness, EI , are provided for strong axis bending. Tension capacity, T' , and compression capacity, P' , are also tabulated. The applicable load duration factor, C_D , is indicated in each of the tables.

5.2 Selection Table Checklist

Checklist for all member types:

The selection tables provide values for allowable design capacities for common species, grades, and sizes of members. The tabulated values apply to members that satisfy the following conditions:

- ✓ “dry” service conditions ($C_M = 1.0$)
- ✓ “normal” temperature range ($C_t = 1.0$)
- ✓ members not incised ($C_i = 1.0$)

In addition, the beam and joist selection tables require the following check:

- ✓ fully laterally supported ($C_L = 1.0$)

The column selection tables include the appropriate column stability factor, C_p , for the stated column length based on the following condition:

- ✓ end conditions pin-pin

If any of these conditions are not satisfied the selection tables should NOT be used directly. The designer should refer to the flowchart (Chapter 1) and follow the procedures for manual calculation.

For manual calculation, two approaches are possible: 1) review the design equations in the chapter and modify the tabulated values as necessary; or 2) compute design capacity directly from the tabulated design values and adjustment factors.

To compute the design capacity for a specific condition, apply the design equations directly. Tabulated design values are provided in the *NDS Supplement* and design adjustment factors are provided in Chapter 4 of this Supplement.

5.3 Capacity Tables

Capacity tables are provided as follows:

- Table 5.1 = tension members
- Table 5.2a = studs (axial compression load only), $C_D = 1.0$
- Table 5.2b = studs (axial compression load only), $C_D = 1.15$
- Table 5.3 = compression members (columns)
- Table 5.4 = joists
- Table 5.5 = beams

Refer to the selection table checklist to see whether your design condition meets the assumptions built into the tabulated values. Note that the load duration factor, C_D , is shown at the top of the table. Thus, the member design capacity can be used directly to select a member that meets the design requirement.

Examples of the development of the capacity table values are shown in the Appendix.

Table 5.1a Tension Member Capacity (T'), Structural Lumber

2-inch nominal thickness Visually Graded Lumber (1.5 inch dry dressed size), $C_D = 1.0$.
 4-inch nominal thickness Visually Graded Lumber (3.5 inch dry dressed size), $C_D = 1.0$.

Species	Width		Tension Member Capacity, T' (lbs.)						
	Nominal in.	Actual in.	Visually Graded Lumber						
			2" nominal thickness				4" nominal thickness		
			Select Structural	No. 1	No. 2	No.3	Select Structural	No. 1	No. 2
Douglas Fir-Larch	4	3.5	7,870	5,310	4,520	2,550	18,300	12,400	10,500
	6	5.5	10,700	7,230	6,160	3,480	25,000	16,800	14,300
	8	7.25	13,000	8,000	7,500	4,240	30,400	20,500	17,500
	10	9.25	15,260	10,300	8,770	4,960	35,600	24,000	20,400
	12	11.25	16,800	11,900	9,700	5,480	39,300	26,500	22,600
Hem-Fir	4	3.5	7,280	4,920	4,130	2,360	16,900	11,400	9,640
	6	5.5	9,900	6,700	5,630	3,210	23,100	15,600	13,100
	8	7.25	12,000	8,150	6,850	3,910	28,100	19,000	15,900
	10	9.25	14,100	9,530	8,010	4,570	32,900	22,200	18,600
	12	11.25	15,600	10,500	8,850	5,060	36,400	24,600	20,600
Southern Pine	4	3.5	8,400	5,510	4,330	2,490	19,600	12,800	10,100
	6	5.5	11,500	7,420	5,980	3,500	26,900	17,300	13,900
	8	7.25	14,100	8,970	7,060	4,350	32,900	20,900	16,400
	10	9.25	15,200	10,000	9,280	4,500	35,600	23,400	18,600
	12	11.25	17,700	11,300	9,280	5,480	41,300	26,500	21,600
Spruce-Pine-Fir	4	3.5	5,510	3,540	3,540	1,960	12,800	8,260	8,260
	6	5.5	7,510	4,820	4,280	2,680	17,500	11,200	11,200
	8	7.25	9,130	5,870	5,870	3,260	21,300	13,700	13,700
	10	9.25	10,600	6,860	6,860	3,810	24,900	16,000	16,000
	12	11.25	11,800	7,590	7,590	4,210	27,500	17,700	17,700
			2" nominal thickness				4" nominal thickness		
			Construction	Standard	Utility	Stud	Construction	Standard	Stud
Douglas Fir-Larch	4	3.5	3,410	1,960	919	2,590	7,960	4,590	6,060
Hem-Fir	4	3.5	3,150	1,700	788	2,310	7,350	3,980	5,390
Southern Pine	4	3.5	3,280	1,830	919	2,490	7,560	4,280	5,810
Spruce-Pine-Fir	4	3.5	2,620	1,440	656	2,020	6,120	3,360	4,710

Table 5.1b Tension Member Capacity (T'), Structural Lumber

2-inch nominal thickness MSR Lumber (1.5 inch dry dressed size), $C_D = 1.0$.

Species	Width		Tension Member Capacity, T' (lbs.)						
	Nominal in.	Actual in.	Machine Stress Rated Lumber						
			2" nominal thickness						
			1200f-1.2E	1350f-1.3E	1450f-1.3E	1650f-1.5E	2100f-1.8E	2250f-1.9E	2400f-2.0E
All Species	4	3.5	3,150	3,938	4,200	5,355	8,269	9,188	10,106
	6	5.5	4,950	6,188	6,600	8,415	12,994	14,438	15,881
	8	7.25	6,525	8,156	8,700	11,093	17,128	19,031	20,934
	10	9.25	8,325	10,406	11,100	14,153	21,853	24,281	26,709
	12	11.25	10,125	12,656	13,500	17,213	26,578	29,531	32,484

Table 5.2a Wall Stud (Axial Compression Only) Capacity (P'), Structural Lumber

2-inch nominal thickness Visually Graded Lumber (1.5 inch dry dressed size), $C_D = 1.0$.

Species	Stud Length (ft.)	Axial Compression Load Capacity, P' (lbs.)							
		Select Structural		No. 1		No. 2		Stud	
		2 x 4 4" width (=3.5")	2 x 6 6" width (=5.5")	2 x 4 4" width (=3.5")	2 x 6 6" width (=5.5")	2 x 4 4" width (=3.5")	2 x 6 6" width (=5.5")	2 x 4 4" width (=3.5")	2 x 6 6" width (=5.5")
Douglas Fir-Larch	4	8,390	14,500	7,430	12,800	6,770	11,600	4,210	6,780
	6	5,670	13,100	5,050	11,600	4,690	10,500	3,400	6,420
	8	3,590	10,700	3,210	9,470	3,000	8,710	2,420	5,800
	10	2,400	8,090	2,140	7,210	2,010	6,700	1,690	4,930
Hem-Fir	4	7,300	12,800	6,650	11,500	6,200	11,000	3,910	6,350
	6	4,840	11,400	4,490	10,400	4,000	9,710	3,070	5,970
	8	3,040	9,190	2,840	8,440	2,490	7,690	2,120	5,320
	10	2,030	6,900	1,890	6,400	1,650	5,700	1,460	4,430
Southern Pine	4	8,670	15,400	7,810	13,600	7,080	12,400	4,540	7,350
	6	5,560	13,500	5,160	12,100	4,780	11,100	3,570	6,910
	8	3,450	10,700	3,240	9,750	3,020	9,050	2,470	6,170
	10	2,290	7,900	2,150	7,330	2,020	6,840	1,710	5,150
Spruce-Pine-Fir	4	6,830	11,900	5,800	9,890	5,800	9,890	3,600	5,780
	6	4,530	10,600	4,060	8,990	4,060	8,990	2,910	5,480
	8	2,850	8,590	2,610	7,510	2,610	7,510	2,070	4,960
	10	1,900	6,460	1,760	5,820	1,760	5,820	1,440	4,220

Table 5.2b Wall Stud (Axial Compression Only) Capacity (P'), Structural Lumber

2-inch nominal thickness Visually Graded Lumber (1.5 inch dry dressed size), $C_D = 1.15$.

Species	Stud Length (ft.)	Axial Compression Load Capacity, P' (lbs.)							
		Select Structural		No. 1		No. 2		Stud	
		2 x 4 4" width (=3.5")	2 x 6 6" width (=5.5")	2 x 4 4" width (=3.5")	2 x 6 6" width (=5.5")	2 x 4 4" width (=3.5")	2 x 6 6" width (=5.5")	2 x 4 4" width (=3.5")	2 x 6 6" width (=5.5")
Douglas Fir-Larch	4	9,240	16,500	8,190	14,600	7,480	13,200	4,740	7,750
	6	5,900	14,500	5,260	12,800	4,890	11,700	3,660	7,250
	8	3,650	11,400	3,260	10,100	3,050	9,330	2,500	6,410
	10	2,420	8,380	2,160	7,470	2,030	6,960	1,720	5,280
Hem-Fir	4	8,020	14,500	7,320	13,100	6,780	12,500	4,390	7,260
	6	5,020	12,600	4,660	11,500	4,140	10,700	3,270	6,730
	8	3,090	9,760	2,880	9,000	2,530	8,130	2,180	5,840
	10	2,040	7,130	1,910	6,620	1,670	5,870	1,480	4,700
Southern Pine	4	9,470	17,500	8,570	15,400	7,790	14,100	5,100	8,400
	6	5,750	14,900	5,350	13,400	4,970	12,300	3,810	7,800
	8	3,500	11,300	3,290	10,400	3,080	9,640	2,540	6,780
	10	2,310	8,140	2,170	7,570	2,040	7,080	1,730	5,470
Spruce-Pine-Fir	4	7,500	13,600	6,430	11,300	6,430	11,300	4,050	6,610
	6	4,700	11,800	4,250	10,000	4,250	10,000	3,130	6,190
	8	2,890	9,140	2,660	8,070	2,660	8,070	2,140	5,480
	10	1,920	6,680	1,770	6,050	1,770	6,050	1,470	4,510

Table 5.3a Column Capacity^{1,2} (P', P'_x, P'_y), Timbers6-inch nominal thickness (5.5 inch dry dressed size), C_D = 1.0.

Species	Column Length (ft.)	Column Capacity (lbs.)								
		Select Structural			No. 1			No. 2		
		6 x 6 6" width (=5.5") P'	6 x 8 8" width (=7.5") P' _x P' _y		6 x 6 6" width (=5.5") P'	6 x 8 8" width (=7.5") P' _x P' _y		6 x 6 6" width (=5.5") P'	6 x 8 8" width (=7.5") P' _x P' _y	
Douglas Fir- Larch	2	34,500	47,200	47,000	30,000	41,100	40,900	21,000	28,800	28,700
	4	33,400	46,400	45,500	29,200	40,500	39,800	20,500	28,400	28,000
	6	31,200	45,000	42,500	27,600	39,500	37,600	19,600	27,800	26,700
	8	27,400	42,800	37,300	24,800	37,800	33,900	18,000	26,900	24,600
	10	22,400	39,300	30,500	21,000	35,300	28,600	15,700	25,400	21,400
	12	17,600	34,700	24,000	16,900	31,900	23,000	13,000	23,400	17,800
	14	13,800	29,600	18,800	13,400	27,900	18,300	10,500	21,000	14,400
	16	10,900	24,800	14,900	10,700	23,800	14,600	8,530	18,300	11,600
Hem-Fir	2	29,200	40,000	39,800	25,500	34,900	34,800	17,300	23,600	23,600
	4	28,200	39,300	38,500	24,800	34,400	33,800	16,900	23,400	23,000
	6	26,300	38,100	35,800	23,300	33,500	31,800	16,200	22,900	22,000
	8	22,900	36,000	31,200	20,800	32,000	28,400	14,900	22,100	20,300
	10	18,500	33,000	25,300	17,400	29,700	23,800	13,100	21,000	17,800
	12	14,400	28,900	19,700	13,900	26,700	19,000	10,900	19,400	14,900
	14	11,300	24,500	15,300	11,000	23,100	15,000	8,860	17,400	12,100
	16	8,910	20,400	12,100	8,770	19,600	12,000	7,180	15,300	9,790
Southern Pine	2	28,500	39,000	38,900	24,800	33,900	33,800	15,800	21,600	21,500
	4	27,700	38,500	37,800	24,200	33,500	33,000	15,500	21,400	21,100
	6	26,200	37,500	35,700	23,100	32,800	31,500	15,000	21,000	20,400
	8	23,500	35,900	32,100	21,200	31,600	28,800	14,100	20,500	19,200
	10	19,800	33,500	27,000	18,400	29,900	25,000	12,700	19,600	17,300
	12	15,900	30,200	21,700	15,200	27,500	20,700	11,000	18,500	15,000
	14	12,600	26,300	17,200	12,200	24,500	16,700	9,170	17,000	12,500
	16	10,100	22,400	13,700	9,880	21,300	13,500	7,560	15,300	10,300
Spruce- Pine-Fir	2	24,000	32,900	32,700	21,000	28,800	28,700	15,000	20,600	20,500
	4	23,400	32,400	31,900	20,500	28,400	28,000	14,700	20,300	20,100
	6	22,100	31,600	30,100	19,600	27,800	26,700	14,100	19,900	19,200
	8	20,000	30,300	27,200	18,000	26,900	24,600	13,100	19,300	17,800
	10	16,900	28,300	23,100	15,700	25,400	21,400	11,600	18,400	15,800
	12	13,700	25,700	18,600	13,000	23,400	17,800	9,730	17,100	13,300
	14	10,900	22,500	14,800	10,500	21,000	14,400	7,960	15,400	10,900
	16	8,700	19,200	11,900	8,530	18,300	11,600	6,480	13,600	8,800

¹ P'_x values are based on a column continuously braced against weak axis buckling.² P'_y values are based on a column continuously braced against strong axis buckling.

Table 5.3b Column Capacity^{1,2} (P', P_x, P_y), Timbers

8-inch nominal thickness (7.5 inch dry dressed size), C_D = 1.0.

Species	Column Length (ft.)	Column Capacity (lbs.)								
		Select Structural			No. 1			No. 2		
		8 x 8 8" width (=7.5") P'	8 x 10 10" width (=9.5") P _x P _y		8 x 8 8" width (=7.5") P'	8 x 10 10" width (=9.5") P _x P _y		8 x 8 8" width (=7.5") P'	8 x 10 10" width (=9.5") P _x P _y	
Douglas Fir-Larch	2	64,400	81,700	81,500	56,000	71,100	70,900	39,200	49,800	49,700
	4	63,300	80,900	80,200	55,200	70,500	70,000	38,800	49,400	49,100
	6	61,400	79,500	77,800	53,800	69,400	68,200	37,900	48,800	48,100
	8	58,300	77,300	73,900	51,600	67,800	65,300	36,600	47,800	46,400
	10	53,600	74,100	67,900	48,200	65,500	61,000	34,700	46,500	43,900
	12	47,400	69,700	60,000	43,500	62,300	55,100	32,000	44,600	40,500
	14	40,400	63,900	51,200	38,000	58,100	48,100	28,600	42,200	36,200
	16	33,800	57,200	42,800	32,400	53,000	41,000	24,900	39,200	31,500
Hem-Fir	2	54,600	69,200	69,100	47,600	60,400	60,300	32,200	40,900	40,800
	4	53,600	68,500	68,000	46,900	59,900	59,400	31,900	40,600	40,400
	6	51,900	67,300	65,800	45,600	58,900	57,800	31,200	40,100	39,500
	8	49,100	65,300	62,200	43,600	57,500	55,200	30,200	39,300	38,200
	10	44,900	62,500	56,900	40,500	55,400	51,300	28,600	38,300	36,200
	12	39,400	58,500	49,900	36,400	52,500	46,100	26,500	36,800	33,500
	14	33,400	53,400	42,300	31,500	48,700	39,900	23,800	34,900	30,100
	16	27,800	47,500	35,200	26,700	44,200	33,800	20,800	32,500	26,400
Southern Pine	2	53,200	67,500	67,400	46,200	58,600	58,600	29,400	37,300	37,300
	4	52,500	66,900	66,500	45,700	58,200	57,900	29,200	37,100	36,900
	6	51,100	65,900	64,700	44,700	57,500	56,600	28,700	36,700	36,300
	8	48,900	64,400	61,900	43,100	56,300	54,600	27,900	36,200	35,300
	10	45,600	62,100	57,800	40,700	54,700	51,600	26,800	35,400	33,900
	12	41,100	59,000	52,100	37,400	52,500	47,400	25,200	34,400	32,000
	14	35,800	55,000	45,400	33,400	49,500	42,300	23,200	33,000	29,400
	16	30,500	50,100	38,600	29,000	45,900	36,700	20,900	31,200	26,400
Spruce-Pine-Fir	2	44,800	56,800	56,800	39,200	49,800	49,700	28,000	35,500	35,500
	4	44,200	56,400	56,000	38,800	49,400	49,100	27,700	35,300	35,100
	6	43,100	55,600	54,600	37,900	48,800	48,100	27,200	34,900	34,400
	8	41,300	54,300	52,300	36,600	47,800	46,400	26,300	34,300	33,300
	10	38,600	52,500	49,000	34,700	46,500	43,900	25,100	33,400	31,700
	12	35,000	50,000	44,300	32,000	44,600	40,500	23,300	32,200	29,500
	14	30,600	46,700	38,800	28,600	42,200	36,200	21,100	30,600	26,700
	16	26,200	42,700	33,200	24,900	39,200	31,500	18,600	28,700	23,500

¹ P_x values are based on a column continuously braced against weak axis buckling.

² P_y values are based on a column continuously braced against strong axis buckling.

MEMBER SELECTION TABLES

Table 5.3c Column Capacity^{1,2} (P', P'_x, P'_y), Timbers10-inch nominal thickness (9.5 inch dry dressed size), C_D = 1.0.

Species	Column Length (ft.)	Column Capacity (lbs.)								
		Select Structural			No. 1			No. 2		
		10 x 10 10" width (=9.5") P'	10 x 12 12" width (=11.5") P' _x P' _y	10 x 10 10" width (=9.5") P'	10 x 12 12" width (=11.5") P' _x P' _y	10 x 10 10" width (=9.5") P'	10 x 12 12" width (=11.5") P' _x P' _y			
Douglas Fir- Larch	2	103,000	125,000 125,000	90,000	109,000 109,000	63,000	76,400 76,300			
	4	102,000	125,000 124,000	89,300	108,000 108,000	62,600	76,000 75,800			
	6	101,000	123,000 122,000	87,900	107,000 106,000	61,800	75,400 74,800			
	8	97,900	121,000 119,000	85,900	106,000 104,000	60,600	74,400 73,300			
	10	93,900	118,000 114,000	83,000	104,000 100,000	58,900	73,100 71,300			
	12	88,300	114,000 107,000	78,900	101,000 95,500	56,600	71,400 68,500			
	14	81,000	108,000 98,000	73,600	96,700 89,100	53,500	69,100 64,700			
	16	72,500	102,000 87,700	67,100	91,800 81,200	49,700	66,300 60,100			
Hem-Fir	2	87,700	106,000 106,000	76,500	92,700 92,600	51,800	62,700 62,700			
	4	86,800	106,000 105,000	75,800	92,100 91,800	51,400	62,400 62,200			
	6	85,200	104,000 103,000	74,600	91,200 90,400	50,800	61,900 61,500			
	8	82,800	102,000 100,000	72,800	89,800 88,100	49,800	61,200 60,300			
	10	79,100	99,700 95,800	70,200	87,800 84,900	48,500	60,100 58,700			
	12	74,100	96,000 89,700	66,500	85,100 80,500	46,600	58,800 56,500			
	14	67,600	91,200 81,900	61,700	81,600 74,700	44,200	57,000 53,500			
	16	60,200	85,100 72,800	56,000	77,100 67,800	41,200	54,800 49,900			
Southern Pine	2	85,500	104,000 104,000	74,300	90,000 89,900	47,300	57,300 57,200			
	4	84,800	103,000 103,000	73,700	89,500 89,300	47,000	57,100 56,900			
	6	83,500	102,000 101,000	72,800	88,800 88,100	46,500	56,700 56,300			
	8	81,500	100,000 98,700	71,300	87,600 86,400	45,800	56,100 55,500			
	10	78,700	98,300 95,300	69,300	86,100 83,900	44,800	55,400 54,300			
	12	74,800	95,400 90,500	66,500	84,000 80,400	43,500	54,300 52,700			
	14	69,600	91,700 84,300	62,700	81,300 75,900	41,800	53,100 50,600			
	16	63,400	86,900 76,800	58,100	77,800 70,300	39,600	51,500 47,900			
Spruce- Pine-Fir	2	72,000	87,200 87,200	63,000	76,400 76,300	45,000	54,500 54,500			
	4	71,400	86,800 86,500	62,600	76,000 75,800	44,700	54,300 54,100			
	6	70,400	85,900 85,200	61,800	75,400 74,800	44,200	53,900 53,500			
	8	68,800	84,700 83,200	60,600	74,400 73,300	43,400	53,300 52,600			
	10	66,500	82,900 80,500	58,900	73,100 71,300	42,300	52,400 51,200			
	12	63,300	80,600 76,600	56,600	71,400 68,500	40,800	51,300 49,400			
	14	59,100	77,500 71,600	53,500	69,100 64,700	38,800	49,800 47,000			
	16	54,000	73,700 65,400	49,700	66,300 60,100	36,300	48,000 44,000			

¹ P'_x values are based on a column continuously braced against weak axis buckling.² P'_y values are based on a column continuously braced against strong axis buckling.

Table 5.4a Bending Member (Joist) Capacity (M', C_rM', V', and EI), Structural Lumber

2-inch nominal thickness (1.5 inch dry dressed size), C_D = 1.0, C_L = 1.0.

Species	Size (b x d)		Select Structural				No. 2			
	Nominal	Actual	M'	C _r M'	V'	x 10 ⁶ EI	M'	C _r M'	V'	x 10 ⁶ EI
	(in.)	(in.)	(Single) lb.-in.	(Repetitive) lb.-in.	lbs.	lb.-in. ²	lb.-in.	(Repetitive) lb.-in.	lbs.	lb.-in. ²
Douglas Fir-Larch	2 x 4	1.5 x 3.5	6,890	7,920	630	10	4,130	4,750	630	9
	2 x 6	1.5 x 5.5	14,700	17,000	990	40	8,850	10,200	990	33
	2 x 8	1.5 x 7.25	23,700	27,200	1,310	91	14,200	16,300	1,310	76
	2 x 10	1.5 x 9.25	35,300	40,600	1,670	188	21,200	24,400	1,670	158
	2 x 12	1.5 x 11.25	47,500	54,600	2,030	338	28,500	32,700	2,030	285
Hem-Fir	2 x 4	1.5 x 3.5	6,430	7,400	525	9	3,900	4,490	525	7
	2 x 6	1.5 x 5.5	13,800	15,900	825	33	8,360	9,610	825	27
	2 x 8	1.5 x 7.25	22,100	25,400	1,090	76	13,400	15,400	1,090	62
	2 x 10	1.5 x 9.25	32,900	37,900	1,390	158	20,000	23,000	1,390	129
	2 x 12	1.5 x 11.25	44,300	50,900	1,690	285	26,900	30,900	1,690	231
Southern Pine	2 x 4	1.5 x 3.5	8,730	10,000	613	10	4,590	5,280	613	9
	2 x 6	1.5 x 5.5	19,300	22,200	963	37	9,450	10,900	963	33
	2 x 8	1.5 x 7.25	30,200	34,800	1,270	86	15,800	18,100	1,270	76
	2 x 10	1.5 x 9.25	43,900	50,400	1,620	178	22,500	25,800	1,620	158
	2 x 12	1.5 x 11.25	60,100	69,100	1,970	320	30,800	35,500	1,970	285
Spruce-Pine-Fir	2 x 4	1.5 x 3.5	5,740	6,600	473	8	4,020	4,620	473	8
	2 x 6	1.5 x 5.5	12,300	14,100	743	31	8,600	9,890	743	29
	2 x 8	1.5 x 7.25	19,700	22,700	979	71	13,800	15,900	979	67
	2 x 10	1.5 x 9.25	29,400	33,800	1,250	148	20,600	23,700	1,250	139
	2 x 12	1.5 x 11.25	39,600	45,500	1,520	267	27,700	31,800	1,520	249

Table 5.4b Bending Member (Joist) Capacity (M', C_rM', V', and EI), Structural Lumber

4-inch nominal thickness (3.5 inch dry dressed size), C_D = 1.0, C_L = 1.0.

Species	Size (b x d)		Select Structural				No. 2			
	Nominal	Actual	M'	C _r M'	V'	x 10 ⁶ EI	M'	C _r M'	V'	x 10 ⁶ EI
	(in.)	(in.)	(Single) lb.-in.	(Repetitive) lb.-in.	lbs.	lb.-in. ²	lb.-in.	(Repetitive) lb.-in.	lbs.	lb.-in. ²
Douglas Fir-Larch	4 x 4	3.5 x 3.5	16,100	18,500	1,470	24	9,650	11,100	1,470	20
	4 x 6	3.5 x 5.5	34,400	39,600	2,310	92	20,600	23,700	2,310	78
	4 x 8	3.5 x 7.25	59,800	68,800	3,050	211	35,900	41,300	3,050	178
	4 x 10	3.5 x 9.25	89,800	103,000	3,890	439	53,900	62,000	3,890	370
	4 x 12	3.5 x 11.25	122,000	140,000	4,730	789	73,100	84,100	4,730	664
Hem-Fir	4 x 4	3.5 x 3.5	15,000	17,300	1,230	20	9,110	10,500	1,230	16
	4 x 6	3.5 x 5.5	32,100	36,900	1,930	78	19,500	22,400	1,930	63
	4 x 8	3.5 x 7.25	55,800	64,200	2,540	178	33,900	39,000	2,540	144
	4 x 10	3.5 x 9.25	83,900	96,400	3,240	369	50,900	58,500	3,240	300
	4 x 12	3.5 x 11.25	114,000	131,000	3,940	664	69,000	79,400	3,940	540
Southern Pine	4 x 4	3.5 x 3.5	20,400	23,400	1,430	23	10,700	12,300	1,430	20
	4 x 6	3.5 x 5.5	45,000	51,700	2,250	87	22,100	25,400	2,250	78
	4 x 8	3.5 x 7.25	77,600	89,200	2,960	200	40,500	46,600	2,960	178
	4 x 10	3.5 x 9.25	113,000	129,000	3,780	416	57,600	66,300	3,780	369
	4 x 12	3.5 x 11.25	154,000	177,000	4,590	748	79,200	91,100	4,590	664
Spruce-Pine-Fir	4 x 4	3.5 x 3.5	13,400	15,400	1,100	19	9,380	10,800	1,100	18
	4 x 6	3.5 x 5.5	28,700	33,000	1,730	73	20,100	23,100	1,730	68
	4 x 8	3.5 x 7.25	49,800	57,300	2,280	167	34,900	40,100	2,280	156
	4 x 10	3.5 x 9.25	74,900	86,100	2,910	346	52,400	60,300	2,910	323
	4 x 12	3.5 x 11.25	102,000	117,000	3,540	623	71,100	81,700	3,540	581

Table 5.5a Bending Member (Beam) Capacity (M', V', and EI), Timbers6-inch nominal thickness (5.5 inch dry dressed size), $C_D = 1.0$, $C_L = 1.0$.

Species	Size (b x d)		Select Structural			No. 2		
	Nominal (in.)	Actual (in.)	M'	V'	x 1000 EI	M'	V'	x 10 ⁶ EI
			lb.-in.	lbs.	lb.-in. ²	lb.-in.	lbs.	lb.-in. ²
Douglas Fir-Larch	6 x 6	5.5 x 5.5	41,600	3,430	122	20,800	3,430	99
	6 x 8	5.5 x 7.5	77,300	4,680	309	38,700	4,680	251
	6 x 10	5.5 x 9.5	132,000	5,920	629	72,400	5,920	511
	6 x 12	5.5 x 11.5	194,000	7,170	1,120	106,000	7,170	906
	6 x 14	5.5 x 13.5	264,000	8,420	1,800	144,000	8,420	1,470
	6 x 16	5.5 x 15.5	342,000	9,660	2,730	187,000	9,660	2,220
Hem-Fir	6 x 6	5.5 x 5.5	33,300	2,820	99	15,900	2,820	84
	6 x 8	5.5 x 7.5	61,900	3,850	251	29,600	3,850	213
	6 x 10	5.5 x 9.5	10,800	4,880	511	55,800	4,880	432
	6 x 12	5.5 x 11.5	15,800	5,900	906	81,800	5,900	767
	6 x 14	5.5 x 13.5	214,000	6,930	1,470	111,000	6,930	1,240
	6 x 16	5.5 x 15.5	278,000	7,960	2,220	144,000	7,960	1,880
Southern Pine	6 x 6	5.5 x 5.5	41,600	3,330	114	23,600	3,330	92
	6 x 8	5.5 x 7.5	77,300	4,540	290	43,800	4,540	232
	6 x 10	5.5 x 9.5	124,000	5,750	589	70,300	5,750	472
Spruce-Pine-Fir	6 x 6	5.5 x 5.5	29,100	2,520	99	13,900	2,520	76
	6 x 8	5.5 x 7.5	54,100	3,440	251	25,800	3,440	193
	6 x 10	5.5 x 9.5	91,000	4,350	511	49,600	4,350	393

Table 5.5b Bending Member (Beam) Capacity (M', V', and EI), Timbers8-inch nominal thickness (7.5 inch dry dressed size), $C_D = 1.0$, $C_L = 1.0$.

Species	Size (b x d)		Select Structural			No. 2		
	Nominal (in.)	Actual (in.)	M'	V'	x 1000 EI	M'	V'	x 10 ⁶ EI
			lb.-in.	lbs.	lb.-in. ²	lb.-in.	lbs.	lb.-in. ²
Douglas Fir-Larch	8 x 8	7.5 x 7.5	105,000	6,380	422	52,700	6,380	343
	8 x 10	7.5 x 9.5	169,000	8,080	857	84,600	8,080	697
	8 x 12	7.5 x 11.5	265,000	9,780	1,520	145,000	9,780	1,240
	8 x 14	7.5 x 13.5	360,000	11,500	2,460	197,000	11,500	2,000
	8 x 16	7.5 x 15.5	467,000	13,200	3,720	255,000	13,200	3,030
Hem-Fir	8 x 8	7.5 x 7.5	84,400	5,250	343	40,400	5,250	290
	8 x 10	7.5 x 9.5	135,000	6,650	697	64,900	6,650	589
	8 x 12	7.5 x 11.5	215,000	8,050	1,240	112,000	8,050	1,050
	8 x 14	7.5 x 13.5	292,000	9,450	2,000	152,000	9,450	1,690
	8 x 16	7.5 x 15.5	379,000	10,900	3,030	197,000	10,900	2,560
Southern Pine	8 x 8	7.5 x 7.5	105,000	6,190	396	59,800	6,190	316
	8 x 10	7.5 x 9.5	169,000	7,840	804	95,900	7,840	643
Spruce-Pine-Fir	8 x 8	7.5 x 7.5	73,800	4,690	343	35,200	4,690	264
	8 x 10	7.5 x 9.5	118,000	5,940	697	56,400	5,940	536

Table 5.5c Bending Member (Beam) Capacity (M', V', and EI), Timbers

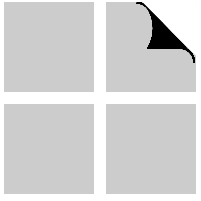
10-inch nominal thickness (9.5 inch dry dressed size), $C_D = 1.0$, $C_L = 1.0$.

Species	Size (b x d)		Select Structural			No. 2		
	Nominal (in.)	Actual (in.)	M'	V'	x 1000 EI	M'	V'	x 10 ⁶ EI
			lb.-in.	lbs.	lb.-in. ²	lb.-in.	lbs.	lb.-in. ²
Douglas Fir-Larch	10 x 10	9.5 x 9.5	214,000	10,200	1,090	107,000	10,200	882
	10 x 12	9.5 x 11.5	314,000	12,400	1,930	157,000	12,400	1,570
	10 x 14	9.5 x 13.5	456,000	14,500	3,120	249,000	14,500	2,530
	10 x 16	9.5 x 15.5	592,000	16,700	4,720	324,000	16,700	3,830
	10 x 18	9.5 x 17.5	744,000	18,800	6,790	407,000	18,800	5,520
	10 x 20	9.5 x 19.5	913,000	21,000	9,390	499,000	21,000	7,630
Hem-Fir	10 x 10	9.5 x 9.5	171,000	8,420	882	82,200	8,420	747
	10 x 12	9.5 x 11.5	251,000	10,200	1,570	120,000	10,200	1,320
	10 x 14	9.5 x 13.5	370,000	12,000	2,530	192,000	12,000	2,140
	10 x 16	9.5 x 15.5	418,000	13,700	3,830	250,000	13,700	3,240
	10 x 18	9.5 x 17.5	604,000	15,500	5,520	314,000	15,500	4,670
	10 x 20	9.5 x 19.5	742,000	17,300	7,630	385,000	17,300	6,460
Southern Pine	10 x 10	9.5 x 9.5	214,000	9,930	1,020	121,000	9,930	815
	10 x 12	9.5 x 11.5	314,000	12,000	1,810	178,000	12,000	1,440
	10 x 14	9.5 x 13.5	427,000	14,100	2,920	242,000	14,100	2,340
Spruce-Pine-Fir	10 x 10	9.5 x 9.5	150,000	7,520	882	71,000	7,520	679
	10 x 12	9.5 x 11.5	220,000	9,100	1,570	105,000	9,100	1,200
	10 x 14	9.5 x 13.5	313,000	10,700	2,530	171,000	10,700	1,950

Table 5.5d Bending Member (Beam) Capacity (M', V', and EI), Timbers

Nominal Dimensions > 10 inch (actual = nominal - 1/2 inch), $C_D = 1.0$, $C_L = 1.0$.

Species	Size (b x d)		Select Structural			No. 2		
	Nominal (in.)	Actual (in.)	M'	V'	x 1000 EI	M'	V'	x 10 ⁶ EI
			lb.-in.	lbs.	lb.-in. ²	lb.-in.	lbs.	lb.-in. ²
Douglas Fir-Larch	12 x 12	11.5 x 11.5	380,000	15,000	2,330	190,000	15,000	1,890
	14 x 14	13.5 x 13.5	607,000	20,700	4,430	304,000	20,700	3,600
	16 x 16	15.5 x 15.5	905,000	27,200	7,700	452,000	27,200	6,250
	18 x 18	17.5 x 17.5	1,280,000	34,700	12,500	642,000	34,700	10,200
	20 x 20	19.5 x 19.5	1,760,000	43,100	19,300	878,000	43,100	15,700
Hem-Fir	12 x 12	11.5 x 11.5	304,000	12,300	1,890	146,000	12,300	1,600
	14 x 14	13.5 x 13.5	486,000	17,000	3,600	233,000	17,000	3,040
	16 x 16	15.5 x 15.5	724,000	22,400	6,250	347,000	22,400	5,290
	18 x 18	17.5 x 17.5	1,030,000	28,600	10,200	493,000	28,600	8,600
	20 x 20	19.5 x 19.5	1,410,000	35,500	15,700	673,000	35,500	13,300
Southern Pine	12 x 12	11.5 x 11.5	380,000	14,500	2,190	215,000	14,500	1,750
	14 x 14	13.5 x 13.5	607,000	20,000	4,150	344,000	20,000	3,320
Spruce-Pine-Fir	12 x 12	11.5 x 11.5	266,000	11,000	1,890	127,000	11,000	1,460
	14 x 14	13.5 x 13.5	425,000	15,200	3,600	202,000	15,200	2,770



OTHER CONSIDERATIONS

6.1	General	L-26
6.2	Dimensional Changes	L-26
6.3	Fire Assemblies	L-27

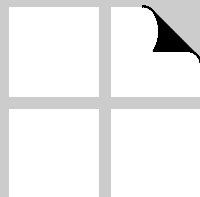
Table 6.1	Coefficient of Moisture Expansion, e_{ME}, and Fiber Saturation Point, (FSP) for Solid Woods	L-27
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Table 6.2	One-Hour Fire-Rated Loadbearing Wood-Frame Wall Assemblies	L-28
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Table 6.3	Two-Hour Fire-Rated Loadbearing Wood-Frame Wall Assemblies	L-28
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Table 6.4	One-Hour Fire-Rated Wood Floor/Ceiling Assemblies	L-29
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Table 6.5	Two-Hour Fire-Rated Wood Floor/Ceiling Assemblies	L-29
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6.1 General

With proper detailing and protection, structural lumber can perform well in a variety of environments. One key to proper detailing is planning for the natural shrinkage and swelling of wood members as they are subjected to various drying and wetting cycles. While moisture changes have the largest impact on lumber dimensions, some designs must also check the effects of temperature on dimensions as well.

The table in Section 6.2 is extracted from more precise scientific and research reports on these topics. The coefficients are conservative (yielding more shrinkage and

expansion than one might expect for most species). This level of information should be adequate for common structural applications. Equations are provided at the end of Section 6.2 for those designers who require more precise calculations.

In addition to designing to accommodate dimensional changes and detailing for durability, another significant issue in the planning of wood structures is that of fire performance.

6.2 Dimensional Changes

Approximate Moisture and Thermal Dimensional Changes

Description	Radial or Tangential Direction
Dimensional change due to moisture content change ¹	1% change in dimension per 4% change in MC
Dimensional change due to temperature change ²	$\approx 20 \times 10^{-6}$ in./in. per degree F

¹ Corresponding longitudinal direction shrinkage/expansion is about 1 to 5 percent of that in radial and tangential directions.

² Corresponding longitudinal direction coefficient is about one-tenth as large as radial and tangential.

Equations for Computing Moisture and Thermal Shrinkage/Expansion

Due to Moisture Changes

For more precise computation of dimensional changes due to changes in moisture, the change in radial (R), tangential (T), and volumetric (V) dimensions due to changes in moisture content can be computed as:

$$X = X_o (\Delta MC) e_{ME}$$

where:

X_o = initial dimension or volume

X = new dimension or volume

ΔMC = moisture content change (%)

e_{ME} = coefficient of moisture expansion: linear (in./in./%MC), or volumetric (in.³/in.³/%MC)

and:

$$\Delta MC = M - M_o$$

where:

M_o = initial moisture content % ($M_o \leq FSP$)

M = new moisture content % ($M \leq FSP$)

FSP = fiber saturation point

Values for e_{ME} and FSP are shown in Table 6.1.

Due to Temperature Changes

For more precise computation of dimensional changes due to changes in temperature, the shrinkage/expansion of solid wood including lumber and timbers can be computed as:

$$X = X_o (\Delta T) e_{TE}$$

where:

X_o = reference dimension at T_o

X = computed dimension at T

T_o = reference temperature (°F)

T = temperature at which the new dimension is computed (°F)

e_{TE} = coefficient of thermal expansion (in./in./°F)

and:

$$\Delta T = T - T_o$$

where:

$$-60^\circ\text{F} \leq T_o \leq 130^\circ\text{F}$$

The coefficient of thermal expansion of oven-dry wood parallel to grain ranges from about 1.7×10^{-6} to 2.5×10^{-6} per °F.

The linear expansion coefficients across the grain (radial and tangential) are proportional to wood density. These coefficients are about five to ten times greater than the parallel-to-the-grain coefficients and are given as:

Radial:

$$e_{TE} = [18(G) + 5.5](10^{-6} \text{ in./in./}^\circ\text{F})$$

Tangential:

$$e_{TE} = [18(G) + 10.2](10^{-6} \text{ in./in./}^\circ\text{F})$$

where:

G is the tabulated specific gravity for the species.

Table 6.1 Coefficient of Moisture Expansion, e_{ME} , and Fiber Saturation Point, (FSP) for Solid Woods

Species	e_{ME}			FSP (%)
	Radial (in./in./%)	Tangential (in./in./%)	Volumetric (in. ³ /in. ³ /%)	
Alaska Cedar	0.0010	0.0021	0.0033	28
Douglas Fir-Larch	0.0018	0.0033	0.0050	28
Englemann Spruce	0.0013	0.0024	0.0037	30
Redwood	0.0012	0.0022	0.0032	22
Red Oak	0.0017	0.0038	0.0063	30
Southern Pine	0.0020	0.0030	0.0047	26
Western Hemlock	0.0015	0.0028	0.0044	28
Yellow Poplar	0.0015	0.0026	0.0041	31

6.3 Fire Assemblies

Building Code Requirements

For occupancies such as stores, apartments, offices, and other commercial and industrial uses, building codes commonly require floor/ceiling and wall assemblies to be fire-resistance rated in accordance with standard fire tests.

Depending on the application, wall assemblies may need to be rated either from one side or both sides. For specific exterior wall applications, the 2000 *International Building Code (IBC)*, the 1999 *National Building Code (NBC)*, and the 1999 *Standard Building Code (SBC)* allow wood-frame, wood-sided walls to be tested for exposure to fire from the inside only. Rating for both interior and exterior exposure is only required when the wall has a fire separation distance of less than 5 feet. Code recog-

nition of one- and two-hour wood-frame wall systems is also predicated on successful fire and hose stream testing in accordance with ASTM E119, *Standard Test Methods for Fire Tests of Building Construction Materials*.

Fire Tested Assemblies

Fire-rated wood-frame assemblies can be found in a number of sources including the *IBC*, Underwriters Laboratories (UL) *Fire Resistance Directory*, Intertek Testing Services' *Directory of Listed Products*, and the Gypsum Association's *Fire Resistance Design Manual*. The American Forest & Paper Association (AF&PA) and its members have tested a number of wood-frame fire-rated

assemblies. Descriptions of these successfully tested assemblies are provided in Tables 6.2 – 6.5.

Updates

Additional tests are being conducted and the Tables will be updated periodically. AF&PA's *Design for Code Acceptance (DCA) No. 3, Fire Rated Wood Floor and Wall Assemblies* incorporates many of these assemblies and is available at www.awc.org.

Table 6.2 One-Hour Fire-Rated Loadbearing Wood-Frame Wall Assemblies

Assemblies Rated From Both Sides					
Studs	Insulation	Sheathing on Both Sides		Fasteners	Details
2x4 @ 16" o.c.	3½" mineral fiber batts	5/8" Type X Gypsum Wallboard (H)		2¼" #6 Type S drywall screws @ 12" o.c.	Figure 6.1
2x6 @ 16" o.c.	(none)	5/8" Type X Gypsum Wallboard (H)		2¼" #6 Type S drywall screws @ 7" o.c.	Figure 6.2
2x6 @ 16" o.c.	5½" mineral fiber batts	5/8" Type X Gypsum Wallboard (H)		2¼" #6 Type S drywall screws @ 12" o.c.	Figure 6.3
Assemblies Rated From One Side (Fire on Interior Only)					
Studs	Insulation	Sheathing		Fasteners	Details
2x4 @ 16" o.c.	3½" mineral fiber batts	I	5/8" Type X Gypsum Wallboard (H)	2¼" #6 Type S drywall screws @ 12" o.c.	Figure 6.4
		E	3/8" wood structural panels (V)	6d common nails @ 6" edges/12" field	
2x4 @ 16" o.c.	4 mil polyethylene 3½" mineral fiber batts	I	5/8" Type X Gypsum Wallboard (V)	6d cement coated box nails @ 7" o.c.	Figure 6.5
		E	½" fiberboard (V)	1½" roofing nails @ 3" edges/6" field	
			3/8" hardboard shiplapped panel siding	8d galv. nails @ 4" edges/8" field	
2x6 @ 16" o.c.	5½" mineral fiber batts	I	5/8" Type X Gypsum Wallboard (H)	2¼" #6 Type S drywall screws @ 12" o.c.	Figure 6.6
		E	7/16" wood structural panels (V)	6d common nails @ 6" edges/12" field	

H- applied horizontally with vertical joints over studs; I- Interior sheathing; V- applied vertically with vertical joints over studs; E- Exterior sheathing

Table 6.3 Two-Hour Fire-Rated Loadbearing Wood-Frame Wall Assemblies

Assemblies Rated From Both Sides					
Studs	Insulation	Sheathing on Both Sides		Fasteners	Details
2x6 @ 24" o.c.	5½" mineral fiber batts	B	5/8" Type X Gypsum Wallboard (H)	2¼" #6 Type S drywall screws @ 24" o.c.	Figure 6.7
		F	5/8" Type X Gypsum Wallboard (H)	2¼" #6 Type S drywall screws @ 8" o.c.	

H- applied horizontally with vertical joints over studs; B- Base layer sheathing; F- Face layer sheathing

Table 6.4 One-Hour Fire-Rated Wood Floor/Ceiling Assemblies

Joists	Insulation	Furring		Ceiling Sheathing	Floor Sheathing	Details
2x10 @ 16" o.c.	none	Optional	F	5/8" Type X Gypsum Wallboard or 1/2" Type X gypsum wallboard	Nom. 1" wood flooring or 19/32" T&G plywood* underlayment (single floor); building paper, and Nom. 1" T&G boards or 15/32" plywood* subfloor	Figure 6.8
2x10 @ 16" o.c.	none	(none)	F	1/2" x24"x48" mineral acoustical ceiling panels (see grid details)	Nom. 19/32" T&G plywood* underlayment (single floor); building paper, and 15/32" plywood* subfloor	Figure 6.9
2x10 @ 16" o.c.	none	Resilient channels	F	5/8" Type X Gypsum Wallboard or 1/2" proprietary Type gypsum wallboard	Nom. 19/32" T&G plywood* underlayment (single floor) or 15/32" plywood* subfloor	Figure 6.10
2x10 @ 24" o.c.	none	Resilient channels	F	5/8" proprietary Type gypsum wallboard	Nom. 23/32" T&G plywood* underlayment (single floor) or 15/32" plywood* subfloor	Figure 6.11

F- Face layer sheathing; *Oriented Strand Board (OSB) panels are permitted for certain designs. Subfloors for certain designs may be nom. 7/16" OSB.

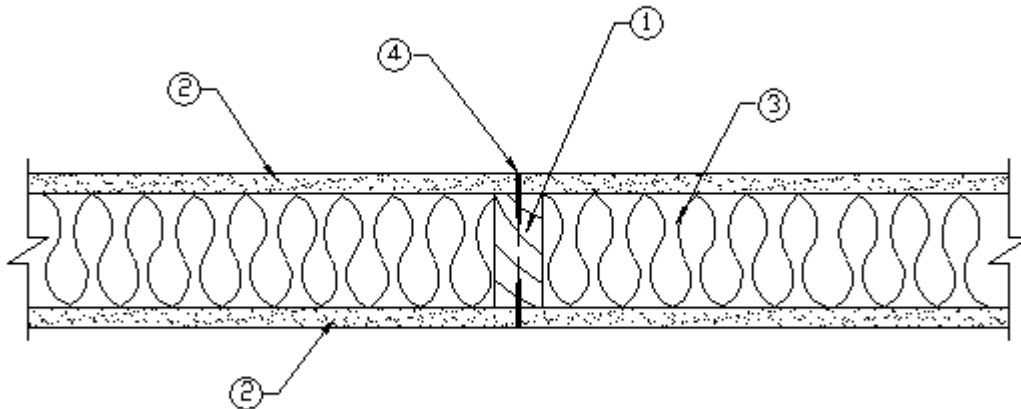
Table 6.5 Two-Hour Fire-Rated Wood Floor/Ceiling Assemblies

Joists	Insulation	Furring		Ceiling Sheathing	Floor Sheathing	Details
2x10 @ 16" o.c.	none	(none)	B	5/8" proprietary Type X gypsum wallboard	Nom. 1" wood flooring or 19/32" T&G plywood* underlayment (single floor); building paper, and Nom. 1" T&G boards or 15/32" plywood* subfloor	Figure 6.12
		Resilient channels	F	5/8" proprietary Type X gypsum wallboard		

B- Base layer sheathing (direct attached); F- Face layer sheathing; *Oriented Strand Board (OSB) panels are permitted for certain designs. Subfloors for certain designs may be nom. 7/16" OSB.

Figure 6.1 One-Hour Fire-Rated Wood Wall Assembly (WS4-1.1)

(2x4 Wood Stud Wall with Insulation: 100% Design Load – Gypsum Both Sides)



1. **Framing:** Nominal 2x4 wood studs, spaced 16 in. o.c., double top plates, single bottom plate.
2. **Sheathing:** 5/8 in. Type X gypsum wallboard, 4 ft. wide, applied horizontally, unblocked. Horizontal application of wallboard represents the direction of least fire resistance as opposed to vertical application.
3. **Insulation:** 3-1/2 in. thick mineral wool insulation.
4. **Fasteners:** 2-1/4 in. Type S drywall screws, spaced 12 in. o.c.
5. **Joints and Fastener Heads:** Wallboard joints covered with paper tape and joint compound, fastener heads covered with joint compound.

Tests conducted at the Fire Test Laboratory of National Gypsum Research Center

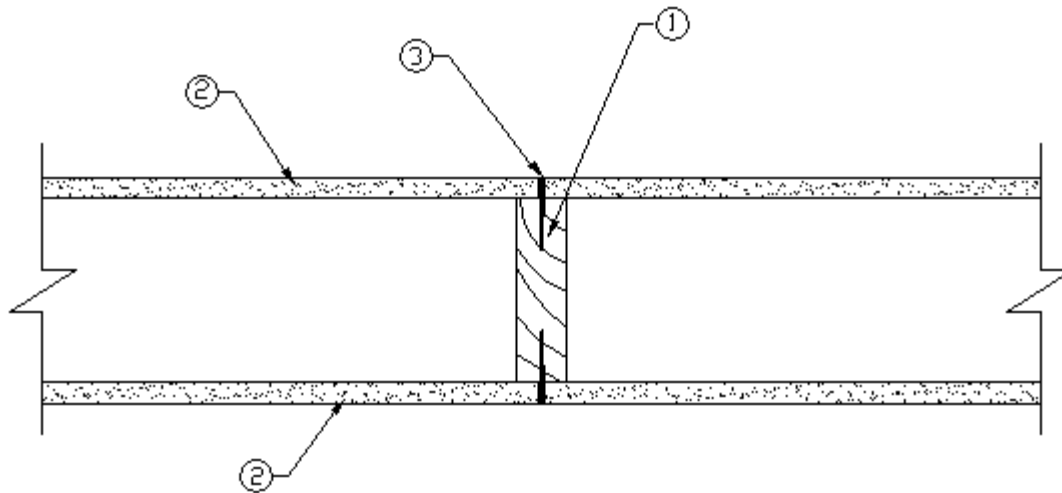
Test No: WP-1248 (Fire Endurance), March 29, 2000
WP-1246 (Hose Stream), March 9, 2000

Third Party Witness: Intertek Testing Services
Report J20-06170.1

This assembly was tested at 100% design load, calculated in accordance with the *National Design Specification for Wood Construction*. The authority having jurisdiction should be consulted to assure acceptance of this report.

Figure 6.2 One-Hour Fire-Rated Wood Wall Assembly (WS6-1.1)

(2x6 Wood Stud Wall without Insulation: 100% Design Load – Gypsum Both Sides)



1. **Framing:** Nominal 2x6 wood studs, spaced 16 in. o.c., double top plates, single bottom plate.
2. **Sheathing:** 5/8 in. Type X gypsum wallboard, 4 ft. wide, applied horizontally, unblocked. Horizontal application of wallboard represents the direction of least fire resistance as opposed to vertical application.
3. **Fasteners:** 2-1/4 in. Type S drywall screws, spaced 7 in. o.c.
4. **Joints and Fastener Heads:** Wallboard joints covered with paper tape and joint compound, fastener heads covered with joint compound.

Tests conducted at the Fire Test Laboratory of National Gypsum Research Center

Test No: WP-1232 (Fire Endurance), September 16, 1999

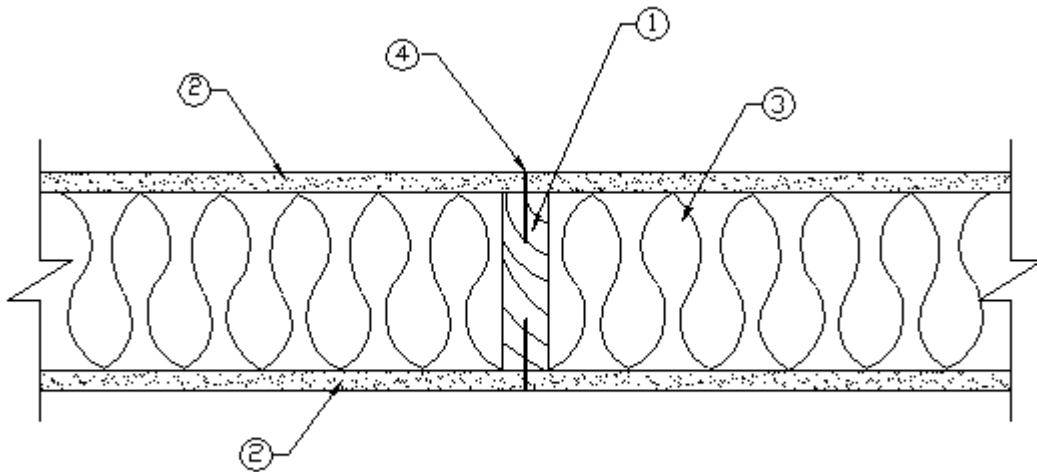
WP-1234 (Hose Stream), September 27, 1999

Third Party Witness: Intertek Testing Services
Report J99-22441.2

This assembly was tested at 100% design load, calculated in accordance with the *National Design Specification for Wood Construction*. The authority having jurisdiction should be consulted to assure acceptance of this report.

Figure 6.3 One-Hour Fire-Rated Wood Wall Assembly (WS6-1.2)

(2x6 Wood Stud Wall with Insulation: 100% Design Load – Gypsum Both Sides)



1. **Framing:** Nominal 2x6 wood studs, spaced 16 in. o.c., double top plates, single bottom plate.
2. **Sheathing:** 5/8 in. Type X gypsum wallboard, 4 ft. wide, applied horizontally, unblocked. Horizontal application of wallboard represents the direction of least fire resistance as opposed to vertical application.
3. **Insulation:** 5-1/2 in. thick mineral wool insulation.
4. **Fasteners:** 2-1/4 in. Type S drywall screws, spaced 12 in. o.c.
5. **Joints and Fastener Heads:** Wallboard joints covered with paper tape and joint compound, fastener heads covered with joint compound.

Tests conducted at the Fire Test Laboratory of National Gypsum Research Center

Test No: WP-1231 (Fire Endurance), September 14, 1999

WP-1230 (Hose Stream), August 30, 1999

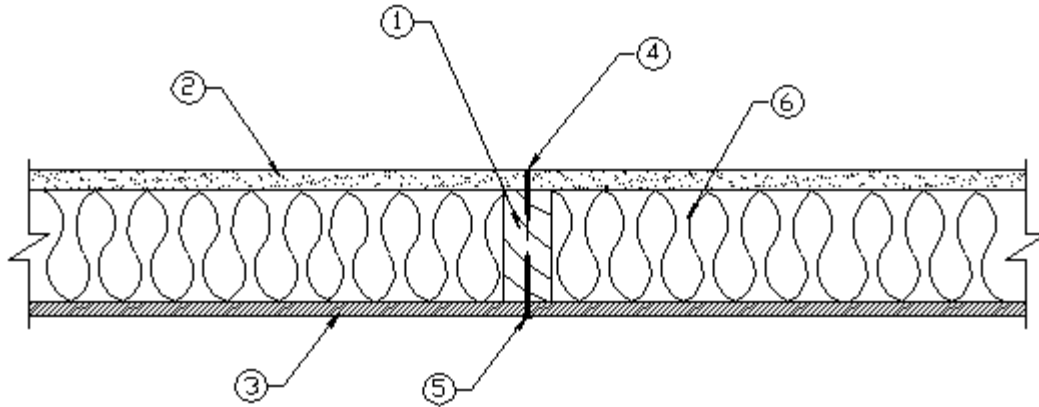
Third Party Witness: Intertek Testing Services

Report J99-22441.1

This assembly was tested at 100% design load, calculated in accordance with the *National Design Specification for Wood Construction*. The authority having jurisdiction should be consulted to assure acceptance of this report.

Figure 6.4 One-Hour Fire-Rated Wood Wall Assembly (WS4-1.2)

(2x4 Wood Stud Wall with Insulation: 100% Design Load – Gypsum One Side, Wood Structural Panels One Side)



1. **Framing:** Nominal 2x4 wood studs, spaced 16 in. o.c., double top plates, single bottom plate.
2. **Interior Sheathing:** 5/8 in. Type X gypsum wallboard, 4 ft. wide, applied horizontally, unblocked. Horizontal application of wallboard represents the direction of least fire resistance as opposed to vertical application.
3. **Exterior Sheathing:** 3/8 in. wood structural panels (oriented strand board), applied vertically, horizontal joints blocked.
4. **Gypsum Fasteners:** 2-1/4 in. Type S drywall screws, spaced 12 in. o.c.
5. **Panel Fasteners:** 6d common nails (bright): 12 in. o.c. in the field, 6 in. o.c. panel edges.
6. **Insulation:** 3-1/2 in. thick mineral wool insulation.
7. **Joints and Fastener Heads:** Wallboard joints covered with paper tape and joint compound, fastener heads covered with joint compound.

Tests conducted at the Fire Test Laboratory of National Gypsum Research Center

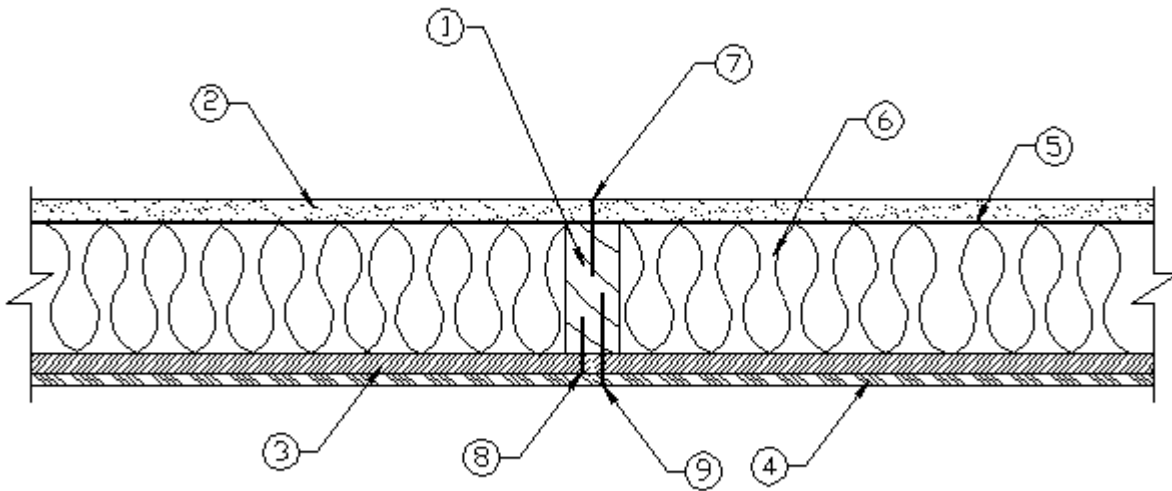
Test No: WP-1261 (Fire Endurance & Hose Stream), November 1, 2000

Third Party Witness: Intertek Testing Services
Report J20-006170.2

This assembly was tested at 100% design load, calculated in accordance with the *National Design Specification for Wood Construction*. The authority having jurisdiction should be consulted to assure acceptance of this report.

Figure 6.5 One-Hour Fire-Rated Wood Wall Assembly (WS4-1.3)

(2x4 Wood Stud Wall with Insulation: 78% Design Load – Gypsum One Side, Fiberboard One Side)



1. **Framing:** Nominal 2x4 wood studs, spaced 16 in. o.c., double top plates, single bottom plate.
2. **Interior Sheathing:** 5/8 in. Type X gypsum wallboard, 4 ft. wide, applied vertically, unblocked.
3. **Exterior Sheathing:** 1/2 in. fiberboard sheathing. *Alternate construction: minimum 1/2 in. lumber siding or 1/2 in. wood-based sheathing.*
4. **Exterior Siding:** 3/8 in. hardboard shiplap edge panel siding. *Alternate construction: lumber, wood based, vinyl, or aluminum siding.*
5. **Vapor Barrier:** 4-mil polyethylene sheeting.
6. **Insulation:** 3-1/2 in. thick mineral wool insulation.
7. **Gypsum Fasteners:** 6d cement coated box nails spaced 7 in. o.c.
8. **Fiberboard Fasteners:** 1-1/2 in. galvanized roofing nails: 6 in. o.c. in the field, 3 in. o.c. panel edges.
9. **Hardboard Fasteners:** 8d galvanized nails: 8 in. o.c. in the field, 4 in. o.c. panel edges.
10. **Joints and Fastener Heads:** Wallboard joints covered with paper tape and joint compound, fastener heads covered with joint compound.

Tests conducted at the Gold Bond Building Products Fire Testing Laboratory

Test No: WP-584 (Fire Endurance & Hose Stream), March 19, 1981

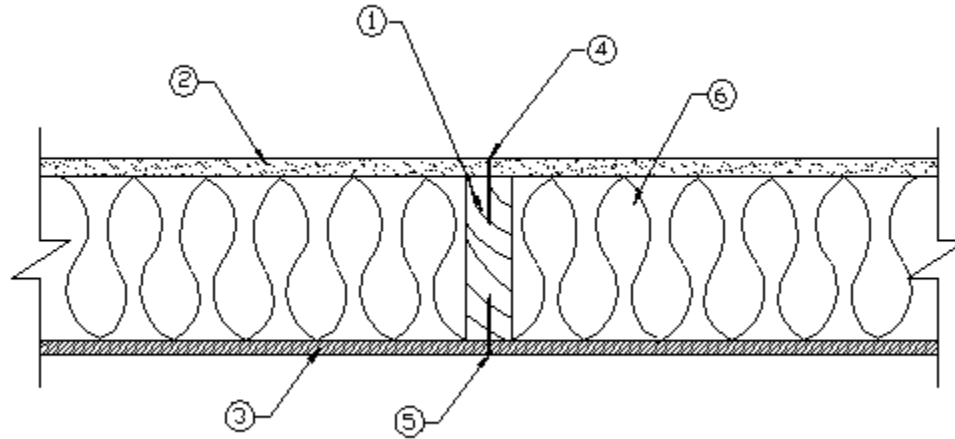
Third Party Witness: Warnock Hersey International, Inc.

Report WHI-690-003

This assembly was tested at 100% design load, calculated in accordance with the *National Design Specification for Wood Construction*. The authority having jurisdiction should be consulted to assure acceptance of this report.

Figure 6.6 One-Hour Fire-Rated Wood Wall Assembly (WS6-1.3)

(2x6 Wood Stud Wall with Insulation: 100% Design Load – Gypsum One Side, Wood Structural Panels One Side)



1. **Framing:** Nominal 2x6 wood studs, spaced 16 in. o.c., double top plates, single bottom plate.
2. **Interior Sheathing:** 5/8 in. Type X gypsum wallboard, 4 ft. wide, applied horizontally, unblocked. Horizontal application of wallboard represents the direction of least fire resistance as opposed to vertical application.
3. **Exterior Sheathing:** 7/16 in. wood structural panels (oriented strand board), applied vertically, horizontal joints blocked.
4. **Gypsum Fasteners:** 2-1/4 in. Type S drywall screws, spaced 12 in. o.c.
5. **Panel Fasteners:** 6d common nails (bright): 12 in. o.c. in the field, 6 in. o.c. panel edges.
6. **Insulation:** 5-1/2 in. thick mineral wool insulation.
7. **Joints and Fastener Heads:** Wallboard joints covered with paper tape and joint compound, fastener heads covered with joint compound.

Tests conducted at the Fire Test Laboratory of National Gypsum Research Center

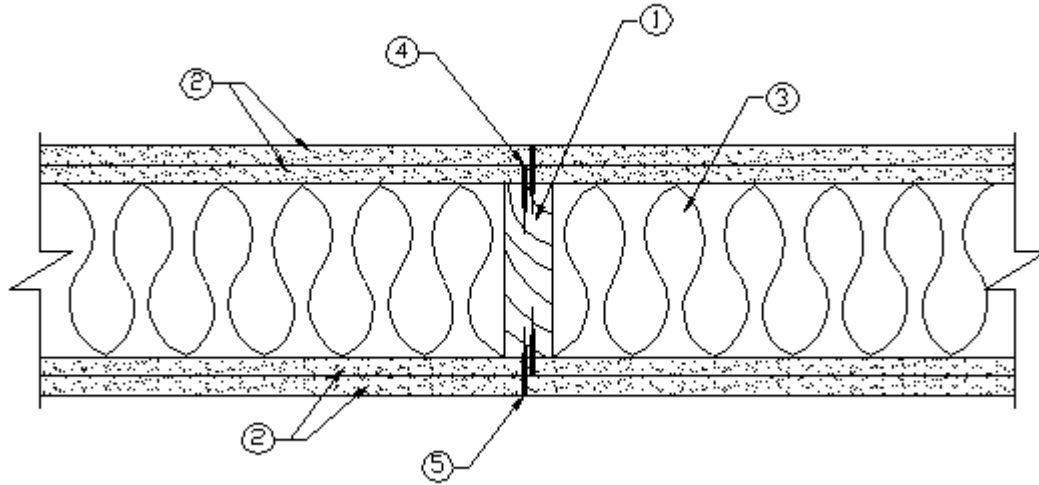
Test No: WP-1244 (Fire Endurance & Hose Stream), February 25, 2000

Third Party Witness: Intertek Testing Services
Report J99-27259.2

This assembly was tested at 100% design load, calculated in accordance with the *National Design Specification for Wood Construction*. The authority having jurisdiction should be consulted to assure acceptance of this report.

Figure 6.7 Two-Hour Fire-Rated Wood Wall Assembly (WS6-2.1)

(2x6 Wood Stud Wall with Insulation: 100% Design Load – Gypsum Both Sides)



1. **Framing:** Nominal 2x6 wood studs, spaced 24 in. o.c., double top plates, single bottom plate.
2. **Sheathing:**
 - Base Layer:** 5/8 in. Type X gypsum wallboard, 4 ft. wide, applied horizontally, unblocked.
 - Face Layer:** 5/8 in. Type X gypsum wallboard, 4 ft. wide, applied horizontally, unblocked.

Horizontal application of wallboard represents the direction of least fire resistance as opposed to vertical application.
3. **Insulation:** 5-1/2 in. thick mineral wool insulation.
4. **Gypsum Fasteners:** Base Layer: 2-1/4 in. Type S dry-wall screws, spaced 24 in. o.c.
5. **Gypsum Fasteners:** Face Layer: 2-1/4 in. Type S dry-wall screws, spaced 8 in. o.c.
6. **Joints and Fastener Heads:** Wallboard joints covered with paper tape and joint compound, fastener heads covered with joint compound.

Tests conducted at the Fire Test Laboratory of National Gypsum Research Center

Test No: WP-1262 (Fire Endurance), November 3, 2000

WP-1268 (Hose Stream), December 8, 2000

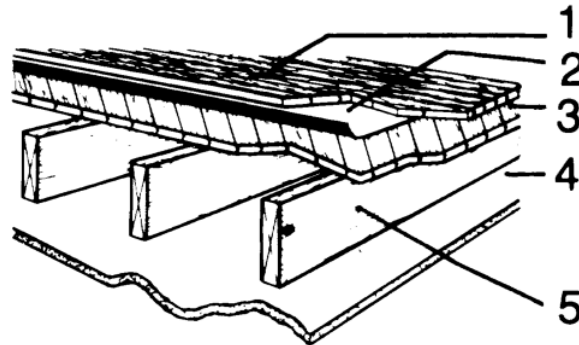
Third Party Witness: Intertek Testing Services

Report J20-006170.3

This assembly was tested at 100% design load, calculated in accordance with the *National Design Specification for Wood Construction*. The authority having jurisdiction should be consulted to assure acceptance of this report.

Figure 6.8 One-Hour Fire-Rated Wood Floor/Ceiling Assembly

(2x10 Wood Joists 16" o.c. – Gypsum Directly Applied or on Optional Resilient Channels)



1. Nom. 1 in. wood flooring or 19/32 in. T&G plywood underlayment (single floor). Oriented Strand Board (OSB) panels are permitted for certain designs.
2. Building paper.
3. Nom. 1 in. T&G boards or 15/32 in. plywood subfloor. Subfloors for certain designs may be nom. 7/16 in. OSB.
4. ½ in. Type X gypsum wallboard (may be attached directly to joists or on resilient channels) or 5/8 in. Type X gypsum wallboard directly applied to joists.
5. 2x10 Wood joists spaced 16 in. o.c.

Fire Tests:**½ in. Type X gypsum directly applied**

UL R1319-66, 11-9-64, Design L512;
 UL R3501-45, 5-27-65, Design L522;
 UL R2717-38, 6-10-65, Design L503;
 UL R3543-6, 11-10-65, Design L519;
 ULC Design M502

½ in. Type X gypsum on resilient channels

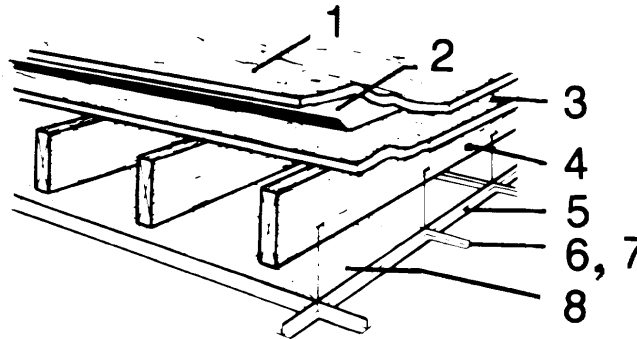
UL R1319-65, 11-16-64, Design L514

5/8 in. Type X Gypsum directly applied

UL R3501-5, 9, 7-15-52;
 UL R1319-2, 3, 6-5-52, Design L 501;
 ULC Design M500

Figure 6.9 One-Hour Fire-Rated Wood Floor/Ceiling Assembly

(2x10 Wood Joists 16" o.c. – Suspended Acoustical Ceiling Panels)



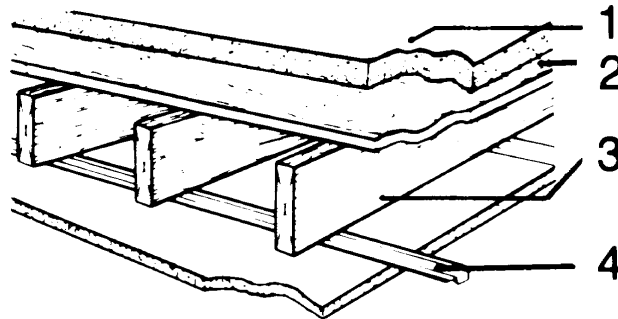
1. Nom. 19/32 in. T&G plywood underlayment (single floor). Oriented Strand Board (OSB) panels are permitted for certain designs.
2. Building paper.
3. 15/32 in. plywood subfloor. Subfloors for certain designs may be nom. 7/16 in. OSB.
4. 2x10 wood joists spaced 16 in. o.c.
5. T-bar grid ceiling system.
6. Main runners spaced 48 in. o.c.
7. Cross-tees spaced 24 in. o.c.
8. ½ in. x 24 in. x 48 in. mineral acoustical ceiling panels installed with hold-down clips.

Fire tests:

UL L209

Figure 6.10 One-Hour Fire-Rated Wood Floor/Ceiling Assembly

(2x10 Wood Joists 16" o.c. – Gypsum on Resilient Channels)



1. 1-1/2 in. lightweight concrete or min. $\frac{3}{4}$ in. proprietary gypsum concrete floor topping. Building paper may be optional and is not shown.
2. 15/32 in. plywood subfloor (subfloors for certain designs may be nom. 7/16 in. OSB) or Nom. 19/32 in. T&G plywood underlayment (single floor). Oriented Strand Board (OSB) panels are permitted for certain designs.
3. 2x10 wood joists spaced 16 in. o.c.
4. 5/8 in. Type X Gypsum Wallboard or 1/2 in. proprietary Type X gypsum wallboard ceiling attached to resilient channels.

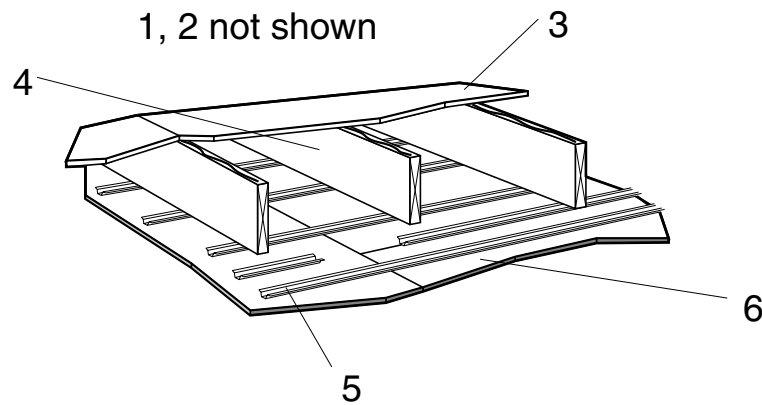
Fire Tests:

UL R1319-65, 11-16-64, Design L514 5/8 in. Type X gypsum

UL R6352, 4-21-71, Design L502 1/2 in. proprietary Type X gypsum

Figure 6.11 One-Hour Fire-Rated Wood Floor/Ceiling Assembly

(2x10 Wood Joists 24" o.c. – Gypsum on Resilient Channels)



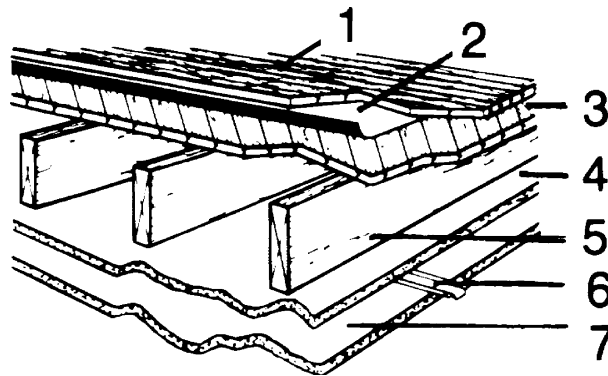
1. 1-1/2 in. lightweight concrete or min. $\frac{3}{4}$ in. proprietary gypsum concrete floor topping.
2. Building paper (may be optional).
3. Nom. 23/32 in. T&G plywood or Oriented Strand Board (OSB) underlayment (single floor).
4. 2x10 wood joists spaced 24 in. o.c.
5. Resilient channels.
6. 5/8 in. Type X gypsum wallboard ceiling.

Fire Tests:

UL R5229-2, 5-25-73, Design L513

Figure 6.12 Two-Hour Fire-Rated Wood Floor/Ceiling Assembly

(2x10 Wood Joists 16" o.c. – Gypsum Directly Applied with Second Layer on Resilient Channels)

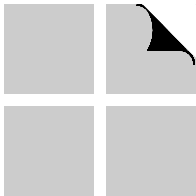


1. Nom. 1 in. wood flooring or 19/32 in. T&G plywood underlayment (single floor). Oriented Strand Board (OSB) panels are permitted for certain designs.
2. Building paper.
3. Nom. 1x6 T&G boards or 15/32 in. plywood subfloor. Subfloors for certain designs may be nom. 7/16 in. OSB.
4. 5/8 in. proprietary Type X gypsum wallboard ceiling attached directly to joists.
5. 2x10 Wood joists space 16 in. o.c.
6. Resilient channels.
7. 5/8 in. proprietary Type X gypsum wallboard ceiling attached to resilient channels.

Fire Tests:

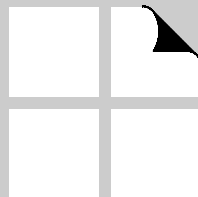
UL R1319-114, 7-21-67, Design L511

UL R2717-35, 10-21-64, Design L505; ULC Design M503



SPAN TABLES

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7.1 Universal Span Tables

The tables in this Section provide joist and rafter spans for design criteria listed at the top of each table. Span tables are provided for the following commonly used load and deflection criteria:

Applications	Live Load (psf)	Dead Load (psf)	Deflection Limit	Table No.
Floor joists	40	10	span/360	7.1
	30	10	span/360	7.2
Ceiling joists	10	5	span/240	7.3
	20	10	span/240	7.4
Roof rafters	20	15	span/240	7.5
	30	15	span/240	7.6
	40	15	span/240	7.7
	20	10	span/240	7.8
	20	10	span/180	7.9

The applications and associated load and deflection criteria listed above are commonly encountered in designs of residential wood structures. The use of the tables is not limited to the applications listed.

These span tables for joists and rafters are calculated on the basis of a series of modulus of elasticity (E) and allowable bending design values (F_b'). The range of values in the tables provides allowable spans for all species and grades of nominal 2-in. framing lumber customarily used in construction. These span tables assume installation of at least three joists or rafters that are spaced not more than 24 in. o.c. The calculated spans assume fully laterally supported members, properly sheathed and nailed on the top edge of the joist or rafter.

Lumber Design Values

Use of these span tables requires reference to the applicable tabulated design values for the various species and grades of lumber. These tabulated design values are found in Tables 4A, 4B, 4C, and 4F of the *NDS Supplement*.

Span Measurement

The tabulated spans are shown in feet and inches. The spans are the distance from face to face of supports which does not include one-half the required bearing length at each end. For sloping rafters, the span is measured along the horizontal projection.

Use of Universal Span Tables

Spans for floor and ceiling joists are calculated on the basis of the modulus of elasticity (E) with the required allowable bending design value (F_b') listed below each span. Spans for rafters are calculated on the basis of allowable bending design value (F_b') with the required modulus of elasticity (E) listed below each span. Values determined from the span tables should be compared to values from Tables 4A, 4B, 4C, and 4F of the *NDS Supplement* modified appropriately by the adjustment factors. Species and grades with allowable bending design values and modulus of elasticity values greater than or equal to those shown in the span tables are appropriate.

Table 7.1 Floor Joist With L/360 Deflection Limits

Design Criteria
Deflection: For 40 psf live load
Limited to span in inches divided by 360
Strength: Live load of 40 psf plus dead load of 10 psf determines the required bending design value

Joist Size (in.)	Spacing (in.)	Modulus of Elasticity, E, in 1,000,000 psi																
		0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4
2 × 6	12.0	8-6	8-10	9-2	9-6	9-9	10-0	10-3	10-6	10-9	10-11	11-2	11-4	11-7	11-9	11-11	12-1	12-3
	16.0	7-9	8-0	8-4	8-7	8-10	9-1	9-4	9-6	9-9	9-11	10-2	10-4	10-6	10-8	10-10	11-0	11-2
	19.2	7-3	7-7	7-10	8-1	8-4	8-7	8-9	9-0	9-2	9-4	9-6	9-8	9-10	10-0	10-2	10-4	10-6
	24.0	6-9	7-0	7-3	7-6	7-9	7-11	8-2	8-4	8-6	8-8	8-10	9-0	9-2	9-4	9-6	9-7	9-9
2 × 8	12.0	11-3	11-8	12-1	12-6	12-10	13-2	13-6	13-10	14-2	14-5	14-8	15-0	15-3	15-6	15-9	15-11	16-2
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	24.0	8-11	9-3	9-7	9-11	10-2	10-6	10-9	11-0	11-3	11-5	11-8	11-11	12-1	12-3	12-6	12-8	12-10
2 × 10	12.0	14-4	14-11	15-5	15-11	16-5	16-10	17-3	17-8	18-0	18-5	18-9	19-1	19-5	19-9	20-1	20-4	20-8
	16.0	13-0	13-6	14-0	14-6	14-11	15-3	15-8	16-0	16-5	16-9	17-0	17-4	17-8	17-11	18-3	18-6	18-9
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2 × 12	12.0	17-5	18-1	18-9	19-4	19-11	20-6	21-0	21-6	21-11	22-5	22-10	23-3	23-7	24-0	24-5	24-9	25-1
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	19.2	14-11	15-6	16-0	16-7	17-0	17-6	17-11	18-4	18-9	19-2	19-6	19-10	20-2	20-6	20-10	21-2	21-6
	24.0	13-10	14-4	14-11	15-4	15-10	16-3	16-8	17-0	17-5	17-9	18-1	18-5	18-9	19-1	19-4	19-8	19-11
F _b	12.0	718	777	833	888	941	993	1043	1092	1140	1187	1233	1278	1323	1367	1410	1452	1494
	16.0	790	855	917	977	1036	1093	1148	1202	1255	1306	1357	1407	1456	1504	1551	1598	1644
	19.2	840	909	975	1039	1101	1161	1220	1277	1333	1388	1442	1495	1547	1598	1649	1698	1747
	24.0	905	979	1050	1119	1186	1251	1314	1376	1436	1496	1554	1611	1667	1722	1776	1829	1882

Note: The required bending design value, F_b, in pounds per square inch is shown at the bottom of each table and is applicable to all lumber sizes shown. Spans are shown in feet-inches. Check sources of supply for availability of lumber in lengths greater than 20'.

Table 7.2 Floor Joist With L/360 Deflection Limits**Design Criteria**

Deflection: For 30 psf live load

Limited to span in inches divided by 360

Strength: Live load of 30 psf plus dead load of 10 psf determines the required bending design value

Joist Size (in.)	Spacing (in.)	Modulus of Elasticity, E, in 1,000,000 psi																			
		0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4			
2 × 6	12.0	9-4	9-9	10-1	10-5	10-9	11-0	11-3	11-7	11-10	12-0	12-3	12-6	12-9	12-11	13-1	13-4	13-6			
	16.0	8-6	8-10	9-2	9-6	9-9	10-0	10-3	10-6	10-9	10-11	11-2	11-4	11-7	11-9	11-11	12-1	12-3			
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	24.0	7-5	7-9	8-0	8-3	8-6	8-9	8-11	9-2	9-4	9-7	9-9	9-11	10-1	10-3	10-5	10-7	10-9			
2 × 8	12.0	12-4	12-10	13-4	13-9	14-2	14-6	14-11	15-3	15-7	15-10	16-2	16-6	16-9	17-0	17-4	17-7	17-10			
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	24.0	9-10	10-2	10-7	10-11	11-3	11-6	11-10	12-1	12-4	12-7	12-10	13-1	13-4	13-6	13-9	13-11	14-2			
2 × 10	12.0	15-9	16-5	17-0	17-6	18-0	18-6	19-0	19-5	19-10	20-3	20-8	21-0	21-5	21-9	22-1	22-5	22-9			
	16.0	14-4	14-11	15-5	15-11	16-5	16-10	17-3	17-8	18-0	18-5	18-9	19-1	19-5	19-9	20-1	20-4	20-8			
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F _b	12.0	696	753	808	861	912	962	1011	1058	1105	1150	1195	1239	1282	1324	1366	1407	1448			
	16.0	766	829	889	947	1004	1059	1112	1165	1216	1266	1315	1364	1411	1458	1504	1549	1593			
	19.2	814	881	945	1007	1067	1125	1182	1238	1292	1345	1398	1449	1499	1549	1598	1646	1693			
	24.0	877	949	1018	1084	1149	1212	1273	1333	1392	1449	1506	1561	1615	1669	1721	1773	1824			

Note: The required bending design value, F_b , in pounds per square inch is shown at the bottom of each table and is applicable to all lumber sizes shown. Spans are shown in feet-inches and are limited to 26 feet. Check sources of supply for availability of lumber in lengths greater than 20'.

Table 7.3 Ceiling Joist With L/240 Deflection Limits

Design Criteria
Deflection: For 10 psf live load
Limited to span in inches divided by 240
Strength: Live load of 10 psf plus dead load of 5 psf determines the required bending design value

Joist Size (in.)	Spacing (in.)	Modulus of Elasticity, E, in 1,000,000 psi																
		0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4
2 × 4	12.0	9-10	10-3	10-7	10-11	11-3	11-7	11-10	12-2	12-5	12-8	12-11	13-2	13-4	13-7	13-9	14-0	14-2
	16.0	8-11	9-4	9-8	9-11	10-3	10-6	10-9	11-0	11-3	11-6	11-9	11-11	12-2	12-4	12-6	12-9	12-11
	19.2	8-5	8-9	9-1	9-4	9-8	9-11	10-2	10-4	10-7	10-10	11-0	11-3	11-5	11-7	11-9	12-0	12-2
	24.0	7-10	8-1	8-5	8-8	8-11	9-2	9-5	9-8	9-10	10-0	10-3	10-5	10-7	10-9	10-11	11-1	11-3
2 × 6	12.0	15-6	16-1	16-8	17-2	17-8	18-2	18-8	19-1	19-6	19-11	20-3	20-8	21-0	21-4	21-8	22-0	22-4
	16.0	14-1	14-7	15-2	15-7	16-1	16-6	16-11	17-4	17-8	18-1	18-5	18-9	19-1	19-5	19-8	20-0	20-3
	19.2	13-3	13-9	14-3	14-8	15-2	15-7	15-11	16-4	16-8	17-0	17-4	17-8	17-11	18-3	18-6	18-10	19-1
	24.0	12-3	12-9	13-3	13-8	14-1	14-5	14-9	15-2	15-6	15-9	16-1	16-4	16-8	16-11	17-2	17-5	17-8
2 × 8	12.0	20-5	21-2	21-11	22-8	23-4	24-0	24-7	25-2	25-8	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0
	16.0	18-6	19-3	19-11	20-7	21-2	21-9	22-4	22-10	23-4	23-10	24-3	24-8	25-2	25-7	25-11	26-0	26-0
	19.2	17-5	18-1	18-9	19-5	19-11	20-6	21-0	21-6	21-11	22-5	22-10	23-3	23-8	24-0	24-5	24-9	25-2
	24.0	16-2	16-10	17-5	18-0	18-6	19-0	19-6	19-11	20-5	20-10	21-2	21-7	21-11	22-4	22-8	23-0	23-4
2 × 10	12.0	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0
	16.0	23-8	24-7	25-5	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0
	19.2	22-3	23-1	23-11	24-9	25-5	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0
	24.0	20-8	21-6	22-3	22-11	23-8	24-3	24-10	25-5	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0
F _b	12.0	711	769	825	880	932	983	1033	1082	1129	1176	1221	1266	1310	1354	1396	1438	1480
	16.0	783	847	909	968	1026	1082	1137	1191	1243	1294	1344	1394	1442	1490	1537	1583	1629
	19.2	832	900	965	1029	1090	1150	1208	1265	1321	1375	1429	1481	1533	1583	1633	1682	1731
	24.0	896	969	1040	1108	1174	1239	1302	1363	1423	1481	1539	1595	1651	1706	1759	1812	1864

Note: The required bending design value, F_b, in pounds per square inch is shown at the bottom of each table and is applicable to all lumber sizes shown. Spans are shown in feet-inches and are limited to 26 feet. Check sources of supply for availability of lumber in lengths greater than 20'.

Table 7.4 Ceiling Joist With L/240 Deflection Limits**Design Criteria**

Deflection: For 20 psf live load

Limited to span in inches divided by 240

Strength: Live Load of 20 psf plus dead load of 10 psf determines the required bending design value

Joist Size (in.)	Spacing (in.)	Modulus of Elasticity, E, in 1,000,000 psi																			
		0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4			
2 × 4	12.0	7-10	8-1	8-5	8-8	8-11	8-11	9-2	9-5	9-8	9-10	10-0	10-3	10-5	10-7	10-9	10-11	11-1	11-3		
	16.0	7-1	7-5	7-8	7-11	8-1	8-4	8-7	8-9	8-11	8-11	9-1	9-4	9-6	9-8	9-9	9-11	10-1	10-3		
	19.2	6-8	6-11	7-2	7-5	7-8	7-10	8-1	8-3	8-5	8-7	8-7	8-9	8-11	9-1	9-3	9-4	9-6	9-8		
	24.0	6-2	6-5	6-8	6-11	7-1	7-3	7-6	7-8	7-10	8-0	8-0	8-1	8-3	8-5	8-7	8-8	8-10	8-11		
2 × 6	12.0	12-3	12-9	13-3	13-8	14-1	14-5	14-9	15-2	15-6	15-9	16-1	16-4	16-8	16-11	17-2	17-5	17-8	17-8		
	16.0	11-2	11-7	12-0	12-5	12-9	13-1	13-5	13-9	14-1	14-4	14-7	14-11	15-2	15-5	15-7	15-10	16-1	16-1		
	19.2	10-6	10-11	11-4	11-8	12-0	12-4	12-8	12-11	13-3	13-6	13-9	14-0	14-3	14-6	14-8	14-11	15-2	15-2		
	24.0	9-9	10-2	10-6	10-10	11-2	11-5	11-9	12-0	12-3	12-6	12-9	13-0	13-3	13-5	13-8	13-10	14-1	14-1		
2 × 8	12.0	16-2	16-10	17-5	18-0	18-6	19-0	19-6	19-11	20-5	20-10	21-2	21-7	21-11	22-4	22-8	23-0	23-4	23-4		
	16.0	14-8	15-3	15-10	16-4	16-10	17-3	17-9	18-1	18-6	18-11	19-3	19-7	19-11	20-3	20-7	20-11	21-2	21-2		
	19.2	13-10	14-5	14-11	15-5	15-10	16-3	16-8	17-1	17-5	17-9	18-1	18-5	18-9	19-1	19-5	19-8	19-11	19-11		
	24.0	12-10	13-4	13-10	14-3	14-8	15-1	15-6	15-10	16-2	16-6	16-10	17-2	17-5	17-9	18-0	18-3	18-6	18-6		
2 × 10	12.0	20-8	21-6	22-3	22-11	23-8	24-3	24-10	25-5	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0	26-0		
	16.0	18-9	19-6	20-2	20-10	21-6	22-1	22-7	23-1	23-8	24-1	24-7	25-0	25-5	25-10	26-0	26-0	26-0	26-0		
	19.2	17-8	18-4	19-0	19-7	20-2	20-9	21-3	21-9	22-3	22-8	23-1	23-7	23-11	24-4	24-9	25-1	25-5	25-5		
	24.0	16-5	17-0	17-8	18-3	18-9	19-3	19-9	20-2	20-8	21-1	21-6	21-10	22-3	22-7	22-11	23-4	23-8	23-8		
F _b	12.0	896	969	1040	1108	1174	1239	1302	1363	1423	1481	1539	1595	1651	1706	1759	1812	1864	1864		
	16.0	986	1067	1145	1220	1293	1364	1433	1500	1566	1631	1694	1756	1817	1877	1936	1995	2052	2052		
	19.2	1048	1134	1216	1296	1374	1449	1522	1594	1664	1733	1800	1866	1931	1995	2058	2120	2181	2181		
	24.0	1129	1221	1310	1396	1480	1561	1640	1717	1793	1866	1939	2010	2080	2149	2217	2283	2349	2349		

Note: The required bending design value, F_b, in pounds per square inch is shown at the bottom of each table and is applicable to all lumber sizes shown. Spans are shown in feet-inches and are limited to 26 feet. Check sources of supply for availability of lumber in lengths greater than 20'.

Table 7.5 Rafters With L/240 Deflection Limitation

Design Criteria
Deflection: For 20 psf live load
Limited to span in inches divided by 240
Strength: Live load of 20 psf plus dead load of 15 psf determines the required bending design value

Rafter Size (in.)	Spacing (in.)	Bending Design Value, F_b , (psi)																								
		300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700
2 × 6	12.0	6-7	7-7	8-6	9-4	10-0	10-9	11-5	12-0	12-7	13-2	13-8	14-2	14-8	15-2	15-8	16-1	16-7	17-0	17-5	17-10	18-2†	18-2†	18-2†	18-2†	18-2†
	16.0	5-8	6-7	7-4	8-1	8-8	9-4	9-10	10-5	10-11	11-5	11-10	12-4	12-9	13-2	13-7	13-11	14-4	14-8	15-1	15-5	15-9	16-1	16-5	16-6†	16-6†
	19.2	5-2	6-0	6-9	7-4	7-11	8-6	9-0	9-6	9-11	10-5	10-10	11-3	11-7	12-0	12-4	12-9	13-1	13-5	13-9	14-1	14-5	14-8	15-0	15-4	15-7†
	24.0	4-8	5-4	6-0	6-7	7-1	7-7	8-1	8-6	8-11	9-4	9-8	10-0	10-5	10-9	11-1	11-5	11-8	12-0	12-4	12-7	12-10	13-2	13-5	13-8	13-11
2 × 8	12.0	8-8	10-0	11-2	12-3	13-3	14-2	15-0	15-10	16-7	17-4	18-0	18-9	19-5	20-0	20-8	21-3	21-10	22-4	22-11	23-6	24-0†	24-0†	24-0†	24-0†	24-0†
	16.0	7-6	8-8	9-8	10-7	11-6	12-3	13-0	13-8	14-4	15-0	15-7	16-3	16-9	17-4	17-10	18-5	18-11	19-5	19-10	20-4	20-9	21-3	21-8	21-9†	21-9†
	19.2	6-10	7-11	8-10	9-8	10-6	11-2	11-10	12-6	13-1	13-8	14-3	14-10	15-4	15-10	16-4	16-9	17-3	17-8	18-1	18-7	19-0	19-5	19-9	20-2	20-6†
	24.0	6-2	7-1	7-11	8-8	9-4	10-0	10-7	11-2	11-9	12-3	12-9	13-3	13-8	14-2	14-7	15-0	15-5	15-10	16-3	16-7	17-0	17-4	17-8	18-0	18-5
2 × 10	12.0	11-1	12-9	14-3	15-8	16-11	18-1	19-2	20-2	21-2	22-1	23-0	23-11	24-9	25-6	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*
	16.0	9-7	11-1	12-4	13-6	14-8	15-8	16-7	17-6	18-4	19-2	19-11	20-8	21-5	22-1	22-10	23-5	24-1	24-9	25-4	25-11	26-0*	26-0*	26-0*	26-0*	26-0*
	19.2	8-9	10-1	11-3	12-4	13-4	14-3	15-2	15-11	16-9	17-6	18-2	18-11	19-7	20-2	20-10	21-5	22-0	22-7	23-1	23-8	24-2	24-9	25-3	25-9	26-0*
	24.0	7-10	9-0	10-1	11-1	11-11	12-9	13-6	14-3	15-0	15-8	16-3	16-11	17-6	18-1	18-7	19-2	19-8	20-2	20-8	21-2	21-8	22-1	22-7	23-0	23-5
2 × 12	12.0	13-5	15-6	17-4	19-0	20-6	21-11	23-3	24-7	25-9	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*
	16.0	11-8	13-5	15-0	16-6	17-9	19-0	20-2	21-3	22-4	23-3	24-3	25-2	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*
	19.2	10-8	12-3	13-9	15-0	16-3	17-4	18-5	19-5	20-4	21-3	22-2	23-0	23-9	24-7	25-4	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*
	24.0	9-6	11-0	12-3	13-5	14-6	15-6	16-6	17-4	18-2	19-0	19-10	20-6	21-3	21-11	22-8	23-3	23-11	24-7	25-2	25-9	26-0*	26-0*	26-0*	26-0*	26-0*
E	12.0	0.12	0.19	0.26	0.35	0.44	0.54	0.64	0.75	0.86	0.98	1.11	1.24	1.37	1.51	1.66	1.81	1.96	2.12	2.28	2.44	2.60	2.60	2.60	2.60	
	16.0	0.11	0.16	0.23	0.30	0.38	0.46	0.55	0.65	0.75	0.85	0.96	1.07	1.19	1.31	1.44	1.56	1.70	1.83	1.97	2.11	2.26	2.41	2.56	2.60	
	19.2	0.10	0.15	0.21	0.27	0.35	0.42	0.51	0.59	0.68	0.78	0.88	0.98	1.09	1.20	1.31	1.43	1.55	1.67	1.80	1.93	2.06	2.20	2.34	2.48	
	24.0	0.09	0.13	0.19	0.25	0.31	0.38	0.45	0.53	0.61	0.70	0.78	0.88	0.97	1.07	1.17	1.28	1.39	1.50	1.61	1.73	1.85	1.97	2.09	2.22	

Note: The required modulus of elasticity, E, in 1,000,000 pounds per square inch is shown at the bottom of each table, is limited to 2.6 million pounds per square inch, and is applicable to all lumber sizes shown.

* Spans are shown in feet-inches and are limited to 26 feet. Check sources of supply for availability of lumber in lengths greater than 20'.

† Spans are controlled by maximum E value of 2.6 million psi.

Table 7.6 Rafters With L/240 Deflection Limitation**Design Criteria**

Deflection: For 30 psf live load

Limited to span in inches divided by 240

Strength: Live load of 30 psf plus dead load of 15 psf determines the required bending design value

Rafter Size (in.)	Spacing (in.)	Bending Design Value, F_b , (psi)																								
		300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700
2 × 6	12.0	5-10	6-8	7-6	8-2	8-10	9-6	10-0	10-7	11-1	11-7	12-1	12-6	13-0	13-5	13-10	14-2	14-7	15-0	15-4	15-8	15-11†	15-11†	15-11†	15-11†	15-11†
	16.0	5-0	5-10	6-6	7-1	7-8	8-2	8-8	9-2	9-7	10-0	10-5	10-10	11-3	11-7	11-11	12-4	12-8	13-0	13-3	13-7	13-11	14-2	14-5†	14-5†	14-5†
	19.2	4-7	5-4	5-11	6-6	7-0	7-6	7-11	8-4	8-9	9-2	9-6	9-11	10-3	10-7	10-11	11-3	11-6	11-10	12-2	12-5	12-8	13-0	13-3	13-6	13-7†
	24.0	4-1	4-9	5-4	5-10	6-3	6-8	7-1	7-6	7-10	8-2	8-6	8-10	9-2	9-6	9-9	10-0	10-4	10-7	10-10	11-1	11-4	11-7	11-10	12-1	12-4
2 × 8	12.0	7-8	8-10	9-10	10-10	11-8	12-6	13-3	13-11	14-8	15-3	15-11	16-6	17-1	17-8	18-2	18-9	19-3	19-9	20-3	20-8	20-11†	20-11†	20-11†	20-11†	20-11†
	16.0	6-7	7-8	8-7	9-4	10-1	10-10	11-6	12-1	12-8	13-3	13-9	14-4	14-10	15-3	15-9	16-3	16-8	17-1	17-6	17-11	18-4	18-9	19-0†	19-0†	19-0†
	19.2	6-0	7-0	7-10	8-7	9-3	9-10	10-6	11-0	11-7	12-1	12-7	13-1	13-6	13-11	14-5	14-10	15-2	15-7	16-0	16-4	16-9	17-1	17-5	17-9	17-11†
	24.0	5-5	6-3	7-0	7-8	8-3	8-10	9-4	9-10	10-4	10-10	11-3	11-8	12-1	12-6	12-10	13-3	13-7	13-11	14-4	14-8	15-0	15-3	15-7	15-11	16-3
2 × 10	12.0	9-9	11-3	12-7	13-9	14-11	15-11	16-11	17-10	18-8	19-6	20-4	21-1	21-10	22-6	23-3	23-11	24-6	25-2	25-10	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*
	16.0	8-5	9-9	10-11	11-11	12-11	13-9	14-8	15-5	16-2	16-11	17-7	18-3	18-11	19-6	20-1	20-8	21-3	21-10	22-4	22-10	23-5	23-11	24-3†	24-3†	24-3†
	19.2	7-8	8-11	9-11	10-11	11-9	12-7	13-4	14-1	14-9	15-5	16-1	16-8	17-3	17-10	18-4	18-11	19-5	19-11	20-5	20-10	21-4	21-10	22-3	22-8	22-10†
	24.0	6-11	8-0	8-11	9-9	10-6	11-3	11-11	12-7	13-2	13-9	14-4	14-11	15-5	15-11	16-5	16-11	17-4	17-10	18-3	18-8	19-1	19-6	19-11	20-4	20-8
2 × 12	12.0	11-10	13-8	15-4	16-9	18-1	19-4	20-6	21-8	22-8	23-9	24-8	25-7	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*
	16.0	10-3	11-10	13-3	14-6	15-8	16-9	17-9	18-9	19-8	20-6	21-5	22-2	23-0	23-9	24-5	25-2	25-10	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*
	19.2	9-4	10-10	12-1	13-3	14-4	15-4	16-3	17-1	17-11	18-9	19-6	20-3	21-0	21-8	22-4	23-0	23-7	24-2	24-10	25-5	25-11	26-0*	26-0*	26-0*	26-0*
	24.0	8-5	9-8	10-10	11-10	12-10	13-8	14-6	15-4	16-1	16-9	17-5	18-1	18-9	19-4	20-0	20-6	21-1	21-8	22-2	22-8	23-3	23-9	24-2	24-8	25-2
E	12.0	0.13	0.19	0.27	0.36	0.45	0.55	0.66	0.77	0.89	1.01	1.14	1.28	1.41	1.56	1.71	1.86	2.02	2.18	2.34	2.51	2.60	2.60	2.60	2.60	
	16.0	0.11	0.17	0.24	0.31	0.39	0.48	0.57	0.67	0.77	0.88	0.99	1.10	1.22	1.35	1.48	1.61	1.75	1.89	2.03	2.18	2.33	2.48	2.60	2.60	
	19.2	0.10	0.15	0.22	0.28	0.36	0.44	0.52	0.61	0.70	0.80	0.90	1.01	1.12	1.23	1.35	1.47	1.59	1.72	1.85	1.99	2.12	2.26	2.41	2.55	2.60
	24.0	0.09	0.14	0.19	0.25	0.32	0.39	0.46	0.54	0.63	0.72	0.81	0.90	1.00	1.10	1.21	1.31	1.43	1.54	1.66	1.78	1.90	2.02	2.15	2.28	2.41

Note: The required modulus of elasticity, E, in 1,000,000 pounds per square inch is shown at the bottom of each table, is limited to 2.6 million pounds per square inch, and is applicable to all lumber sizes shown.

* Spans are shown in feet-inches and are limited to 26 feet. Check sources of supply for availability of lumber in lengths greater than 20'.

† Spans are controlled by maximum E value of 2.6 million psi.

Table 7.7 Rafters With L/240 Deflection Limitation

Design Criteria
Deflection: For 40 psf live load
Limited to span in inches divided by 240
Strength: Live load of 40 psf plus dead load of 15 psf determines the required bending design value

Rafter Size (in.)	Spacing (in.)	Bending Design Value, F_b , (psi)																								
		300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700
2 × 6	12.0	5-3	6-1	6-9	7-5	8-0	8-7	9-1	9-7	10-0	10-6	10-11	11-4	11-9	12-1	12-6	12-10	13-2	13-6	13-10	14-2	14-5†	14-5†	14-5†	14-5†	14-5†
	16.0	4-6	5-3	5-10	6-5	6-11	7-5	7-10	8-3	8-8	9-1	9-5	9-10	10-2	10-6	10-10	11-1	11-5	11-9	12-0	12-4	12-7	12-10	13-1†	13-1†	13-1†
	19.2	4-2	4-9	5-4	5-10	6-4	6-9	7-2	7-7	7-11	8-3	8-8	8-11	9-3	9-7	9-10	10-2	10-5	10-8	11-0	11-3	11-6	11-9	12-0	12-2	12-4†
	24.0	3-8	4-3	4-9	5-3	5-8	6-1	6-5	6-9	7-1	7-5	7-9	8-0	8-3	8-7	8-10	9-1	9-4	9-7	9-10	10-0	10-3	10-6	10-8	10-11	11-1
2 × 8	12.0	6-11	8-0	8-11	9-9	10-7	11-3	12-0	12-7	13-3	13-10	14-5	14-11	15-5	16-0	16-5	16-11	17-5	17-10	18-3	18-9	19-0†	19-0†	19-0†	19-0†	19-0†
	16.0	6-0	6-11	7-9	8-6	9-2	9-9	10-4	10-11	11-6	12-0	12-6	12-11	13-5	13-10	14-3	14-8	15-1	15-5	15-10	16-3	16-7	16-11	17-3†	17-3†	17-3†
	19.2	5-6	6-4	7-1	7-9	8-4	8-11	9-6	10-0	10-6	10-11	11-5	11-10	12-3	12-7	13-0	13-5	13-9	14-1	14-6	14-10	15-2	15-5	15-9	16-1	16-3†
	24.0	4-11	5-8	6-4	6-11	7-6	8-0	8-6	8-11	9-4	9-9	10-2	10-7	10-11	11-3	11-8	12-0	12-4	12-7	12-11	13-3	13-6	13-10	14-1	14-5	14-8
2 × 10	12.0	8-10	10-2	11-5	12-6	13-6	14-5	15-3	16-1	16-11	17-8	18-4	19-1	19-9	20-4	21-0	21-7	22-2	22-9	23-4	23-11	24-3†	24-3†	24-3†	24-3†	24-3†
	16.0	7-8	8-10	9-10	10-10	11-8	12-6	13-3	13-11	14-8	15-3	15-11	16-6	17-1	17-8	18-2	18-9	19-3	19-9	20-2	20-8	21-2	21-7	22-1†	22-1†	22-1†
	19.2	7-0	8-1	9-0	9-10	10-8	11-5	12-1	12-9	13-4	13-11	14-6	15-1	15-7	16-1	16-7	17-1	17-7	18-0	18-5	18-11	19-4	19-9	20-2	20-6	20-9†
	24.0	6-3	7-2	8-1	8-10	9-6	10-2	10-10	11-5	11-11	12-6	13-0	13-6	13-11	14-5	14-10	15-3	15-8	16-1	16-6	16-11	17-3	17-8	18-0	18-4	18-9
2 × 12	12.0	10-9	12-5	13-10	15-2	16-5	17-6	18-7	19-7	20-6	21-5	22-4	23-2	24-0	24-9	25-6	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*
	16.0	9-3	10-9	12-0	13-2	14-2	15-2	16-1	17-0	17-9	18-7	19-4	20-1	20-9	21-5	22-1	22-9	23-5	24-0	24-7	25-2	25-9	26-0*	26-0*	26-0*	26-0*
	19.2	8-6	9-10	10-11	12-0	12-11	13-10	14-8	15-6	16-3	17-0	17-8	18-4	19-0	19-7	20-2	20-9	21-4	21-11	22-5	23-0	23-6	24-0	24-6	25-0	25-3†
	24.0	7-7	8-9	9-10	10-9	11-7	12-5	13-2	13-10	14-6	15-2	15-9	16-5	17-0	17-6	18-1	18-7	19-1	19-7	20-1	20-6	21-0	21-5	21-11	22-4	22-9
E	12.0	0.12	0.19	0.27	0.35	0.44	0.54	0.65	0.76	0.88	1.00	1.13	1.26	1.40	1.54	1.68	1.83	1.99	2.15	2.31	2.48	2.60	2.60	2.60	2.60	
	16.0	0.11	0.17	0.23	0.31	0.39	0.47	0.56	0.66	0.76	0.86	0.98	1.09	1.21	1.33	1.46	1.59	1.72	1.86	2.00	2.15	2.29	2.45	2.60	2.60	
	19.2	0.10	0.15	0.21	0.28	0.35	0.43	0.51	0.60	0.69	0.79	0.89	0.99	1.10	1.22	1.33	1.45	1.57	1.70	1.83	1.96	2.09	2.23	2.37	2.52	2.60
	24.0	0.09	0.14	0.19	0.25	0.31	0.38	0.46	0.54	0.62	0.71	0.80	0.89	0.99	1.09	1.19	1.30	1.41	1.52	1.63	1.75	1.87	2.00	2.12	2.25	2.38

Note: The required modulus of elasticity, E, in 1,000,000 pounds per square inch is shown at the bottom of each table, is limited to 2.6 million pounds per square inch, and is applicable to all lumber sizes shown.

* Spans are shown in feet-inches and are limited to 26 feet. Check sources of supply for availability of lumber in lengths greater than 20'.

† Spans are controlled by maximum E value of 2.6 million psi.

Table 7.8 Rafters With L/240 Deflection Limitation**Design Criteria**

Deflection: For 20 psf live load

Limited to span in inches divided by 240

Strength: Live load of 20 psf plus dead load of 10 psf determines the required bending design value

Rafter Size (in.)	Spacing (in.)	Bending Design Value, F_b , (psi)																					
		300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
2 × 6	12.0	7-1	8-2	9-2	10-0	10-10	11-7	12-4	13-0	13-7	14-2	14-9	15-4	15-11	16-5	16-11	17-5	17-10	18-2†	18-2†	18-2†	18-2†	18-2†
	16.0	6-2	7-1	7-11	8-8	9-5	10-0	10-8	11-3	11-9	12-4	12-10	13-3	13-9	14-2	14-8	15-1	15-6	15-11	16-3	16-6†	16-6†	16-6†
	19.2	5-7	6-6	7-3	7-11	8-7	9-2	9-9	10-3	10-9	11-3	11-8	12-2	12-7	13-0	13-4	13-9	14-2	14-6	14-10	15-2	15-7†	15-7†
	24.0	5-0	5-10	6-6	7-1	7-8	8-2	8-8	9-2	9-7	10-0	10-5	10-10	11-3	11-7	11-11	12-4	12-8	13-0	13-3	13-7	13-11	14-2
2 × 8	12.0	9-4	10-10	12-1	13-3	14-4	15-3	16-3	17-1	17-11	18-9	19-6	20-3	20-11	21-7	22-3	22-11	23-7	24-0†	24-0†	24-0†	24-0†	24-0†
	16.0	8-1	9-4	10-6	11-6	12-5	13-3	14-0	14-10	15-6	16-3	16-10	17-6	18-1	18-9	19-4	19-10	20-5	20-11	21-5	21-9†	21-9†	21-9†
	19.2	7-5	8-7	9-7	10-6	11-4	12-1	12-10	13-6	14-2	14-10	15-5	16-0	16-7	17-1	17-7	18-1	18-7	19-1	19-7	20-0	20-6†	20-6†
	24.0	6-7	7-8	8-7	9-4	10-1	10-10	11-6	12-1	12-8	13-3	13-9	14-4	14-10	15-3	15-9	16-3	16-8	17-1	17-6	17-11	18-4	18-9
2 × 10	12.0	11-11	13-9	15-5	16-11	18-3	19-6	20-8	21-10	22-10	23-11	24-10	25-10	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*
	16.0	10-4	11-11	13-4	14-8	15-10	16-11	17-11	18-11	19-10	20-8	21-6	22-4	23-1	23-11	24-7	25-4	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*
	19.2	9-5	10-11	12-2	13-4	14-5	15-5	16-4	17-3	18-1	18-11	19-8	20-5	21-1	21-10	22-6	23-1	23-9	24-5	25-0	25-7	26-0*	26-0*
	24.0	8-5	9-9	10-11	11-11	12-11	13-9	14-8	15-5	16-2	16-11	17-7	18-3	18-11	19-6	20-1	20-8	21-3	21-10	22-4	22-10	23-5	23-11
2 × 12	12.0	14-6	16-9	18-9	20-6	22-2	23-9	25-2	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*
	16.0	12-7	14-6	16-3	17-9	19-3	20-6	21-9	23-0	24-1	25-2	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*
	19.2	11-6	13-3	14-10	16-3	17-6	18-9	19-11	21-0	22-0	23-0	23-11	24-10	25-8	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*	26-0*
	24.0	10-3	11-10	13-3	14-6	15-8	16-9	17-9	18-9	19-8	20-6	21-5	22-2	23-0	23-9	24-5	25-2	25-10	26-0*	26-0*	26-0*	26-0*	26-0*
E	12.0	0.15	0.24	0.33	0.44	0.55	0.67	0.80	0.94	1.09	1.24	1.40	1.56	1.73	1.91	2.09	2.28	2.47	2.60	2.60	2.60	2.60	2.60
	16.0	0.13	0.21	0.29	0.38	0.48	0.58	0.70	0.82	0.94	1.07	1.21	1.35	1.50	1.65	1.81	1.97	2.14	2.31	2.48	2.60	2.60	2.60
	19.2	0.12	0.19	0.26	0.35	0.44	0.53	0.64	0.75	0.86	0.98	1.10	1.23	1.37	1.51	1.65	1.80	1.95	2.11	2.27	2.43	2.60	2.60
	24.0	0.11	0.17	0.24	0.31	0.39	0.48	0.57	0.67	0.77	0.88	0.99	1.10	1.22	1.35	1.48	1.61	1.75	1.89	2.03	2.18	2.33	2.48

Note: The required modulus of elasticity, E , in 1,000,000 pounds per square inch is shown at the bottom of each table, is limited to 2.6 million pounds per square inch, and is applicable to all lumber sizes shown.

* Spans are shown in feet-inches and are limited to 26 feet. Check sources of supply for availability of lumber in lengths greater than 20'.

† Spans are controlled by maximum E value of 2.6 million psi.

Table 7.9 Rafters With L/180 Deflection Limitation

Design Criteria
Deflection: For 20 psf live load
Limited to span in inches divided by 180
Strength: Live load of 20 psf plus dead load of 10 psf determines the required bending design value

Rafter Size (in.)	Spacing (in.)	Bending Design Value, F_b , (psi)																																
		200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700	2800	2900	3000				
2 x 4	12.0	3-8	4-6	5-3	5-10	6-5	6-11	7-5	7-10	8-3	8-8	9-0	9-5	9-9	10-1	10-5	10-9	11-1	11-4	11-8	11-11	12-3	12-6	12-9†	12-9†	12-9†	12-9†	12-9†	12-9†	12-9†				
	16.0	3-2	3-11	4-6	5-1	5-6	6-0	6-5	7-2	7-6	7-10	8-2	8-5	8-9	9-0	9-4	9-7	9-10	10-1	10-4	10-7	10-10	11-1	11-4	11-6	11-7†	11-7†	11-7†	11-7†	11-7†				
	19.2	2-11	3-7	4-1	4-7	5-1	5-5	5-10	6-2	6-6	6-10	7-2	7-5	7-9	8-0	8-3	8-6	8-9	9-0	9-3	9-5	9-8	9-11	10-1	10-4	10-6	10-9	10-10	10-11†	10-11†	10-11†			
	24.0	2-7	3-2	3-8	4-1	4-6	4-11	5-3	5-6	5-10	6-1	6-5	6-8	6-11	7-2	7-5	7-7	7-10	8-0	8-3	8-5	8-8	8-10	9-0	9-3	9-5	9-7	9-9	9-11	10-1	10-1			
2 x 6	12.0	5-10	7-1	8-2	9-2	10-0	10-10	11-7	12-4	13-0	13-7	14-2	14-9	15-4	15-11	16-5	16-11	17-5	17-10	18-4	18-9	19-3	19-8	20-0†	20-0†	20-0†	20-0†	20-0†	20-0†	20-0†	20-0†			
	16.0	5-0	6-2	7-1	7-11	8-8	9-5	10-0	10-8	11-3	11-9	12-4	12-10	13-3	13-9	14-2	14-8	15-1	15-6	15-11	16-3	16-8	17-0	17-5	17-9	18-1	18-2†	18-2†	18-2†	18-2†	18-2†			
	19.2	4-7	5-7	6-6	7-3	7-11	8-7	9-2	9-9	10-3	10-9	11-3	11-8	12-2	12-7	13-0	13-4	13-9	14-2	14-6	14-10	15-2	15-7	15-11	16-2	16-6	16-10	17-1†	17-1†	17-1†	17-1†	17-1†		
	24.0	4-1	5-0	5-10	6-6	7-1	7-8	8-2	8-8	9-2	9-7	10-0	10-5	10-10	11-3	11-7	11-11	12-4	12-8	13-0	13-3	13-7	13-11	14-2	14-6	14-9	15-1	15-4	15-7	15-11	15-11	15-11		
2 x 8	12.0	7-8	9-4	10-10	12-1	13-3	14-4	15-3	16-3	17-1	17-11	18-9	19-6	20-3	20-11	21-7	22-3	22-11	23-7	24-2	24-9	25-4	25-11	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†		
	16.0	6-7	8-1	9-4	10-6	11-6	12-5	13-3	14-0	14-10	15-6	16-3	16-10	17-6	18-1	18-9	19-4	19-10	20-5	20-11	21-5	21-11	22-5	22-11	23-5	23-10	24-0†	24-0†	24-0†	24-0†	24-0†	24-0†		
	19.2	6-0	7-5	8-7	9-7	10-6	11-4	12-1	12-10	13-6	14-2	14-10	15-5	16-0	16-7	17-1	17-7	18-1	18-7	19-1	19-7	20-0	20-6	20-11	21-4	21-9	22-2	22-7†	22-7†	22-7†	22-7†	22-7†	22-7†	
	24.0	5-5	6-7	7-8	8-7	9-4	10-1	10-10	11-6	12-1	12-8	13-3	13-9	14-4	14-10	15-3	15-9	16-3	16-8	17-1	17-6	17-11	18-4	18-9	19-1	19-6	19-10	20-3	20-7	20-11	20-11	20-11	20-11	
2 x 10	12.0	9-9	11-11	13-9	15-5	16-11	18-3	19-6	20-8	21-10	22-10	23-11	24-10	25-10	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†		
	16.0	8-5	10-4	11-11	13-4	14-8	15-10	16-11	17-11	18-11	19-10	20-8	21-6	22-4	23-1	23-11	24-7	25-4	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	
	19.2	7-8	9-5	10-11	12-2	13-4	14-5	15-5	16-4	17-3	18-1	18-11	19-8	20-5	21-1	21-10	22-6	23-1	23-9	24-5	25-0	25-7	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†
	24.0	6-11	8-5	9-9	10-11	11-11	12-11	13-9	14-8	15-5	16-2	16-11	17-7	18-3	18-11	19-6	20-1	20-8	21-3	21-10	22-4	22-10	23-5	23-11	24-5	24-10	25-4	25-10	26-0†	26-0†	26-0†	26-0†	26-0†	26-0†
E	12.0	0.06	0.12	0.18	0.25	0.33	0.41	0.51	0.60	0.71	0.82	0.93	1.05	1.17	1.30	1.43	1.57	1.71	1.85	2.00	2.15	2.31	2.47	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	
	16.0	0.05	0.10	0.15	0.22	0.28	0.36	0.44	0.52	0.61	0.71	0.80	0.91	1.01	1.13	1.24	1.36	1.48	1.60	1.73	1.86	2.00	2.14	2.28	2.42	2.57	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60
	19.2	0.05	0.09	0.14	0.20	0.26	0.33	0.40	0.48	0.56	0.64	0.73	0.83	0.93	1.03	1.13	1.24	1.35	1.46	1.58	1.70	1.82	1.95	2.08	2.21	2.34	2.48	2.60	2.60	2.60	2.60	2.60	2.60	2.60
	24.0	0.04	0.08	0.13	0.18	0.23	0.29	0.36	0.43	0.50	0.58	0.66	0.74	0.83	0.92	1.01	1.11	1.21	1.31	1.41	1.52	1.63	1.74	1.86	1.98	2.10	2.22	2.34	2.47	2.60	2.60	2.60	2.60	2.60

Note: The required modulus of elasticity, E , in 1,000,000 pounds per square inch is shown at the bottom of each table, is limited to 2.6 million pounds per square inch, and is applicable to all lumber sizes shown.

* Spans are shown in feet-inches and are limited to 26 feet. Check sources of supply for availability of lumber in lengths greater than 20'.

† Spans are controlled by maximum E value of 2.6 million psi.

7.2 Species Specific Span Tables

The tables in this Section provide joist and rafter spans for design criteria listed at the top of each table. These span tables are based on the most commonly available softwood lumber species used in construction and include:

- Douglas Fir-Larch
- Hem-Fir
- Southern Pine
- Spruce-Pine-Fir

Tables have been developed for the following applications:

Applications	Live Load (psf)	Dead Load (psf)	Deflection Limit	Table No.
Floor joists	40	10 & 20	Span/360	7.10
Ceiling joists	20	10	Span/240	7.11
Rafters	20	10 & 20	Span/240	7.12

Table 7.10 Floor Joist Spans for Common Lumber Species

(Residential Areas, Live Load = 40 psf, L/Δ = 360)

Joist Spacing	Species and Grade	Dead Load = 10 psf				Dead Load = 20 psf				
		2x6	2x8	2x10	2x12	2x6	2x8	2x10	2x12	
		Maximum Floor Joist Spans								
		(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)	
12 in.	Douglas Fir-Larch	SS	11 - 4	15 - 0	19 - 1	23 - 3	11 - 4	15 - 0	19 - 1	23 - 3
	Douglas Fir-Larch	#1	10 - 11	14 - 5	18 - 5	22 - 0	10 - 11	14 - 2	17 - 4	20 - 1
	Douglas Fir-Larch	#2	10 - 9	14 - 2	18 - 0	20 - 11	10 - 8	13 - 6	16 - 5	19 - 1
	Douglas Fir-Larch	#3	8 - 11	11 - 3	13 - 9	16 - 0	8 - 1	10 - 3	12 - 7	14 - 7
	Hem-Fir	SS	10 - 9	14 - 2	18 - 0	21 - 11	10 - 9	14 - 2	18 - 0	21 - 11
	Hem-Fir	#1	10 - 6	13 - 10	17 - 8	21 - 6	10 - 6	13 - 10	17 - 1	19 - 10
	Hem-Fir	#2	10 - 0	13 - 2	16 - 10	20 - 4	10 - 0	13 - 1	16 - 0	18 - 6
	Hem-Fir	#3	8 - 8	11 - 0	13 - 5	15 - 7	7 - 11	10 - 0	12 - 3	14 - 3
	Southern Pine	SS	11 - 2	14 - 8	18 - 9	22 - 10	11 - 2	14 - 8	18 - 9	22 - 10
	Southern Pine	#1	10 - 11	14 - 5	18 - 5	22 - 5	10 - 11	14 - 5	18 - 5	22 - 5
	Southern Pine	#2	10 - 9	14 - 2	18 - 0	21 - 9	10 - 9	14 - 2	16 - 11	19 - 10
	Southern Pine	#3	9 - 4	11 - 11	14 - 0	16 - 8	8 - 6	10 - 10	12 - 10	15 - 3
	Spruce-Pine Fir	SS	10 - 6	13 - 10	17 - 8	21 - 6	10 - 6	13 - 10	17 - 8	21 - 6
	Spruce-Pine Fir	#1	10 - 3	13 - 6	17 - 3	20 - 7	10 - 3	13 - 3	16 - 3	18 - 10
	Spruce-Pine Fir	#2	10 - 3	13 - 6	17 - 3	20 - 7	10 - 3	13 - 3	16 - 3	18 - 10
	Spruce-Pine Fir	#3	8 - 8	11 - 0	13 - 5	15 - 7	7 - 11	10 - 0	12 - 3	14 - 3
16 in.	Douglas Fir-Larch	SS	10 - 4	13 - 7	17 - 4	21 - 1	10 - 4	13 - 7	17 - 4	21 - 1
	Douglas Fir-Larch	#1	9 - 11	13 - 1	16 - 5	19 - 1	9 - 8	12 - 4	15 - 0	17 - 5
	Douglas Fir-Larch	#2	9 - 9	12 - 9	15 - 7	18 - 1	9 - 3	11 - 8	14 - 3	16 - 6
	Douglas Fir-Larch	#3	7 - 8	9 - 9	11 - 11	13 - 10	7 - 0	8 - 11	10 - 11	12 - 7
	Hem-Fir	SS	9 - 9	12 - 10	16 - 5	19 - 11	9 - 9	12 - 10	16 - 5	19 - 11
	Hem-Fir	#1	9 - 6	12 - 7	16 - 0	18 - 10	9 - 6	12 - 2	14 - 10	17 - 2
	Hem-Fir	#2	9 - 1	12 - 0	15 - 2	17 - 7	8 - 11	11 - 4	13 - 10	16 - 1
	Hem-Fir	#3	7 - 6	9 - 6	11 - 8	13 - 6	6 - 10	8 - 8	10 - 7	12 - 4
	Southern Pine	SS	10 - 2	13 - 4	17 - 0	20 - 9	10 - 2	13 - 4	17 - 0	20 - 9
	Southern Pine	#1	9 - 11	13 - 1	16 - 9	20 - 4	9 - 11	13 - 1	16 - 4	19 - 6
	Southern Pine	#2	9 - 9	12 - 10	16 - 1	18 - 10	9 - 6	12 - 4	14 - 8	17 - 2
	Southern Pine	#3	8 - 1	10 - 3	12 - 2	14 - 6	7 - 4	9 - 5	11 - 1	13 - 2
	Spruce-Pine Fir	SS	9 - 6	12 - 7	16 - 0	19 - 6	9 - 6	12 - 7	16 - 0	19 - 6
	Spruce-Pine Fir	#1	9 - 4	12 - 3	15 - 5	17 - 10	9 - 1	11 - 6	14 - 1	16 - 3
	Spruce-Pine Fir	#2	9 - 4	12 - 3	15 - 5	17 - 10	9 - 1	11 - 6	14 - 1	16 - 3
	Spruce-Pine Fir	#3	7 - 6	9 - 6	11 - 8	13 - 6	6 - 10	8 - 8	10 - 7	12 - 4
19.2 in.	Douglas Fir-Larch	SS	9 - 8	12 - 10	16 - 4	19 - 10	9 - 8	12 - 10	16 - 4	19 - 6
	Douglas Fir-Larch	#1	9 - 4	12 - 4	15 - 0	17 - 5	8 - 10	11 - 3	13 - 8	15 - 11
	Douglas Fir-Larch	#2	9 - 2	11 - 8	14 - 3	16 - 6	8 - 5	10 - 8	13 - 0	15 - 1
	Douglas Fir-Larch	#3	7 - 0	8 - 11	10 - 11	12 - 7	6 - 5	8 - 2	9 - 11	11 - 6
	Hem-Fir	SS	9 - 2	12 - 1	15 - 5	18 - 9	9 - 2	12 - 1	15 - 5	18 - 9
	Hem-Fir	#1	9 - 0	11 - 10	14 - 10	17 - 2	8 - 9	11 - 1	13 - 6	15 - 8
	Hem-Fir	#2	8 - 7	11 - 3	13 - 10	16 - 1	8 - 2	10 - 4	12 - 8	14 - 8
	Hem-Fir	#3	6 - 10	8 - 8	10 - 7	12 - 4	6 - 3	7 - 11	9 - 8	11 - 3
	Southern Pine	SS	9 - 6	12 - 7	16 - 0	19 - 6	9 - 6	12 - 7	16 - 0	19 - 6
	Southern Pine	#1	9 - 4	12 - 4	15 - 9	19 - 2	9 - 4	12 - 4	14 - 11	17 - 9
	Southern Pine	#2	9 - 2	12 - 1	14 - 8	17 - 2	8 - 8	11 - 3	13 - 5	15 - 8
	Southern Pine	#3	7 - 4	9 - 5	11 - 1	13 - 2	6 - 9	8 - 7	10 - 1	12 - 1
	Spruce-Pine Fir	SS	9 - 0	11 - 10	15 - 1	18 - 4	9 - 0	11 - 10	15 - 1	17 - 9
	Spruce-Pine Fir	#1	8 - 9	11 - 6	14 - 1	16 - 3	8 - 3	10 - 6	12 - 10	14 - 10
	Spruce-Pine Fir	#2	8 - 9	11 - 6	14 - 1	16 - 3	8 - 3	10 - 6	12 - 10	14 - 10
	Spruce-Pine Fir	#3	6 - 10	8 - 8	10 - 7	12 - 4	6 - 3	7 - 11	9 - 8	11 - 3
24 in.	Douglas Fir-Larch	SS	9 - 0	11 - 11	15 - 2	18 - 5	9 - 0	11 - 11	15 - 0	17 - 5
	Douglas Fir-Larch	#1	8 - 8	11 - 0	13 - 5	15 - 7	7 - 11	10 - 0	12 - 3	14 - 3
	Douglas Fir-Larch	#2	8 - 3	10 - 5	12 - 9	14 - 9	7 - 6	9 - 6	11 - 8	13 - 6
	Douglas Fir-Larch	#3	6 - 3	8 - 0	9 - 9	11 - 3	5 - 9	7 - 3	8 - 11	10 - 4
	Hem-Fir	SS	8 - 6	11 - 3	14 - 4	17 - 5	8 - 6	11 - 3	14 - 4	16 - 10
	Hem-Fir	#1	8 - 4	10 - 10	13 - 3	15 - 5	7 - 10	9 - 11	12 - 1	14 - 0
	Hem-Fir	#2	7 - 11	10 - 2	12 - 5	14 - 4	7 - 4	9 - 3	11 - 4	13 - 1
	Hem-Fir	#3	6 - 2	7 - 9	9 - 6	11 - 0	5 - 7	7 - 1	8 - 8	10 - 1
	Southern Pine	SS	8 - 10	11 - 8	14 - 11	18 - 1	8 - 10	11 - 8	14 - 11	18 - 1
	Southern Pine	#1	8 - 8	11 - 5	14 - 7	17 - 5	8 - 8	11 - 3	13 - 4	15 - 11
	Southern Pine	#2	8 - 6	11 - 0	13 - 1	15 - 5	7 - 9	10 - 0	12 - 0	14 - 0
	Southern Pine	#3	6 - 7	8 - 5	9 - 11	11 - 10	6 - 0	7 - 8	9 - 1	10 - 9
	Spruce-Pine Fir	SS	8 - 4	11 - 0	14 - 0	17 - 0	8 - 4	11 - 0	13 - 8	15 - 11
	Spruce-Pine Fir	#1	8 - 1	10 - 3	12 - 7	14 - 7	7 - 5	9 - 5	11 - 6	13 - 4
	Spruce-Pine Fir	#2	8 - 1	10 - 3	12 - 7	14 - 7	7 - 5	9 - 5	11 - 6	13 - 4
	Spruce-Pine Fir	#3	6 - 2	7 - 9	9 - 6	11 - 0	5 - 7	7 - 1	8 - 8	10 - 1

Check sources for availability of lumber in lengths greater than 20 feet.

Table 7.11 Ceiling Joist Spans for Common Lumber Species(Uninhabitable Attics With Limited Storage, Live Load = 20 psf, $L/\Delta = 240$)

Joist Spacing		Species and Grade		Dead Load = 10 psf			
				2x4	2x6	2x8	2x10
				Maximum Ceiling Joist Spans ¹			
		(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)		
12 in.	Douglas Fir-Larch	SS	10 - 5	16 - 4	21 - 7	*	
	Douglas Fir-Larch	#1	10 - 0	15 - 9	20 - 1	24 - 6	
	Douglas Fir-Larch	#2	9 - 10	15 - 0	19 - 1	23 - 3	
	Douglas Fir-Larch	#3	7 - 10	11 - 6	14 - 7	17 - 9	
	Hem-Fir	SS	9 - 10	15 - 6	20 - 5	*	
	Hem-Fir	#1	9 - 8	15 - 2	19 - 10	24 - 3	
	Hem-Fir	#2	9 - 2	14 - 5	18 - 6	22 - 7	
	Hem-Fir	#3	7 - 8	11 - 2	14 - 2	17 - 4	
	Southern Pine	SS	10 - 3	16 - 1	21 - 2	*	
	Southern Pine	#1	10 - 0	15 - 9	20 - 10	*	
	Southern Pine	#2	9 - 10	15 - 6	20 - 1	24 - 0	
	Southern Pine	#3	8 - 2	12 - 0	15 - 4	18 - 1	
	Spruce-Pine Fir	SS	9 - 8	15 - 2	19 - 11	25 - 5	
	Spruce-Pine Fir	#1	9 - 5	14 - 9	18 - 9	22 - 11	
	Spruce-Pine Fir	#2	9 - 5	14 - 9	18 - 9	22 - 11	
	Spruce-Pine Fir	#3	7 - 8	11 - 2	14 - 2	17 - 4	
16 in.	Douglas Fir-Larch	SS	9 - 6	14 - 11	19 - 7	25 - 0	
	Douglas Fir-Larch	#1	9 - 1	13 - 9	17 - 5	21 - 3	
	Douglas Fir-Larch	#2	8 - 11	13 - 0	16 - 6	20 - 2	
	Douglas Fir-Larch	#3	6 - 10	9 - 11	12 - 7	15 - 5	
	Hem-Fir	SS	8 - 11	14 - 1	18 - 6	23 - 8	
	Hem-Fir	#1	8 - 9	13 - 7	17 - 2	21 - 0	
	Hem-Fir	#2	8 - 4	12 - 8	16 - 0	19 - 7	
	Hem-Fir	#3	6 - 8	9 - 8	12 - 4	15 - 0	
	Southern Pine	SS	9 - 4	14 - 7	19 - 3	24 - 7	
	Southern Pine	#1	9 - 1	14 - 4	18 - 11	23 - 1	
	Southern Pine	#2	8 - 11	13 - 6	17 - 5	20 - 9	
	Southern Pine	#3	7 - 1	10 - 5	13 - 3	15 - 8	
	Spruce-Pine Fir	SS	8 - 9	13 - 9	18 - 2	23 - 1	
	Spruce-Pine Fir	#1	8 - 7	12 - 10	16 - 3	19 - 10	
	Spruce-Pine Fir	#2	8 - 7	12 - 10	16 - 3	19 - 10	
	Spruce-Pine Fir	#3	6 - 8	9 - 8	12 - 4	15 - 0	
19.2 in.	Douglas Fir-Larch	SS	8 - 11	14 - 0	18 - 5	23 - 7	
	Douglas Fir-Larch	#1	8 - 7	12 - 6	15 - 10	19 - 5	
	Douglas Fir-Larch	#2	8 - 2	11 - 11	15 - 1	18 - 5	
	Douglas Fir-Larch	#3	6 - 2	9 - 1	11 - 6	14 - 1	
	Hem-Fir	SS	8 - 5	13 - 3	17 - 5	22 - 3	
	Hem-Fir	#1	8 - 3	12 - 4	15 - 8	19 - 2	
	Hem-Fir	#2	7 - 10	11 - 7	14 - 8	17 - 10	
	Hem-Fir	#3	6 - 1	8 - 10	11 - 3	13 - 8	
	Southern Pine	SS	8 - 9	13 - 9	18 - 2	23 - 1	
	Southern Pine	#1	8 - 7	13 - 6	17 - 9	21 - 1	
	Southern Pine	#2	8 - 5	12 - 3	15 - 10	18 - 11	
	Southern Pine	#3	6 - 5	9 - 6	12 - 1	14 - 4	
	Spruce-Pine Fir	SS	8 - 3	12 - 11	17 - 1	21 - 8	
	Spruce-Pine Fir	#1	8 - 0	11 - 9	14 - 10	18 - 2	
	Spruce-Pine Fir	#2	8 - 0	11 - 9	14 - 10	18 - 2	
	Spruce-Pine Fir	#3	6 - 1	8 - 10	11 - 3	13 - 8	
24 in.	Douglas Fir-Larch	SS	8 - 3	13 - 0	17 - 2	21 - 3	
	Douglas Fir-Larch	#1	7 - 8	11 - 2	14 - 2	17 - 4	
	Douglas Fir-Larch	#2	7 - 3	10 - 8	13 - 6	16 - 5	
	Douglas Fir-Larch	#3	5 - 7	8 - 1	10 - 3	12 - 7	
	Hem-Fir	SS	7 - 10	12 - 3	16 - 2	20 - 6	
	Hem-Fir	#1	7 - 7	11 - 1	14 - 0	17 - 1	
	Hem-Fir	#2	7 - 1	10 - 4	13 - 1	16 - 0	
	Hem-Fir	#3	5 - 5	7 - 11	10 - 0	12 - 3	
	Southern Pine	SS	8 - 1	12 - 9	16 - 10	21 - 6	
	Southern Pine	#1	8 - 0	12 - 6	15 - 10	18 - 10	
	Southern Pine	#2	7 - 8	11 - 0	14 - 2	16 - 11	
	Southern Pine	#3	5 - 9	8 - 6	10 - 10	12 - 10	
	Spruce-Pine Fir	SS	7 - 8	12 - 0	15 - 10	19 - 5	
	Spruce-Pine Fir	#1	7 - 2	10 - 6	13 - 3	16 - 3	
	Spruce-Pine Fir	#2	7 - 2	10 - 6	13 - 3	16 - 3	
	Spruce-Pine Fir	#3	5 - 5	7 - 11	10 - 0	12 - 3	

¹ Bracing shall be provided in accordance with 3.3.1.4.

* Spans are limited to 26 feet in length. Check sources for availability of lumber in lengths greater than 20 feet.

Table 7.12 Rafter Spans for Common Lumber Species

(Ceiling Attached to Rafters, Live Load = 20 psf, L/Δ = 240)

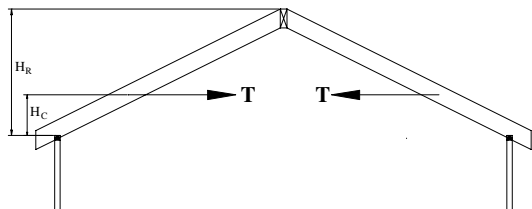
Joist Spacing	Species and Grade	Dead Load = 10 psf					Dead Load = 20 psf				
		2x4	2x6	2x8	2x10	2x12	2x4	2x6	2x8	2x10	2x12
		Maximum Rafter Spans ^{1,2,3}									
(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)	
12 in.	Douglas Fir-Larch SS	10 - 5	16 - 4	21 - 7	*	*	10 - 5	16 - 4	21 - 7	*	*
	Douglas Fir-Larch #1	10 - 0	15 - 9	20 - 10	*	*	10 - 0	15 - 4	19 - 5	23 - 9	*
	Douglas Fir-Larch #2	9 - 10	15 - 6	20 - 5	*	*	9 - 10	14 - 7	18 - 5	22 - 6	*
	Douglas Fir-Larch #3	8 - 9	12 - 10	16 - 3	19 - 10	23 - 0	7 - 7	11 - 1	14 - 1	17 - 2	19 - 11
	Hem-Fir SS	9 - 10	15 - 6	20 - 5	*	*	9 - 10	15 - 6	20 - 5	*	*
	Hem-Fir #1	9 - 8	15 - 2	19 - 11	25 - 5	*	9 - 8	15 - 2	19 - 2	23 - 5	*
	Hem-Fir #2	9 - 2	14 - 5	19 - 0	24 - 3	*	9 - 2	14 - 2	17 - 11	21 - 11	25 - 5
	Hem-Fir #3	8 - 7	12 - 6	15 - 10	19 - 5	22 - 6	7 - 5	10 - 10	13 - 9	16 - 9	19 - 6
	Southern Pine SS	10 - 3	16 - 1	21 - 2	*	*	10 - 3	16 - 1	21 - 2	*	*
	Southern Pine #1	10 - 0	15 - 9	20 - 10	*	*	10 - 0	15 - 9	20 - 10	25 - 10	*
	Southern Pine #2	9 - 10	15 - 6	20 - 5	*	*	9 - 10	15 - 1	19 - 5	23 - 2	*
	Southern Pine #3	9 - 1	13 - 6	17 - 2	20 - 3	24 - 1	7 - 11	11 - 8	14 - 10	17 - 6	20 - 11
	Spruce-Pine Fir SS	9 - 8	15 - 2	19 - 11	25 - 5	*	9 - 8	15 - 2	19 - 11	25 - 5	*
	Spruce-Pine Fir #1	9 - 5	14 - 9	19 - 6	24 - 10	*	9 - 5	14 - 4	18 - 2	22 - 3	25 - 9
	Spruce-Pine Fir #2	9 - 5	14 - 9	19 - 6	24 - 10	*	9 - 5	14 - 4	18 - 2	22 - 3	25 - 9
Spruce-Pine Fir #3	8 - 7	12 - 6	15 - 10	19 - 5	22 - 6	7 - 5	10 - 10	13 - 9	16 - 9	19 - 6	
16 in.	Douglas Fir-Larch SS	9 - 6	14 - 11	19 - 7	25 - 0	*	9 - 6	14 - 11	19 - 7	25 - 0	*
	Douglas Fir-Larch #1	9 - 1	14 - 4	18 - 11	23 - 9	*	9 - 1	13 - 3	16 - 10	20 - 7	23 - 10
	Douglas Fir-Larch #2	8 - 11	14 - 1	18 - 5	22 - 6	*	8 - 7	12 - 7	16 - 0	19 - 6	22 - 7
	Douglas Fir-Larch #3	7 - 7	11 - 1	14 - 1	17 - 2	19 - 11	6 - 7	9 - 8	12 - 2	14 - 11	17 - 3
	Hem-Fir SS	8 - 11	14 - 1	18 - 6	23 - 8	*	8 - 11	14 - 1	18 - 6	23 - 8	*
	Hem-Fir #1	8 - 9	13 - 9	18 - 2	23 - 1	*	8 - 9	13 - 1	16 - 7	20 - 4	23 - 7
	Hem-Fir #2	8 - 4	13 - 1	17 - 3	21 - 11	25 - 5	8 - 4	12 - 3	15 - 6	19 - 0	22 - 0
	Hem-Fir #3	7 - 5	10 - 10	13 - 9	16 - 9	19 - 6	6 - 5	9 - 5	11 - 11	14 - 6	16 - 10
	Southern Pine SS	9 - 4	14 - 7	19 - 3	24 - 7	*	9 - 4	14 - 7	19 - 3	24 - 7	*
	Southern Pine #1	9 - 1	14 - 4	18 - 11	24 - 1	*	9 - 1	14 - 4	18 - 10	22 - 4	*
	Southern Pine #2	8 - 11	14 - 1	18 - 6	23 - 2	*	8 - 11	13 - 0	16 - 10	20 - 1	23 - 7
	Southern Pine #3	7 - 11	11 - 8	14 - 10	17 - 6	20 - 11	6 - 10	10 - 1	12 - 10	15 - 2	18 - 1
	Spruce-Pine Fir SS	8 - 9	13 - 9	18 - 2	23 - 1	*	8 - 9	13 - 9	18 - 2	23 - 0	*
	Spruce-Pine Fir #1	8 - 7	13 - 5	17 - 9	22 - 3	25 - 9	8 - 6	12 - 5	15 - 9	19 - 3	22 - 4
	Spruce-Pine Fir #2	8 - 7	13 - 5	17 - 9	22 - 3	25 - 9	8 - 6	12 - 5	15 - 9	19 - 3	22 - 4
Spruce-Pine Fir #3	7 - 5	10 - 10	13 - 9	16 - 9	19 - 6	6 - 5	9 - 5	11 - 11	14 - 6	16 - 10	
19.2 in.	Douglas Fir-Larch SS	8 - 11	14 - 0	18 - 5	23 - 7	*	8 - 11	14 - 0	18 - 5	23 - 0	*
	Douglas Fir-Larch #1	8 - 7	13 - 6	17 - 9	21 - 8	25 - 2	8 - 4	12 - 2	15 - 4	18 - 9	21 - 9
	Douglas Fir-Larch #2	8 - 5	13 - 3	16 - 10	20 - 7	23 - 10	7 - 10	11 - 6	14 - 7	17 - 10	20 - 8
	Douglas Fir-Larch #3	6 - 11	10 - 2	12 - 10	15 - 8	18 - 3	6 - 0	8 - 9	11 - 2	13 - 7	15 - 9
	Hem-Fir SS	8 - 5	13 - 3	17 - 5	22 - 3	*	8 - 5	13 - 3	17 - 5	22 - 3	25 - 9
	Hem-Fir #1	8 - 3	12 - 11	17 - 1	21 - 5	24 - 10	8 - 2	12 - 0	15 - 2	18 - 6	21 - 6
	Hem-Fir #2	7 - 10	12 - 4	16 - 3	20 - 0	23 - 2	7 - 8	11 - 2	14 - 2	17 - 4	20 - 1
	Hem-Fir #3	6 - 9	9 - 11	12 - 7	15 - 4	17 - 9	5 - 10	8 - 7	10 - 10	13 - 3	15 - 5
	Southern Pine SS	8 - 9	13 - 9	18 - 2	23 - 1	*	8 - 9	13 - 9	18 - 2	23 - 1	*
	Southern Pine #1	8 - 7	13 - 6	17 - 9	22 - 8	*	8 - 7	13 - 6	17 - 2	20 - 5	24 - 4
	Southern Pine #2	8 - 5	13 - 3	17 - 5	21 - 2	24 - 10	8 - 4	11 - 11	15 - 4	18 - 4	21 - 6
	Southern Pine #3	7 - 3	10 - 8	13 - 7	16 - 0	19 - 1	6 - 3	9 - 3	11 - 9	13 - 10	16 - 6
	Spruce-Pine Fir SS	8 - 3	12 - 11	17 - 1	21 - 9	*	8 - 3	12 - 11	17 - 1	21 - 0	24 - 4
	Spruce-Pine Fir #1	8 - 1	12 - 8	16 - 7	20 - 3	23 - 6	7 - 9	11 - 4	14 - 4	17 - 7	20 - 4
	Spruce-Pine Fir #2	8 - 1	12 - 8	16 - 7	20 - 3	23 - 6	7 - 9	11 - 4	14 - 4	17 - 7	20 - 4
Spruce-Pine Fir #3	6 - 9	9 - 11	12 - 7	15 - 4	17 - 9	5 - 10	8 - 7	10 - 10	13 - 3	15 - 5	
24 in.	Douglas Fir-Larch SS	8 - 3	13 - 0	17 - 2	21 - 10	*	8 - 3	13 - 0	16 - 10	20 - 7	23 - 10
	Douglas Fir-Larch #1	8 - 0	12 - 6	15 - 10	19 - 5	22 - 6	7 - 5	10 - 10	13 - 9	16 - 9	19 - 6
	Douglas Fir-Larch #2	7 - 10	11 - 11	15 - 1	18 - 5	21 - 4	7 - 0	10 - 4	13 - 0	15 - 11	18 - 6
	Douglas Fir-Larch #3	6 - 2	9 - 1	11 - 6	14 - 1	16 - 3	5 - 4	7 - 10	10 - 0	12 - 2	14 - 1
	Hem-Fir SS	7 - 10	12 - 3	16 - 2	20 - 8	25 - 1	7 - 10	12 - 3	16 - 2	19 - 10	23 - 0
	Hem-Fir #1	7 - 8	12 - 0	15 - 8	19 - 2	22 - 2	7 - 4	10 - 9	13 - 7	16 - 7	19 - 3
	Hem-Fir #2	7 - 3	11 - 5	14 - 8	17 - 10	20 - 9	6 - 10	10 - 0	12 - 8	15 - 6	17 - 11
	Hem-Fir #3	6 - 1	8 - 10	11 - 3	13 - 8	15 - 11	5 - 3	7 - 8	9 - 9	11 - 10	13 - 9
	Southern Pine SS	8 - 1	12 - 9	16 - 10	21 - 6	*	8 - 1	12 - 9	16 - 10	21 - 6	*
	Southern Pine #1	8 - 0	12 - 6	16 - 6	21 - 1	25 - 2	8 - 0	12 - 3	15 - 4	18 - 3	21 - 9
	Southern Pine #2	7 - 10	12 - 3	15 - 10	18 - 11	22 - 2	7 - 5	10 - 8	13 - 9	16 - 5	19 - 3
	Southern Pine #3	6 - 5	9 - 6	12 - 1	14 - 4	17 - 1	5 - 7	8 - 3	10 - 6	12 - 5	14 - 9
	Spruce-Pine Fir SS	7 - 8	12 - 0	15 - 10	20 - 2	24 - 7	7 - 8	12 - 0	15 - 4	18 - 9	21 - 9
	Spruce-Pine Fir #1	7 - 6	11 - 9	14 - 10	18 - 2	21 - 0	6 - 11	10 - 2	12 - 10	15 - 8	18 - 3
	Spruce-Pine Fir #2	7 - 6	11 - 9	14 - 10	18 - 2	21 - 0	6 - 11	10 - 2	12 - 10	15 - 8	18 - 3
Spruce-Pine Fir #3	6 - 1	8 - 10	11 - 3	13 - 8	15 - 11	5 - 3	7 - 8	9 - 9	11 - 10	13 - 9	

* Spans are limited to 26 feet in length. Check sources for availability of lumber in lengths greater than 20 feet. See footnotes 1-3.

7
SPAN TABLES

Footnotes to Table 7.12

- ¹ Tabulated rafter spans assume ceiling joists or rafter ties are located at the bottom of the attic space to resist thrust. When ceiling joists or rafter ties are located higher in the attic space, the rafter spans shall be multiplied by the factors given in the following table:



ceiling Height/Roof Ridge Height (H_C/H_R)	Rafter Span Adjustment Factors
1/2	0.58
1/3	0.67
1/4	0.76
1/5	0.83
1/6	0.90
1/7.5 and less	1.00

Note: Lateral deflection of the rafter below the rafter ties may exceed 3/4 inch when rafter ties are located above one-third of the ridge height, H_r , or when H_c is greater than 2 feet and may require additional consideration.

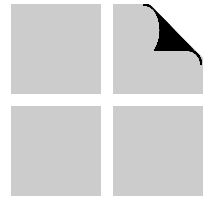
- ² Tabulated rafter spans are based on roof dead and live loads. For Exposure B wind loads, the rafter span adjustment factor, which shall not exceed 1.0, shall be multiplied times the rafter spans in Table 7.12. For Exposure C, rafter span adjustments shall be multiplied by 0.8.

RAFTER SPAN ADJUSTMENT FOR EXPOSURE B & C WIND LOADS

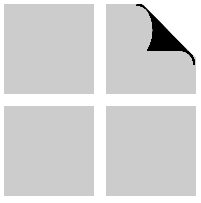
Three Second Gust Wind Speed (mph)	85	90	100	110	120	130	140	150
Roof Pitch	Rafter Span Adjustment Factor for Dual-Pitched Roofs							
0:12	1.18	1.10	0.97	0.87	0.79	0.73	0.67	0.62
1:12	1.17	1.09	0.97	0.87	0.79	0.72	0.67	0.62
2:12	1.16	1.08	0.96	0.86	0.78	0.72	0.66	0.61
3:12	1.34	1.25	1.10	0.98	0.89	0.81	0.75	0.70
4:12	1.30	1.21	1.07	0.96	0.87	0.79	0.73	0.68
5:12	1.24	1.15	1.02	0.91	0.83	0.76	0.70	0.65
6:12	1.17	1.09	0.96	0.86	0.78	0.72	0.66	0.62
7:12	1.52	1.41	1.23	1.09	0.98	0.90	0.82	0.76
8:12	1.42	1.31	1.15	1.02	0.92	0.84	0.78	0.72
9:12	1.32	1.22	1.07	0.96	0.87	0.79	0.73	0.68
10:12	1.22	1.14	1.00	0.89	0.81	0.74	0.68	0.63
11:12	1.14	1.06	0.93	0.84	0.76	0.69	0.64	0.59
12:12	1.06	0.98	0.87	0.78	0.71	0.65	0.60	0.56

- ³ Tabulated rafter spans in Table 7.12 shall be permitted to be multiplied by the sloped roof adjustment factors in the following table, for roof pitches greater than 4:12:

Roof Pitch	20 psf Live, 20 psf Dead	20 psf Live, 20 psf Dead
	Adjustment Factor for Sloped Roofs	
5:12	1.02	1.01
6:12	1.04	1.03
7:12	1.05	1.04
8:12	1.07	1.05
9:12	1.10	1.07
10:12	1.12	1.08
11:12	1.14	1.10
12:12	1.17	1.12



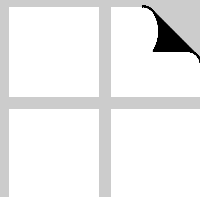
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SECTION PROPERTIES

8.1 Cross-Section Properties L-62

Table 8.1 Section Properties of Standard Dressed (S4S)
Sawn Lumber L-62



8.1 Cross-Section Properties¹

Table 8.1 Section Properties of Standard Dressed (S4S) Sawn Lumber

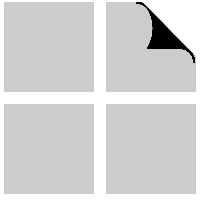
Nominal Size b × d	Standard Dressed Size (S4S) b × d inches × inches	Area of Section A in. ²	X-X AXIS		Y-Y AXIS		Approximate weight in pounds per linear foot (lb/ft) of piece when density of wood equals:					
			Section Modulus S _x in. ³	Moment of Inertia I _x in. ⁴	Section Modulus S _y in. ³	Moment of Inertia I _y in. ⁴	25 lb./ft. ³	30 lb./ft. ³	35 lb./ft. ³	40 lb./ft. ³	45 lb./ft. ³	50 lb./ft. ³
1 × 3	3/4 × 2-1/2	1.875	0.781	0.977	0.234	0.088	0.326	0.391	0.456	0.521	0.586	0.651
1 × 4	3/4 × 3-1/2	2.625	1.531	2.680	0.328	0.123	0.456	0.547	0.638	0.729	0.820	0.911
1 × 6	3/4 × 5-1/2	4.125	3.781	10.40	0.516	0.193	0.716	0.859	1.003	1.146	1.289	1.432
1 × 8	3/4 × 7-1/4	5.438	6.570	23.82	0.680	0.255	0.944	1.133	1.322	1.510	1.699	1.888
1 × 10	3/4 × 9-1/4	6.938	10.70	49.47	0.867	0.325	1.204	1.445	1.686	1.927	2.168	2.409
1 × 12	3/4 × 11-1/4	8.438	15.82	88.99	1.055	0.396	1.465	1.758	2.051	2.344	2.637	2.930
2 × 3	1-1/2 × 2-1/2	3.750	1.563	1.953	0.938	0.703	0.651	0.781	0.911	1.042	1.172	1.302
2 × 4	1-1/2 × 3-1/2	5.250	3.063	5.359	1.313	0.984	0.911	1.094	1.276	1.458	1.641	1.823
2 × 5	1-1/2 × 4-1/2	6.750	5.063	11.39	1.688	1.266	1.172	1.406	1.641	1.875	2.109	2.344
2 × 6	1-1/2 × 5-1/2	8.250	7.563	20.80	2.063	1.547	1.432	1.719	2.005	2.292	2.578	2.865
2 × 8	1-1/2 × 7-1/4	10.88	13.14	47.63	2.719	2.039	1.888	2.266	2.643	3.021	3.398	3.776
2 × 10	1-1/2 × 9-1/4	13.88	21.39	98.93	3.469	2.602	2.409	2.891	3.372	3.854	4.336	4.818
2 × 12	1-1/2 × 11-1/4	16.88	31.64	178.0	4.219	3.164	2.930	3.516	4.102	4.688	5.273	5.859
2 × 14	1-1/2 × 13-1/4	19.88	43.89	290.8	4.969	3.727	3.451	4.141	4.831	5.521	6.211	6.901
3 × 4	2-1/2 × 3-1/2	8.750	5.104	8.932	3.646	4.557	1.519	1.823	2.127	2.431	2.734	3.038
3 × 5	2-1/2 × 4-1/2	11.25	8.438	18.98	4.688	5.859	1.953	2.344	2.734	3.125	3.516	3.906
3 × 6	2-1/2 × 5-1/2	13.75	12.60	34.66	5.729	7.161	2.387	2.865	3.342	3.819	4.297	4.774
3 × 8	2-1/2 × 7-1/4	18.13	21.90	79.39	7.552	9.440	3.147	3.776	4.405	5.035	5.664	6.293
3 × 10	2-1/2 × 9-1/4	23.13	35.65	164.9	9.635	12.04	4.015	4.818	5.621	6.424	7.227	8.030
3 × 12	2-1/2 × 11-1/4	28.13	52.73	296.6	11.72	14.65	4.883	5.859	6.836	7.813	8.789	9.766
3 × 14	2-1/2 × 13-1/4	33.13	73.15	484.6	13.80	17.25	5.751	6.901	8.051	9.201	10.35	11.50
3 × 16	2-1/2 × 15-1/4	38.13	96.90	738.9	15.89	19.86	6.619	7.943	9.266	10.59	11.91	13.24
4 × 4	3-1/2 × 3-1/2	12.25	7.146	12.51	7.146	12.51	2.127	2.552	2.977	3.403	3.828	4.253
4 × 5	3-1/2 × 4-1/2	15.75	11.81	26.58	9.188	16.08	2.734	3.281	3.828	4.375	4.922	5.469
4 × 6	3-1/2 × 5-1/2	19.25	17.65	48.53	11.23	19.65	3.342	4.010	4.679	5.347	6.016	6.684
4 × 8	3-1/2 × 7-1/4	25.38	30.66	111.1	14.80	25.90	4.405	5.286	6.168	7.049	7.930	8.811
4 × 10	3-1/2 × 9-1/4	32.38	49.91	230.8	18.89	33.05	5.621	6.745	7.869	8.993	10.12	11.24
4 × 12	3-1/2 × 11-1/4	39.38	73.83	415.3	22.97	40.20	6.836	8.203	9.570	10.94	12.30	13.67
4 × 14	3-1/2 × 13-1/4	46.38	102.4	678.5	27.05	47.34	8.051	9.661	11.27	12.88	14.49	16.10
4 × 16	3-1/2 × 15-1/4	53.38	135.7	1034	31.14	54.49	9.266	11.12	12.97	14.83	16.68	18.53
5 × 5	4-1/2 × 4-1/2	20.25	15.19	34.17	15.19	34.17	3.516	4.219	4.922	5.625	6.328	7.031
6 × 6	5-1/2 × 5-1/2	30.25	27.73	76.26	27.73	76.26	5.252	6.302	7.352	8.403	9.453	10.50
6 × 8	5-1/2 × 7-1/2	41.25	51.56	193.4	37.81	104.0	7.161	8.594	10.03	11.46	12.89	14.32
6 × 10	5-1/2 × 9-1/2	52.25	82.73	393.0	47.90	131.7	9.071	10.89	12.70	14.51	16.33	18.14
6 × 12	5-1/2 × 11-1/2	63.25	121.2	697.1	57.98	159.4	10.98	13.18	15.37	17.57	19.77	21.96
6 × 14	5-1/2 × 13-1/2	74.25	167.1	1128	68.06	187.2	12.89	15.47	18.05	20.63	23.20	25.78
6 × 16	5-1/2 × 15-1/2	85.25	220.2	1707	78.15	214.9	14.80	17.76	20.72	23.68	26.64	29.60
6 × 18	5-1/2 × 17-1/2	96.25	280.7	2456	88.23	242.6	16.71	20.05	23.39	26.74	30.08	33.42
6 × 20	5-1/2 × 19-1/2	107.3	348.6	3398	98.31	270.4	18.62	22.34	26.07	29.79	33.52	37.24
6 × 22	5-1/2 × 21-1/2	118.3	423.7	4555	108.4	298.1	20.53	24.64	28.74	32.85	36.95	41.06
6 × 24	5-1/2 × 23-1/2	129.3	506.2	5948	118.5	325.8	22.44	26.93	31.41	35.90	40.39	44.88
8 × 8	7-1/2 × 7-1/2	56.25	70.31	263.7	70.31	263.7	9.766	11.72	13.67	15.63	17.58	19.53
8 × 10	7-1/2 × 9-1/2	71.25	112.8	535.9	89.06	334.0	12.37	14.84	17.32	19.79	22.27	24.74
8 × 12	7-1/2 × 11-1/2	86.25	165.3	950.5	107.8	404.3	14.97	17.97	20.96	23.96	26.95	29.95
8 × 14	7-1/2 × 13-1/2	101.3	227.8	1538	126.6	474.6	17.58	21.09	24.61	28.13	31.64	35.16
8 × 16	7-1/2 × 15-1/2	116.3	300.3	2327	145.3	544.9	20.18	24.22	28.26	32.29	36.33	40.36
8 × 18	7-1/2 × 17-1/2	131.3	382.8	3350	164.1	615.2	22.79	27.34	31.90	36.46	41.02	45.57
8 × 20	7-1/2 × 19-1/2	146.3	475.3	4634	182.8	685.5	25.39	30.47	35.55	40.63	45.70	50.78
8 × 22	7-1/2 × 21-1/2	161.3	577.8	6211	201.6	755.9	27.99	33.59	39.19	44.79	50.39	55.99
8 × 24	7-1/2 × 23-1/2	176.3	690.3	8111	220.3	826.2	30.60	36.72	42.84	48.96	55.08	61.20
10 × 10	9-1/2 × 9-1/2	90.25	142.9	678.8	142.9	678.8	15.67	18.80	21.94	25.07	28.20	31.34
10 × 12	9-1/2 × 11-1/2	109.3	209.4	1204	173.0	821.7	18.97	22.76	26.55	30.35	34.14	37.93
10 × 14	9-1/2 × 13-1/2	128.3	288.6	1948	203.1	964.5	22.27	26.72	31.17	35.63	40.08	44.53
10 × 16	9-1/2 × 15-1/2	147.3	380.4	2948	233.1	1107	25.56	30.68	35.79	40.90	46.02	51.13
10 × 18	9-1/2 × 17-1/2	166.3	484.9	4243	263.2	1250	28.86	34.64	40.41	46.18	51.95	57.73
10 × 20	9-1/2 × 19-1/2	185.3	602.1	5870	293.3	1393	32.16	38.59	45.03	51.46	57.89	64.32
10 × 22	9-1/2 × 21-1/2	204.3	731.9	7868	323.4	1536	35.46	42.55	49.64	56.74	63.83	70.92
10 × 24	9-1/2 × 23-1/2	223.3	874.4	10270	353.5	1679	38.76	46.51	54.26	62.01	69.77	77.52

¹ Nominal and minimum dressed sizes are provided in Table 8.1 for boards, dimension lumber, and timbers. The table provides the corresponding section properties about the primary (X-X) and secondary (Y-Y) axes for these products. This table is a reprint of Table 1B of the *NDS Supplement*.

Table 8.1 Section Properties of Standard Dressed (S4S) Sawn Lumber¹ (Cont.)

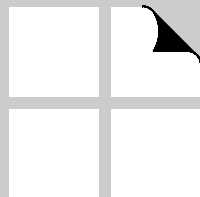
Nominal Size b × d	Standard Dressed Size (S4S) b × d inches × inches	Area of Section A in. ²	X-X AXIS		Y-Y AXIS		Approximate weight in pounds per linear foot (lb/ft) of piece when density of wood equals:					
			Section Modulus S _x in. ³	Moment of Inertia I _x in. ⁴	Section Modulus S _y in. ³	Moment of Inertia I _y in. ⁴	25 lb./ft. ³	30 lb./ft. ³	35 lb./ft. ³	40 lb./ft. ³	45 lb./ft. ³	50 lb./ft. ³
12 × 12	11-1/2 × 11-1/2	132.3	253.5	1458	253.5	1458	22.96	27.55	32.14	36.74	41.33	45.92
12 × 14	11-1/2 × 13-1/2	155.3	349.3	2358	297.6	1711	26.95	32.34	37.73	43.13	48.52	53.91
12 × 16	11-1/2 × 15-1/2	178.3	460.5	3569	341.6	1964	30.95	37.14	43.32	49.51	55.70	61.89
12 × 18	11-1/2 × 17-1/2	201.3	587.0	5136	385.7	2218	34.94	41.93	48.91	55.90	62.89	69.88
12 × 20	11-1/2 × 19-1/2	224.3	728.8	7106	429.8	2471	38.93	46.72	54.51	62.29	70.08	77.86
12 × 22	11-1/2 × 21-1/2	247.3	886.0	9524	473.9	2725	42.93	51.51	60.10	68.68	77.27	85.85
12 × 24	11-1/2 × 23-1/2	270.3	1058	12440	518.0	2978	46.92	56.30	65.69	75.07	84.45	93.84
14 × 14	13-1/2 × 13-1/2	182.3	410.1	2768	410.1	2768	31.64	37.97	44.30	50.63	56.95	63.28
14 × 16	13-1/2 × 15-1/2	209.3	540.6	4189	470.8	3178	36.33	43.59	50.86	58.13	65.39	72.66
14 × 18	13-1/2 × 17-1/2	236.3	689.1	6029	531.6	3588	41.02	49.22	57.42	65.63	73.83	82.03
14 × 20	13-1/2 × 19-1/2	263.3	855.6	8342	592.3	3998	45.70	54.84	63.98	73.13	82.27	91.41
14 × 22	13-1/2 × 21-1/2	290.3	1040	11180	653.1	4408	50.39	60.47	70.55	80.63	90.70	100.8
14 × 24	13-1/2 × 23-1/2	317.3	1243	14600	713.8	4818	55.08	66.09	77.11	88.13	99.14	110.2
16 × 16	15-1/2 × 15-1/2	240.3	620.6	4810	620.6	4810	41.71	50.05	58.39	66.74	75.08	83.42
16 × 18	15-1/2 × 17-1/2	271.3	791.1	6923	700.7	5431	47.09	56.51	65.93	75.35	84.77	94.18
16 × 20	15-1/2 × 19-1/2	302.3	982.3	9578	780.8	6051	52.47	62.97	73.46	83.96	94.45	104.9
16 × 22	15-1/2 × 21-1/2	333.3	1194	12840	860.9	6672	57.86	69.43	81.00	92.57	104.1	115.7
16 × 24	15-1/2 × 23-1/2	364.3	1427	16760	941.0	7293	63.24	75.89	88.53	101.2	113.8	126.5
18 × 18	17-1/2 × 17-1/2	306.3	893.2	7816	893.2	7816	53.17	63.80	74.44	85.07	95.70	106.3
18 × 20	17-1/2 × 19-1/2	341.3	1109	10810	995.3	8709	59.24	71.09	82.94	94.79	106.6	118.5
18 × 22	17-1/2 × 21-1/2	376.3	1348	14490	1097	9602	65.32	78.39	91.45	104.5	117.6	130.6
18 × 24	17-1/2 × 23-1/2	411.3	1611	18930	1199	10500	71.40	85.68	99.96	114.2	128.5	142.8
20 × 20	19-1/2 × 19-1/2	380.3	1236	12050	1236	12050	66.02	79.22	92.42	105.6	118.8	132.0
20 × 22	19-1/2 × 21-1/2	419.3	1502	16150	1363	13280	72.79	87.34	101.9	116.5	131.0	145.6
20 × 24	19-1/2 × 23-1/2	458.3	1795	21090	1489	14520	79.56	95.47	111.4	127.3	143.2	159.1
22 × 22	21-1/2 × 21-1/2	462.3	1656	17810	1656	17810	80.25	96.30	112.4	128.4	144.5	160.5
22 × 24	21-1/2 × 23-1/2	505.3	1979	23250	1810	19460	87.72	105.3	122.8	140.3	157.9	175.4
24 × 24	23-1/2 × 23-1/2	552.3	2163	25420	2163	25420	95.88	115.1	134.2	153.4	172.6	191.8

¹ Nominal and minimum dressed sizes are provided in Table 8.1 for boards, dimension lumber, and timbers. The table provides the corresponding section properties about the primary (X-X) and secondary (Y-Y) axes for these products. This table is a reprint of Table 1B of the *NDS Supplement*.



APPENDIX

Example of Chapter 5 Capacity Table Development	L-66
Tension Capacity Tables	L-66
Stud Wall Capacity Tables/Column Capacity Tables	L-66
Joist Capacity Tables	L-67
Beam Capacity Tables	L-68

A

Appendix: Example of Chapter 5 Capacity Table Development¹

Tension Capacity Tables

The general design equation for tension members is:

$$T' \geq T$$

where

T = tension force due to design loads

T' = allowable tension capacity

Example 1: Application — tension member

Species: Hem-Fir

Size: 2 x 6 (1.5 in. by 5.5 in.)

Grade: 1650f-1.5E MSR

F_t' : 1,020 psi

A: 8.25 in.²

Tension Capacity

$$\begin{aligned} T' &= F_t' A \\ &= (1,020)(8.25) \\ &= 8,415 \text{ lbs} \end{aligned}$$

Stud Wall Capacity Tables / Column Capacity Tables

The general design equation is:

$$P' \geq P$$

where:

P = compressive force due to design loads

P' = allowable compression capacity

Axial Capacity

$$P' = C_p A F_c'$$

where:

$$C_p = \frac{1 + \alpha_c}{2c} - \sqrt{\left(\frac{1 + \alpha_c}{2c}\right)^2 - \frac{\alpha_c}{c}}$$

$$\alpha_c = \frac{F_{cE}}{F_c^*}$$

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

and

F_c* = tabulated compression design value multiplied by all applicable adjustment factors except C_p

A = area

C_p = column stability factor

F_c' = allowable parallel-to-grain compression design value

E' = allowable modulus of elasticity

K_{cE} = 0.3 for visually graded lumber

= 0.384 for MEL

= 0.418 for MSR

c = 0.8 for solid sawn members

Example 2: Application — wall stud laterally supported in the weak direction and axially loaded (prismatic column)

Species: Southern Pine

Size: 2 x 4 (1.5 in. by 3.5 in.) by 8'

Grade: Stud (dry)

F_c' : 975 psi

E' : 1.4 x 10⁶ psi

A: 5.25 in.²

C_D = 1.0

K_e = 1.0

$$\begin{aligned} F_{cE} &= \frac{K_{cE} E'}{(\ell_e / d)^2} \\ &= \frac{0.3 \times 1,400,000}{(96 / 3.5)^2} \\ &= 558 \text{ psi} \end{aligned}$$

$$\begin{aligned} \alpha_c &= \frac{F_{cE}}{F_c^*} \\ &= \frac{558}{975} \\ &= 0.573 \end{aligned}$$

¹ Due to rounding, the calculated and tabulated values may differ.

$$\begin{aligned}
 C_P &= \frac{1+\alpha_c}{2c} - \sqrt{\left(\frac{1+\alpha_c}{2c}\right)^2 - \frac{\alpha_c}{c}} \\
 &= \frac{1+0.573}{1.6} - \sqrt{\left(\frac{1+0.573}{1.6}\right)^2 - \frac{0.573}{0.80}} \\
 &= 0.483
 \end{aligned}$$

$$\begin{aligned}
 P' &= (0.483)(5.25)(975) \\
 &= 2,470 \text{ lb.}
 \end{aligned}$$

Example 3: Application — Simple column

Species: Douglas Fir-Larch

Size: 6 x 8 (5.5 in. by 7.5 in.) by 12 ft.

Grade: No. 1 (dry)

F_c' : 1,000 psi

E' : 1,600,000 psi

A : 41.25 in²

Column Capacity — x-axis

$$\begin{aligned}
 F_{cE} &= \frac{K_{cE}E'}{(\ell_e/d_x)^2} \\
 &= \frac{(0.3)(1,600,000)}{(144/7.5)^2} \\
 &= 1,302 \text{ psi}
 \end{aligned}$$

$$\begin{aligned}
 \alpha_{cx} &= \frac{F_{cE}}{F_c^*} \\
 &= \frac{1,302.08}{1,000} \\
 &= 1.302
 \end{aligned}$$

$$\begin{aligned}
 C_{Px} &= \frac{1+\alpha_{cx}}{2c} - \sqrt{\left(\frac{1+\alpha_{cx}}{2c}\right)^2 - \frac{\alpha_{cx}}{c}} \\
 &= \frac{1+1.302}{1.6} - \sqrt{\left(\frac{1+1.302}{1.6}\right)^2 - \frac{1.302}{0.80}} \\
 &= 0.774
 \end{aligned}$$

$$\begin{aligned}
 P'_x &= (0.774)(41.25)(1,000) \\
 &= 31,928 \text{ lb.}
 \end{aligned}$$

Column Capacity — y-axis

$$\begin{aligned}
 F_{cE} &= \frac{K_{cE}E'}{(\ell_e/d_y)^2} \\
 &= \frac{0.3 \times 1,600,000}{(144/5.5)^2} \\
 &= 700 \text{ psi}
 \end{aligned}$$

$$\begin{aligned}
 \alpha_{cy} &= \frac{F_{cE}}{F_c^*} \\
 &= \frac{700}{1,000} \\
 &= 0.700
 \end{aligned}$$

$$\begin{aligned}
 C_{Py} &= \frac{1+\alpha_{cy}}{2c} - \sqrt{\left(\frac{1+\alpha_{cy}}{2c}\right)^2 - \frac{\alpha_{cy}}{c}} \\
 &= \frac{1+0.700}{1.6} - \sqrt{\left(\frac{1+0.700}{1.6}\right)^2 - \frac{0.700}{0.80}} \\
 &= 0.559
 \end{aligned}$$

$$\begin{aligned}
 P'_y &= (0.559)(41.25)(1,000) \\
 &= 23,059 \text{ lb.}
 \end{aligned}$$

Joist Capacity Tables

The general design equation for flexural bending is:

$$M' \geq M$$

where

M = moment due to design loads

M' = allowable moment capacity

The general design equation for flexural shear is:

$$V' \geq V$$

where:

V = shear force due to design loads

V' = allowable shear capacity

Example 4: Application — floor joist

Species: Douglas Fir-Larch

Size: 2 x 6 (1.5 in. by 5.5 in.)

Grade: No. 2

C_F : 1.3 (size factor)

C_r : 1.15 (repetitive member factor)

F_b' : 900 psi

F_v' : 180 psi

E: 1,600,000 psi

A: 8.25 in.²

S: 7.56 in.³

I: 20.80 in.⁴

Moment Capacity

$$\begin{aligned} C_r M' &= F_b' C_r C_r S \\ &= (900)(1.3)(1.15)(7.56) \\ &= 10,172 \text{ lb.-in.} \end{aligned}$$

Shear Capacity

$$\begin{aligned} V' &= F_v' A \left(\frac{2}{3} \right) \\ &= (180)(8.25) \left(\frac{2}{3} \right) \\ &= 990 \text{ lb.} \end{aligned}$$

Flexural Stiffness

$$EI = (1,600,000)(20.80) = 33 \times 10^6 \text{ lb.-in.}^2$$

Beam Capacity Tables

Tabulated design values for beams are selected from Table 4D of *NDS Supplement*.

The general design equation for flexural bending is:

$$M' \geq M$$

where:

M = moment due to design loads

M' = allowable moment capacity

The general design equation for flexural shear is:

$$V' \geq V$$

where

V = shear force due to design loads

V' = allowable shear capacity

Example 5: Application — Beam

Species: Douglas Fir-Larch

Size: 6 x 12 (5.5 in. by 11.5 in.)

Grade: No. 2

F_b' : 875 psi

F_v' : 170 psi

E: 1,300,000 psi

A: 63.25 in.²

S: 121.23 in.³

I: 697.07 in.⁴

Moment Capacity

$$\begin{aligned} M' &= F_b' S \\ &= (875)(121.23) \\ &= 106,076 \text{ lb.-in.} \end{aligned}$$

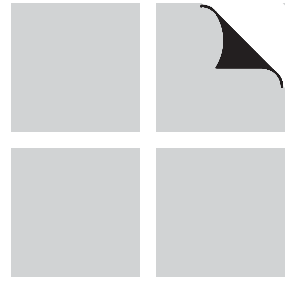
Shear Capacity

$$\begin{aligned} V' &= F_v' A \left(\frac{2}{3} \right) \\ &= (170)(63.25) \left(\frac{2}{3} \right) \\ &= 7,168 \text{ lb.} \end{aligned}$$

Flexural Stiffness

$$EI = (1,300,000)(697.07) = 906 \times 10^6 \text{ lb.-in.}^2$$

SUPPLEMENT
**Structural Glued
Laminated Timber**

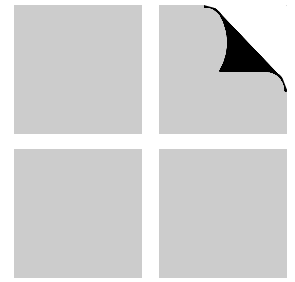


A S D

ALLOWABLE | STRESS | DESIGN

**MANUAL FOR ENGINEERED
WOOD CONSTRUCTION**

SUPPLEMENT
Structural Glued
Laminated Timber



A S D

ALLOWABLE STRESS DESIGN

MANUAL FOR ENGINEERED
WOOD CONSTRUCTION

Preface

This Supplement contains adjustment factors, dimensions, design capacities, allowable stresses and moduli of elasticity and other properties required to design structural glued laminated timber in the ASD format.

The member capacity values tabulated in this supplement are to be used in conjunction with the design methodologies provided in ANSI/AF&PA NDS-2001, *National Design Specification® (NDS®) for Wood Construction*.

The tabulated allowable values are to be used within the reference end-use conditions defined therein. When the end-use conditions fall outside the range of the refer-

ence conditions, the allowable values shall be adjusted by the product of applicable adjustment factors provided in this Supplement, and also as defined in ANSI/AF&PA NDS-2001. For unusual end-use conditions, the designer should consult additional literature for possible further adjustments.

This Supplement was developed by Engineered Wood Systems, a related corporation of APA - The Engineered Wood Association, phone (253) 565-6600, fax (253) 565-7265, e-mail help@apawood.org, or internet address <http://www.apawood.org>.

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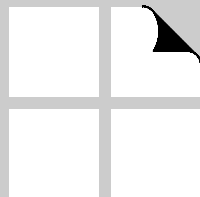
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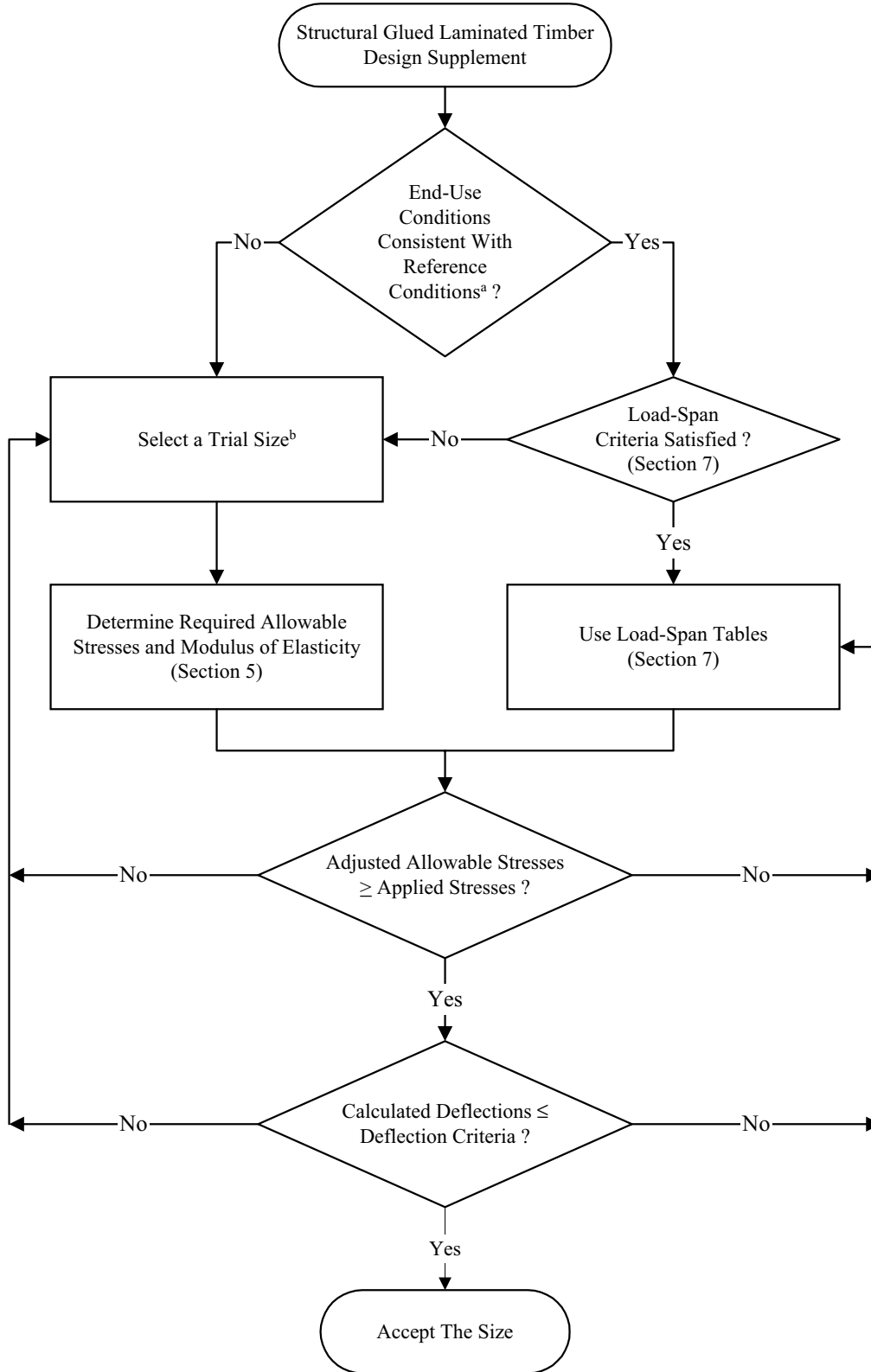
DESIGNER FLOWCHART

1.1 Flowchart

GL-2



1.1 Flowchart



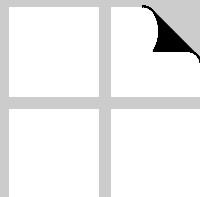
^a See Section 4.

^b Tables 3.1 and 3.2 provide design properties for various layup combinations. This information could be used in conjunction with Tables 5.1 through 5.4 to determine the trial size.

INTRODUCTION TO STRUCTURAL GLUED LAMINATED TIMBER

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2.1 Products Description

Structural glued laminated timber (glulam) is a structural member glued up from suitably selected and prepared pieces of wood either in a straight or curved form with the grain of all pieces parallel to the longitudinal axis of the member. The allowable stresses and capacities given in this Supplement are applicable only to glued laminated timber members produced in accordance with *American National Standard for Wood Products — Structural Glued Laminated Timber*, ANSI/AITC A190.1.

Glued laminated timber members are produced in laminating plants by gluing together dry lumber, normally of 2-inch or 1-inch nominal thickness, under controlled conditions of temperature and pressure. Members with a wide variety of sizes, profiles, and lengths can be produced having superior characteristics of strength, serviceability, and appearance. Glued laminated timber beams are manufactured with the strongest laminations on the bottom and top of the beam, where greatest tension and compression stresses occur in bending. This allows a more efficient use of the lumber resource by placing higher grade lumber in zones that have higher stresses and lumber with less structural quality in lower stressed zones.

Glued laminated timber members are manufactured from several softwood species, primarily Douglas Fir-Larch and Southern Pine, Hem-Fir, Spruce-Pine-Fir, Eastern Spruce, Western Woods, Alaska Cedar, Durango Pine, and California Redwood. In addition, several hardwood species, including Red Oak, Red Maple, and Yellow Poplar, are also used. Standard glued laminated timber sizes are given in Section 9 of this Supplement. Any length, up to the maximum length permitted by transportation and handling restrictions, is available.

A glued laminated timber member can be manufactured using a single grade or multiple grades of lumber, depending on the intended use. In addition, a mixed-species glued laminated timber member is also possible. When the member is intended to be primarily loaded either axially or in bending with the loads acting parallel to the wide faces of the laminations, a single grade combination

is recommended. On the other hand, a multiple grade combination provides better cost-effectiveness when the member is primarily loaded in bending due to loads applied perpendicular to the wide faces of the laminations.

On a multiple grade combination, a glued laminated timber member can be produced as either a balanced or unbalanced combination, depending on the geometrical arrangement of the laminations about the mid-depth of the member. As shown in Figure 2.1, a balanced combination is symmetrical about the mid-depth, so both faces have the same allowable bending stress. Unbalanced combinations are asymmetrical and when used as a beam, the face with a lower allowable bending stress is stamped as TOP. The balanced combination is intended for use in continuous or cantilevered over supports to provide equal capacity in both positive and negative bending. Whereas the unbalanced combination is primarily for use in simple span applications, they can also be used for short cantilever applications (cantilever less than 20% of the back span) or for continuous span applications when the design is controlled by shear or deflection.

Figure 2.1 Unbalanced and Balanced Layup Combinations

No. 2D	Tension Lam
No. 2	No. 1
No. 2	No. 2
No. 3	No. 3
No. 3	No. 3
No. 3	No. 3
No. 2	No. 2
No. 1	No. 1
Tension Lam	Tension Lam
Unbalanced	Balanced

2.2 Common Uses

Glued laminated timber members can be used as primary or secondary load-carrying components in structures. Table 2.1 lists economical spans for selected timber framing systems using glued laminated timber members in buildings. Other common uses of glued laminated timber members are for utility structures, pedestrian bridges, high-

way bridges, railroad bridges, marine structures, noise barriers, and towers. Table 2.1 may be used for preliminary design purposes to determine the economical span ranges for the selected framing systems. However, all systems require a more extensive analysis for final design.

Table 2.1 Economical Spans for Glued Laminated Timber Framing Systems

Type of Framing System	Economical Spans (ft.)
ROOF	
Simple Span Beams	
Straight or slightly cambered	10 - 100
Tapered, double tapered-pitched, or curved	25 - 105
Cantilevered Beams (Main span)	up to 90
Continuous Beams (Interior spans)	10 - 50
Girders	40 - 100
Three-Hinged Arches	
Gothic	40 - 100
Tudor	40 - 140
A-Frame	20 - 100
Three-centered, Parabolic, or Radial	40 - 250
Two-Hinged Arches	
Radial or Parabolic	50 - 200
Trusses (4 or more ply chords)	
Flat or parallel chord	50 - 150
Triangular or pitched	50 - 150
Bowstring (continuous chord)	50 - 200
Trusses (2 or 3 ply chords)	
Flat or parallel chord	20 - 75
Triangular or pitched	20 - 75
Tied arches	50 - 200
Dome structures	200 - 500+
FLOOR	
Simple Span Beams	10 - 40
Continuous Beams (Individual spans)	10 - 40
HEADERS	
Windows and Doors	< 10
Garage Doors	9 - 18

2.3 Appearance Classifications

Glued laminated timber members are typically produced in four appearance classifications, Premium, Architectural, Industrial, and Framing classifications. Premium and Architectural beams are higher in appearance qualities and are surfaced for a smooth finish ready for staining or painting. Industrial classification beams are normally used in concealed applications or in construction where appearance is not important. Framing classification beams are typically used for headers and other concealed applications in residential construction. Design values for glued laminated timber members are independent of the appearance classifications.

For more information concerning the detail description of these appearance classifications and their typical use, refer to *APA EWS* Technical Note Y110 or AITC Standard 110.

2.4 Availability

Glued laminated timber members are available in both custom and stock sizes. Custom beams are manufactured to the specifications of a specific project, while stock beams are made in common dimensions, shipped to distribution yards, and cut to length when the beam is ordered. Stock beams are available in virtually every major metropolitan areas. Although glued laminated timber members can be custom fabricated to provide a nearly infinite variety of forms and sizes, the best economy is generally realized by using standard-size members as noted in Tables 9.1 and 9.2. When in doubt, the designer is advised to check with the glued laminated timber suppliers or manufacturers concerning the availability of a specific size glued laminated timber members prior to specification. The following associations are available for technical assistance:

APA - The Engineered Wood Association and Engineered Wood Systems, a related corporation of APA
7011 South 19th Street
Tacoma, WA 98466
Phone: (253) 565-6600
Fax: (253) 565-7265

American Institute of Timber Construction
7012 South Revere Parkway, Suite 140
Englewood, CO 80112
Phone: (303) 792-9559
Fax: (303) 792-0669

ALLOWABLE STRESS AND STIFFNESS

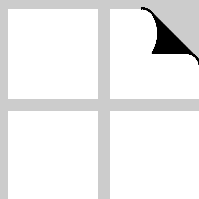
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Table 3.1 Design Values for Structural Glued Laminated Softwood Timber (Members stressed primarily in bending) GL-9

Table 3.2 Design Values for Structural Glued Laminated Softwood Timber (Members stressed primarily in axial tension or compression) GL-10

Table 3.3 Allowable Properties and Moduli of Elasticity for Glued Laminated Timber with Tapered Cuts on Compression Face GL-11

Table 3.4 Allowable Radial Stresses GL-11



3.1 General

The allowable stresses and mean moduli of elasticity of glued laminated timber are affected by the layout of members composed of various grades of lumber as well as the direction of applied bending forces. As a result, different design values are assigned for glued laminated timber used primarily in bending, Table 3.1, and primarily in axial loading, Table 3.2. The design values are used in conjunction with the dimensions provided in Tables 9.1

(Western species) and 9.2 (Southern Pine) of Section 9, but are applicable to any sizes of structural glued laminated timber when the appropriate modification factors given in Section 4 are applied. It is noted that the layout combinations given in Tables 3.1 and 3.2 are those most often used by designers. For other layout combinations that are also available, refer to APA EWS Technical Note Y117, AITC 117, or NDS-2001.

3.2 Allowable Stress and Modulus of Elasticity

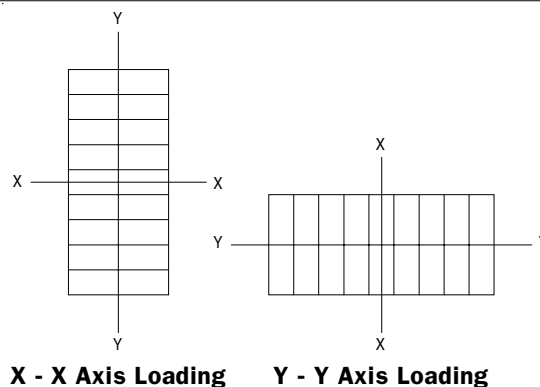
Allowable properties are given in Table 3.1 for bending about the X-X axis (see Figure 3.1). Although permitted, axial loading or bending about the Y-Y axis (also see Figure 1) is not efficient in using the glued laminated timber combinations given in Table 3.1. In such cases, the designer should select glued laminated timber from Table 3.2. Similarly, glued laminated timber combinations in Table 3.2 are inefficiently utilized if the primary use is bending about the X-X axis.

The values for allowable stresses and moduli of elasticity given in Tables 3.1 and 3.2 are based on use under normal duration of load (10 years) and dry conditions (less than 16% moisture content). When used under other conditions, see Section 4 of this Supplement for adjustment factors. The allowable flexural stresses are based on members loaded as simple beams. When glued laminated timber is used in continuous or cantilevered beams, the allowable flexural stresses given in Column 4 of Table 3.1 should be used for the design of stress reversal (when compression zone is stressed in tension).

It is noted that horizontal shear values for glulam are based on full scale bending tests. The results of these tests supported values that are 10% higher than the tabulated

values. The tabulated values were arbitrarily reduced to allow for checking in the shear critical zone of up to 10% of the width of the member. If the designer does not want to include this arbitrary allowance for checking, the tabulated values can be increased by 10%. It is noted that checking seldom occurs in the shear critical zone of glulam beams.

Figure 3.1 Loading in the X-X and Y-Y Axes



3.3 Straight-Tapered End Cuts on the Compression Face

Straight-tapered end cuts on the top of a beam are sometimes used to improve drainage, to provide extra head for downspouts and scuppers, to facilitate discharge of water, and to reduce the height of the wall. Table 3.3 provides allowable stresses and mean moduli of elasticity for glued laminated timber with straight-tapered end cuts on the compression face. The allowable stresses are provided for bending, F_b , and compression perpendicular to grain,

$F_{c,L}$, and replace the allowable values provided in Table 3.1 when tapered end cut members are used.

Table 3.1 Design Values for Structural Glued Laminated Softwood Timber

(Members stressed primarily in bending) (Tabulated design values are for normal load duration and dry service conditions. See NDS 5.3 for a comprehensive description of design value adjustment factors.)

Stress Class	Bending About X-X Axis Loaded Perpendicular to Wide Faces of Laminations				Bending About Y-Y Axis Loaded Parallel to Wide Faces of Laminations				Axially Loaded			Fasteners			
	Extreme Fiber in Bending		Compression Perpendicular to Grain	Shear Parallel to Grain (Horizontal)	Modulus of Elasticity	Extreme Fiber in Bending	Compression Perpendicular to Grain	Shear Parallel to Grain (Horizontal)	Modulus of Elasticity	Tension Parallel to Grain	Compression Parallel to Grain	Modulus of Elasticity	Specific Gravity for Dowel-Type Fastener Design	Species Group for Split Ring and Shear Plate Connectors	
	Tension Zone Stressed in Tension (Positive Bending)	Compression Zone Stressed in Tension (Negative Bending)	$F_{c,x}$ (psi)	$F_{v,x}^{(4)}$ (psi)	E_x (10^6 psi)	$F_{b,x}^{+ (1)}$ (psi)	$F_{c,y}$ (psi)	$F_{v,y}^{(4)(5)}$ (psi)	E_y (10^6 psi)	F_t (psi)	F_c (psi)	E_{axial} (10^6 psi)	G	Top or Bottom Face	Side Face
	$F_{b,x}^{+}$ (psi)	$F_{b,x}^{- (1)}$ (psi)	$F_{c,x}$ (psi)	$F_{v,x}^{(4)}$ (psi)	E_x (10^6 psi)	$F_{b,y}$ (psi)	$F_{c,y}$ (psi)	$F_{v,y}^{(4)(5)}$ (psi)	E_y (10^6 psi)	F_t (psi)	F_c (psi)	E_{axial} (10^6 psi)		G	
16F-1.3E	1600	925	315	175	1.3	800	315	155	1.1	625	725	1.2	0.35	C	C
20F-1.5E	2000	1100	425	190 ⁽⁶⁾	1.5	800	315	155	1.2	725	925	1.3	0.42	C	C
24F-1.7E	2400	1450	500	190 ⁽⁶⁾	1.7	850	315	160	1.3	775	1000	1.4	0.42	C	C
24F-1.8E	2400	1450 ⁽²⁾	650	240 ⁽³⁾	1.8	1450	560	210 ⁽³⁾	1.6	1100	1600	1.7	0.50 ⁽¹⁰⁾	A	B
26F-1.9E ⁽⁷⁾	2600	1950	650	240 ⁽³⁾	1.9	1600	560	210 ⁽³⁾	1.6	1150	1600	1.7	0.50 ⁽¹⁰⁾	A	B
28F-2.1E SP ⁽⁷⁾	2800	2300	740	270	2.1 ⁽⁸⁾	1600	650	235	1.7	1250	1750	1.7	0.55	A	A
30F-2.1E SP ⁽⁷⁾⁽⁸⁾	3000	2400	740	270	2.1 ⁽⁸⁾	1750	650	235	1.7	1250	1750	1.7	0.55	A	A
Wet-use factors ⁽¹¹⁾	0.8				0.833	0.8	0.53	0.875	0.833	0.8	0.73	0.833	See Section 10.3.3 of NDS-2001		

- For balanced layouts, $F_{b,x}^+$ shall be equal to $F_{b,x}^-$ for the stress class. Designer shall specify when balanced layout is required.
- Negative bending stress, $F_{b,x}^-$, is permitted to be increased to 1850 psi for Douglas Fir and to 1950 psi for Southern Pine for specific combinations. Designer shall specify when these increased stresses are required.
- For structural glued laminated timber of **Southern Pine**, shear stress is permitted to be increased to: $F_{v,x} = 270$ psi, $F_{v,y} = 235$ psi.
- For non-prismatic members, notched members, members subject to impact or cyclic loading, or shear design of bending members at connections (NDS 3.4.3.3), the design value for shear shall be multiplied by a factor of 0.8. For the determination of radial tension design values (NDS 5.2.2), the design value for shear shall be multiplied by a factor of 0.7 for DF-L and SP or by 0.8 for all other species. Design values are for timbers with laminations made from a single piece of lumber across the width or multiple pieces that have been edge bonded. For timbers manufactured from multiple piece laminations (across width) that are not edge bonded, value shall be multiplied by 0.4 for members with 5, 7, or 9 laminations or by 0.5 for all other members. This reduction shall be cumulative with the adjustment in footnote (4).
- Certain Southern Pine combinations may contain coarse grain lumber with wane. If lumber with wane is used, the design value for shear parallel to grain, $F_{v,x}$, shall be multiplied by 0.67 if wane is allowed on both sides. If wane is limited to one side, $F_{v,x}$ shall be multiplied by 0.83. This reduction shall be cumulative with the adjustment in footnote (4).
- 26F, 28F, and 30F beams are not produced by all manufacturers, therefore, availability may be limited. Contact supplier or manufacturer for details.
- 30F combinations are restricted to a maximum 6 in. nominal width. The design value for shear parallel to grain ($F_{v,x}$) shall be permitted to be increased by 10% when checking is not a design concern.
- For 28F and 30F members with more than 15 laminations, $E_x = 2.0$ million psi.
- For structural glued laminated timber of Southern Pine, specific gravity for fastener design is permitted to be increased to 0.55.
- The tabulated design values are for dry conditions of use (moisture content in service is less than 16% as in most covered structures). For wet conditions of use (moisture content in service is 16% or higher), multiply the tabulated values by the factors shown at the end of the table.

Design values in this table represent design values for groups of similar glued laminated timber combinations. Higher design values may be obtained by specifying a particular combination listed in AITC 117-2001 Design, APA Y11.7, or the 2001 NDS Supplement. Design values are for members with 4 or more laminations. For 2 and 3 lamination members, see Table 3.2. Some stress classes are not available in all species. Contact structural glued laminated timber manufacturer for availability.



ALLOWABLE STRESS AND STIFFNESS

Table 3.2 Design Values for Structural Glued Laminated Softwood Timber

(Members stressed primarily in axial tension or compression)^{1,2,8} (Tabulated design values are for normal load duration and dry service conditions. See NDS 5.3 for a comprehensive description of design value adjustment factors.)

Combination Symbol	Species	Grade	All Loading			Axially Loaded			Bending about Y-Y Axis				Bending About X-X Axis				
			Modulus of Elasticity E (10 ⁶ psi)	Compression Perpendicular to Grain F _{cL} (psi)	2 or More Laminations F _t (psi)	Tension Parallel to Grain	Compression Parallel to Grain	Bending		Loaded Parallel to Wide Faces of Laminations		Loaded Perpendicular to Wide Faces of Laminations		Shear Parallel to Grain ⁽⁸⁾			
								4 or More Laminations F _c (psi)	2 or 3 Laminations F _c (psi)	3 Laminations F _{by} (psi)	2 Laminations F _{by} (psi)	4 or More Laminations for members with multiple piece laminations ⁽⁴⁾ F _{vy} (psi)	4 or More Laminations without Special Tension Lams ⁽⁷⁾ F _{bx} (psi)		2 Laminations 15 in. Deep ⁽⁶⁾ Special Tension Lams F _{bx} (psi)		
Visually Graded Western Species																	
1	DF	L3	560	1200	900	1550	1200	1450	1250	1000	105	210	200	180	1250	1500	240
2	DF	L2	560	1600	1250	1950	1600	1800	1600	1300	105	210	200	180	1700	2000	240
3	DF	L2D	650	1850	1450	2300	1850	2100	1850	1550	105	210	200	180	2000	2300	240
5	DF	L1	650	2100	1600	2400	2100	2400	1800	1800	105	210	200	180	2200	2400	240
22 ⁽⁶⁾	SW	L3	315	850	525	850	675	800	700	550	80	155	145	130	725	850	175
70	AC	L2	470	1450	975	1450	1450	1400	1250	1000	105	210	200	180	1350	1550	240
Visually Graded Southern Pine																	
47	SP	N2M14	650	1900	1200	1900	1150	1750	1550	1300	120	235	225	205	1400	1600	270
48	SP	N2D14	740	2200	1400	2200	1350	2000	1800	1500	120	235	225	205	1600	1900	270
49	SP	N1M16	650	2100	1350	2100	1450	1950	1750	1500	120	235	225	205	1800	2100	270
50	SP	N1D14	740	2300	1550	2300	1700	2300	2100	1750	120	235	225	205	2100	2400	270
Wet Service Factors ⁽⁹⁾			0.833	0.53	0.8	0.73	0.73	0.8	0.8	0.8	0.875	0.875	0.875	0.875	0.8	0.8	0.875

- Design values in this table are for combinations conforming to AITC 117-2001 Design or APA-EWS Y117 and manufactured in accordance with American National Standard ANSI/AITC A190.1-1992.
- The combinations in this table are intended primarily for members loaded axially or in bending with the loads acting parallel to the wide faces of the laminations (bending about Y-Y axis). Design values for bending due to loading applied perpendicular to the wide faces of the laminations (bending about X-X axis) are also included; however, the combinations in Table 3.1 are preferred for this condition of loading.
- For non-prismatic members, notched members, members subject to impact or cyclic loading, or shear design of bending members at connections (NDS 3.4.3.3), the design value for shear shall be multiplied by 0.8. For the determination of radial tension design values (NDS 5.2.2), the design value for shear shall be multiplied by a factor of 0.7 for DF-L and SP or by 0.8 for all other species.
- Values apply to members manufactured using multiple piece laminations with unbanded edge joints. For members with 5, 7, or 9 laminations, value shall be multiplied by 0.8. This reduction shall be cumulative with the reduction in footnote (3).
- When Western Cedars, Western Cedars (North), Western Woods, and Redwood (open grain) are used in combinations for Softwood Species (SW), the design values for modulus of elasticity (E_x and E_y) shall be reduced by 100,000 psi. When Coast Sitka Spruce, Coast Species, Western White Pine and Eastern White Pine are used in combinations for Softwood Species (SW) design values for shear parallel to grain (F_{vx} and F_{vy}) shall be reduced by 10 psi.
- For members greater than 15 in. deep, values shall be reduced by multiplying by a factor of 0.88.
- These design values require the use of special tension laminations. If these design values are used, the designer shall specify the required design value as well as the combination symbol.
- Species groups for split ring and shear plate connectors shall be determined by associated compression design values perpendicular to grain, F_{cL}, as follows:

Species Group for Split Ring and Shear Plate Connectors	F _{cL} (psi)
A	650 or 740
B	560 or 590
C	315, 375, 470, or 500
D	255
- The tabulated design values are for dry conditions of use. For wet conditions of use, multiply the tabulated values by the factors shown at the end of the table.

3.4 Radial Tension and Compression

When a curved member is loaded in bending, radial stresses are induced. When the bending moment is in the direction that tends to decrease the curvature or increase the radius, the radial stress is in radial tension, F_{rt} . On the other hand, when the bending moment is in the direction that tends to increase the curvature or decrease the radius, the radial stress is in radial compression, F_{rc} . Table 3.4 provides allowable radial tensile stresses for glued laminated timber. These values are subject to adjustments for duration of load and wet conditions of use (16% moisture content or higher). If the adjusted value is exceeded, appropriate mechanical reinforcements shall be used to resist all applied radial tensile stresses. The maximum moisture content of the laminations shall not exceed 12% at the time of the reinforcement manufacturing.

The allowable radial compressive stress has been traditionally limited to the design value in compression perpendicular to grain, F_{cL} , of the grade and species being used. Also given in Table 3.4 are allowable radial compressive stresses for glued laminated timber. These allowable radial compressive stresses are not subject to the adjustments for the duration of load, but shall be adjusted for wet conditions of use when appropriate.

Table 3.3 Allowable Properties and Moduli of Elasticity for Glued Laminated Timber with Tapered Cuts on Compression Face

Stress class	$F_{bx}^{(a)}$, psi	$F_{cLx}^{(b)}$, psi	$E_x^{(a)}$, 10 ⁶ psi
16F-1.3E	1,050	315	1.2
20F-1.5E	1,250	375	1.4
24F-1.7E	1,250	375	1.4
24F-1.8E	2,000	560	1.7
26F-1.9E	2,000	560	1.7
28F-2.1E	2,400	650	1.9
30F-2.1E	2,400	650	1.9

^a Value is applicable to members that have up to 2/3 the depth on the compression side removed by taper cutting. Value is for dry conditions of use.

^b Design value in compression perpendicular to grain for the core laminations of the combination.

Table 3.4 Allowable Radial Stresses^a

Species	Radial Tension (F_{rt}), psi		Radial Compression (F_{rc}), psi
	Wind and Earthquake	Other Loadings	
Alaska Cedar	63	15	470
California Redwood	42	42	315
Canadian Spruce Pine	53	15	560
Douglas Fir-Larch	55	15	560
Douglas Fir-South	55	15	560
Eastern Spruce	48	15	300
Hem-Fir	52	15	375
Softwood Species (WW)	47	15	255
Southern Pine	67	67	650

^a The wet use factor, C_M , is equal to 0.875 for radial tensile stresses and 0.53 for radial compressive stresses.

3.5 Structural Glued Laminated Timber Combinations Meeting Stress Class Requirements

Examples of the structural glued laminated timber combinations from AITC 117 and APA Y117 that meet the requirements of each stress class are listed below. The species group used in the outer laminations/core laminations for each combination is also shown. Combinations that are not included in AITC 117 or APA Y117, but meet

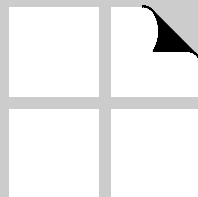
all requirements of a stress class, are permitted for use in that stress class. Combinations not included in AITC 117 or APA Y117 shall be developed in accordance with NER-466 or NER-486.

Stress Class	Western Species		Southern Pine	
	Unbalanced	Balanced	Unbalanced	Balanced
16F-1.3E	16F-V1 (DF/SW) 16F-V2 (HF/HF) 16F-V3 (DF/DF) 16F-V4 (DF/SW) 16F-E1 (SW/SW) 16F-E2 (HF/HF) 16F-E3 (DF/DF)	16F-V6 (DF/DF) 16F-V7 (HF/HF)	16F-V2 (SP/SP) 16F-V3 (SP/SP) 16F-E1 (SP/SP)	16F-V5 (SP/SP) 16F-E3 (SP/SP)
20F-1.5E	20F-V3 (DF/DF) 20F-V4 (DF/DF) 20F-V10 (DF/HF) 20F-V12 (AC/AC) 20F-E2 (HF/HF) 20F-E3 (DF/DF) 20F-E8 (ES/ES) 22F-V3 (DF/DF) 22F-V10 (DF/DFS)	20F-V7 (DF/DF) 20F-V8 (DF/DF) 20F-V9 (HF/HF) 20F-V13 (AC/AC) 20F-E6 (DF/DF) 20F-E7 (HF/HF) 22F-V8 (DF/DF)	20F-V2 (SP/SP) 20F-E1 (SP/SP) 22F-V1 (SP/SP) 22F-V2 (SP/SP) 22F-V3 (SP/SP) 22F-V4 (SP/SP) 22F-E1 (SP/SP)	20F-V5 (SP/SP) 20F-E3 (SP/SP) 22F-V5 (SP/SP) 22F-E3 (SP/SP)
24F-1.7E	24F-V5 (DF/HF) 24F-V11 (DF/DFS) 24F-E2 (HF/HF) 24F-E3 (DF/HF) 24F-E15 (HF/HF)	24F-V10 (DF/HF) 24F-E10 (DF/HF) 24F-E11 (HF/HF)	24F-V1 (SP/SP) 24F-V4 (SP/SP)	24F-V5 (SP/SP)
24F-1.8E	24F-V4 (DF/DF) 24F-E1 (DF/DF) 24F-E4 (DF/DF)	24F-V8 (DF/DF) 24F-E13 (DF/DF) 24F-E18 (DF/DF)	24F-V3 (SP/SP) 24F-E1 (SP/SP) 24F-E2 (SP/SP)	24F-E4 SP (SP/SP) 24F-V5M1 (SP/SP)
26F-1.9E	26F-E/DF1 (DF/DF)	26F-E/DF1M1 (DF/DF)	26F-V1 (SP/SP) 26F-V2 (SP/SP) 26F-V3 (SP/SP)	26F-V4 (SP/SP)
28F-2.1E			28F-E1 (SP/SP) 28F-E1M1 (SP/SP)	28F-E2 (SP/SP) 28F-E2M1 (SP/SP)
30F-2.1E			30F-E1 (SP/SP)	30F-E2 (SP/SP)

DESIGN ADJUSTMENT FACTORS

4.1	General	GL-14
4.2	Load Duration Factor, C_D	GL-14
4.3	Wet Service Factor, C_M	GL-14
4.4	Temperature Factor, C_t	GL-14
4.5	Preservative Treatment	GL-15
4.6	Fire Retardant Treatment	GL-15
4.7	Beam Stability Factor, C_L	GL-15
4.8	Column Stability Factor, C_P	GL-15
4.9	Volume Factor, C_V	GL-16
4.10	Curvature Factor, C_c	GL-16
4.11	Flat Use Factor, C_{fu}	GL-16

Table 4.1	Load Duration Factor for Glued Laminated Timber, C_D	GL-14
Table 4.2	Temperature Factor for Glued Laminated Timber Exposed to Sustained Elevated Temperature, C_t	GL-14
Table 4.3	Preservative Treatment Effect on Glued Laminated Timber	GL-15
Table 4.4	Flat Use Factor, C_{fu}	GL-16
Table 4.5	Volume Factor for Bending about X-X Axis <i>Western Species</i> Glued Laminated Timber	GL-17
Table 4.6	Volume Factor for Bending about X-X Axis <i>Southern Pine</i> Glued Laminated Timber	GL-23



4.1 General

The adjustment factors provided in this section are for non-reference end use conditions and material modification effects. These factors shall be used to modify the

allowable properties when one or more of the specific end use or material modification conditions fall outside the limits of the reference conditions given in this section.

4.2 Load Duration Factor, C_D

Allowable properties tabulated in Section 3 apply to normal load duration, which means a structural member is subject to full design loads for a cumulative duration of approximately 10 years. For other cumulative duration of the full design loads, the allowable properties, except for modulus of elasticity and compression perpendicular to grain, shall be adjusted by the load duration factor given in Table 4.1.

Table 4.1 Load Duration Factor for Glued Laminated Timber, C_D

Load Duration	C_D	Typical Design Loads
Permanent	0.9	Dead Load
10 Years	1.0	Occupancy Live Load
2 Months	1.15	Snow Load
7 Days	1.25	Construction Load
10 Minutes	1.6	Wind/Earthquake Load
Impact ^a	2.0	Impact Load

^a The impact load duration factor shall not apply to glued laminated timber members treated with waterborne preservatives to a heavy retention required for marine exposure, nor to members pressured treated with fire retardant chemicals.

4.3 Wet Service Factor, C_M

Design values provided in this Supplement are applicable to dry use conditions of glued laminated timber (moisture content in service is less than 16%, as in most covered structures) and its connections. When glued lami-

nated timber members are exposed to wet service conditions, the adjustment factors given in Tables 3.1 and 3.2 apply.

4.4 Temperature Factor, C_t

The temperature factor, C_t , shall be applied when glued laminated timber member is exposed to a sustained elevated temperature ranging from 100° to 150°F. When the equilibrium moisture content of a glued laminated timber member exceeds the reference condition limitation during sustained elevated temperature exposure, both the

temperature and wet service (moisture) factors shall be applied. When the equilibrium moisture content of a glued laminated timber falls within the limits of the reference conditions during sustained exposure to elevated temperatures, only the temperature factor shall be applied. The temperature factors are given in Table 4.2.

Table 4.2 Temperature Factor for Glued Laminated Timber Exposed to Sustained Elevated Temperature, C_t

Design Values	In Service Moisture Conditions ^a	C_t		
		$T \leq 100^\circ\text{F}$	$100^\circ\text{F} < T \leq 125^\circ\text{F}$	$125^\circ\text{F} < T \leq 150^\circ\text{F}$
F_t, E	Dry or Wet	1.0	0.9	0.9
F_b, F_v, F_c and F_{cL}	Dry	1.0	0.8	0.7
	Wet	1.0	0.7	0.5

^a In service conditions are defined in Section 4.3.

4.5 Preservative Treatment

Whenever practical, the moisture content of permanent structural wood members should be kept below 20%. If this is not feasible then preservative treatment may be required unless the heartwood of a naturally decay resistant species such as Redwood and Cedar is used.

Most preservative chemicals used today do not significantly alter the strength properties of structural wood products. However, the method of pre- and post-condi-

tioning, as well as the treatment method itself, may weaken the wood. For preservative treatment methods with AWPAs accepted manufacturing control, as listed in Table 4.3, the effect on strength degradation of glulam can be eliminated. For more information concerning preservative treatment of glulam, refer to APA Technical Note S580 or AITC Standard 109.

Table 4.3 Preservative Treatment Effect on Glued Laminated Timber

No adjustment is required when glued laminated timber is preservative-treated using the following American Wood Preservers' Association Standards

Designation	Title
C1-98	All Timber Products - Preservative Treatment by Pressure Processes
C14-98	Wood For Highway Construction - Preservative Treatment by Pressure Processes
C15-98	Wood for Commercial - Residential Construction - Preservative Treatment by Pressure Processes
C28-98	Standard for Preservative Treatment of Structural Glued Laminated Members and Laminations Before Gluing of Southern Pine, Coastal Douglas fir, Hem Fir, and Western Hemlock by Pressure Processes

4.6 Fire Retardant Treatment

Effects of fire retardant treatments on allowable design stresses shall be considered for wood products treated with pressure impregnated fire-retardants. However, the glued laminated timber industry does not recommend the use of fire-retardant treatments with glued laminated timber and therefore, specific adjustment factors for

fire-retardants used in conjunction with glued laminated timber shall be obtained from the company providing the treatment services and the glulam manufacturer accepts no responsibility for any structural glued laminated timber that is fire retardant treated.

4.7 Beam Stability Factor, C_L

Allowable bending stresses of glued laminated timber shall be adjusted by the beam stability factor, C_L , whenever applicable. Refer to Section 3.3.3 of the *NDS* for the determination of an appropriate beam stability fac-

tor. It is important to note that C_L is not accumulative with the volume factor, C_v , given in Section 4.9 of this Supplement for the design of structural glued laminated timber.

4.8 Column Stability Factor, C_p

Allowable values for compression parallel to grain of glued laminated timber are affected by the dimensions and modulus of elasticity. Refer to Section 3.7.1 of the *NDS* for the determination of an appropriate column stability factor.

4.9 Volume Factor, C_v

Allowable bending stresses of glued laminated timber are affected by geometry and size. Generally, larger sizes have a correspondingly lower allowable bending stress than smaller members. To account for this behavior, a volume factor, C_v , shall be applied. C_v shall not exceed 1.0 and is computed as follows:

$$C_v = (21/L)^{1/x} (12/d)^{1/x} (5.125/b)^{1/x} \leq 1.0 \quad (4.1)$$

L = length of bending member between points of zero moment, ft.

d = depth of bending member, in.

b = width (breadth) of bending member. For multiple piece width layouts, b = width of widest piece used in the layout. Thus, $b \leq 10.75$ "

x = 20 for Southern Pine

x = 10 for all other species

Note that separate exponent values are given for Western species and for Southern Pine. No volume adjustment is required for properties other than allowable bending stresses when the load is applied perpendicular to the wide face of the laminations. Tables 4.5 and 4.6 give some C_v values for Western species and Southern Pine glued laminated timbers, respectively.

4.10 Curvature Factor, C_c

The curvature factor, C_c , is used to adjust the allowable bending stresses of curved glued laminated timber members only. It takes into account the difference in extreme outer fiber stress between a curved member and a straight prismatic member, as well as any residual stresses that may remain in a lamination that has been bent to the stated curvature. However, the curvature factor, C_c , shall not be applied to the allowable bending stress in the straight portion of a member, regardless of curvature in other portions. Also, this factor is not applicable to cambered glued laminated timber members or in the design of pitched and tapered curved glued laminated timber members. The cur-

vature factor, C_c , shall be calculated in accordance with the following equation:

$$C_c = 1 - 2000 \left(\frac{t}{R} \right)^2 \quad [4.2]$$

where:

t = thickness of lamination, in.

R = radius of curvature of inside face of lamination, in.

$t/R \leq 1/100$ for hardwoods and Southern Pine

$t/R \leq 1/125$ for other species

4.11 Flat Use Factor, C_{fu}

Allowable bending stresses of glued laminated timber shall be adjusted by the flat use factor, C_{fu} , when loaded in bending parallel to wide faces of the laminations (the y-y axis). The allowable bending stresses in the parallel to wide faces of the laminations, F_{by} , as given in Tables 3.1 and 3.2 of this Supplement, are based on members with laminations 12 inches wide. For members with laminations less than 12 inches wide, the tabulated F_{by} values shall be adjusted by a flat use factor, C_{fu} , as listed in Table 4.4. When the width of the laminations is greater than 12 inches, as may occur in members with multiple-piece laminations, C_{fu} shall be obtained by use of the equation given in footnote (a) to Table 4.4.

Table 4.4 Flat Use Factor^a, C_{fu}

Member Dimensions Parallel to Wide Faces of Laminations	C_{fu}
10-3/4 or 10-1/2	1.01
8-3/4 or 8-1/2	1.04
6-3/4	1.07
5-1/8 or 5	1.10
3-1/8 or 3	1.16
2-1/2	1.19

^a Values for C_{fu} are rounded values from the equation $(12/d)^{1/9}$ where d is the dimension of the wide faces of the laminations.

Table 4.5 Volume Factor for Bending about X-X Axis Western Species Glued Laminated Timber

Depth d (in.)	C _v when Span (ft.) is										
	8	12	16	20	24	28	32	36	40	44	48
2-1/2 in. Width											
6	1.000	1.000	--	--	--	--	--	--	--	--	--
7-1/2	1.000	1.000	1.000	--	--	--	--	--	--	--	--
9	1.000	1.000	1.000	1.000	--	--	--	--	--	--	--
10-1/2	1.000	1.000	1.000	1.000	1.000	--	--	--	--	--	--
12	1.000	1.000	1.000	1.000	1.000	1.000	--	--	--	--	--
13-1/2	1.000	1.000	1.000	1.000	1.000	1.000	1.000	--	--	--	--
15	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.996	--	--	--
16-1/2	1.000	1.000	1.000	1.000	1.000	1.000	0.998	0.986	0.976	--	--
18	1.000	1.000	1.000	1.000	1.000	1.000	0.989	0.978	0.967	0.958	--
19-1/2	1.000	1.000	1.000	1.000	1.000	0.994	0.981	0.970	0.960	0.951	0.942
21	1.000	1.000	1.000	1.000	1.000	0.987	0.974	0.963	0.953	0.944	0.935
3-1/8 in. Width											
6	1.000	1.000	--	--	--	--	--	--	--	--	--
7-1/2	1.000	1.000	1.000	--	--	--	--	--	--	--	--
9	1.000	1.000	1.000	1.000	--	--	--	--	--	--	--
10-1/2	1.000	1.000	1.000	1.000	1.000	--	--	--	--	--	--
12	1.000	1.000	1.000	1.000	1.000	1.000	--	--	--	--	--
13-1/2	1.000	1.000	1.000	1.000	1.000	1.000	0.996	--	--	--	--
15	1.000	1.000	1.000	1.000	1.000	0.998	0.985	0.974	--	--	--
16-1/2	1.000	1.000	1.000	1.000	1.000	0.989	0.976	0.964	0.954	--	--
18	1.000	1.000	1.000	1.000	0.996	0.980	0.967	0.956	0.946	0.937	--
19-1/2	1.000	1.000	1.000	1.000	0.988	0.973	0.960	0.948	0.938	0.930	0.922
21	1.000	1.000	1.000	0.998	0.980	0.965	0.953	0.941	0.932	0.923	0.915
22-1/2	1.000	1.000	1.000	0.992	0.974	0.959	0.946	0.935	0.925	0.916	0.908
24	1.000	1.000	1.000	0.985	0.967	0.953	0.940	0.929	0.919	0.910	0.903
3-1/2 in. Width											
6	1.000	1.000	--	--	--	--	--	--	--	--	--
7-1/2	1.000	1.000	1.000	--	--	--	--	--	--	--	--
9	1.000	1.000	1.000	1.000	--	--	--	--	--	--	--
10-1/2	1.000	1.000	1.000	1.000	1.000	--	--	--	--	--	--
12	1.000	1.000	1.000	1.000	1.000	1.000	--	--	--	--	--
13-1/2	1.000	1.000	1.000	1.000	1.000	0.998	0.984	--	--	--	--
15	1.000	1.000	1.000	1.000	1.000	0.987	0.974	0.963	--	--	--
16-1/2	1.000	1.000	1.000	1.000	0.993	0.978	0.965	0.954	0.944	--	--
18	1.000	1.000	1.000	1.000	0.984	0.969	0.956	0.945	0.935	0.926	--
19-1/2	1.000	1.000	1.000	0.994	0.977	0.962	0.949	0.938	0.928	0.919	0.911
21	1.000	1.000	1.000	0.987	0.969	0.954	0.942	0.931	0.921	0.912	0.904
22-1/2	1.000	1.000	1.000	0.980	0.963	0.948	0.935	0.924	0.915	0.906	0.898
24	1.000	1.000	0.996	0.974	0.956	0.942	0.929	0.918	0.909	0.900	0.892

4
DESIGN ADJUSTMENT FACTORS

Table 4.5 Volume Factor for Bending about X-X Axis Western Species Glued Laminated Timber (Cont.)

Depth d (in.)	C _v when Span (ft.) is										
	8	12	16	20	24	28	32	36	40	44	48
5-1/8 in. Width											
6	1.000	1.000	--	--	--	--	--	--	--	--	--
7-1/2	1.000	1.000	1.000	--	--	--	--	--	--	--	--
9	1.000	1.000	1.000	1.000	--	--	--	--	--	--	--
10-1/2	1.000	1.000	1.000	1.000	1.000	--	--	--	--	--	--
12	1.000	1.000	1.000	1.000	0.987	0.972	--	--	--	--	--
13-1/2	1.000	1.000	1.000	0.993	0.975	0.960	0.948	--	--	--	--
15	1.000	1.000	1.000	0.983	0.965	0.950	0.938	0.927	--	--	--
16-1/2	1.000	1.000	0.995	0.973	0.956	0.941	0.929	0.918	0.908	--	--
18	1.000	1.000	0.987	0.965	0.948	0.933	0.921	0.910	0.900	0.892	--
19-1/2	1.000	1.000	0.979	0.957	0.940	0.926	0.913	0.903	0.893	0.885	0.877
21	1.000	1.000	0.972	0.950	0.933	0.919	0.907	0.896	0.887	0.878	0.871
22-1/2	1.000	0.993	0.965	0.944	0.927	0.912	0.900	0.890	0.880	0.872	0.865
24	1.000	0.987	0.959	0.938	0.921	0.907	0.895	0.884	0.875	0.867	0.859
25-1/2	1.000	0.981	0.953	0.932	0.915	0.901	0.889	0.879	0.870	0.861	0.854
27	1.000	0.975	0.948	0.927	0.910	0.896	0.884	0.874	0.865	0.856	0.849
28-1/2	1.000	0.970	0.942	0.922	0.905	0.891	0.879	0.869	0.860	0.852	0.844
30	1.000	0.965	0.938	0.917	0.900	0.887	0.875	0.865	0.856	0.847	0.840
31-1/2	1.000	0.960	0.933	0.912	0.896	0.882	0.871	0.860	0.851	0.843	0.836
33	0.995	0.956	0.929	0.908	0.892	0.878	0.867	0.856	0.847	0.839	0.832
34-1/2	0.991	0.952	0.925	0.904	0.888	0.874	0.863	0.853	0.844	0.836	0.828
36	0.987	0.948	0.921	0.900	0.884	0.871	0.859	0.849	0.840	0.832	0.825
5-1/2 in. Width											
6	1.000	1.000	--	--	--	--	--	--	--	--	--
7-1/2	1.000	1.000	1.000	--	--	--	--	--	--	--	--
9	1.000	1.000	1.000	1.000	--	--	--	--	--	--	--
10-1/2	1.000	1.000	1.000	1.000	0.993	--	--	--	--	--	--
12	1.000	1.000	1.000	0.998	0.980	0.965	--	--	--	--	--
13-1/2	1.000	1.000	1.000	0.986	0.968	0.954	0.941	--	--	--	--
15	1.000	1.000	0.998	0.976	0.958	0.944	0.931	0.920	--	--	--
16-1/2	1.000	1.000	0.988	0.967	0.949	0.935	0.922	0.911	0.902	--	--
18	1.000	1.000	0.980	0.958	0.941	0.926	0.914	0.903	0.894	0.886	--
19-1/2	1.000	1.000	0.972	0.951	0.933	0.919	0.907	0.896	0.887	0.878	0.871
21	1.000	0.993	0.965	0.944	0.926	0.912	0.900	0.890	0.880	0.872	0.864
22-1/2	1.000	0.986	0.958	0.937	0.920	0.906	0.894	0.884	0.874	0.866	0.858
24	1.000	0.980	0.952	0.931	0.914	0.900	0.888	0.878	0.869	0.860	0.853
25-1/2	1.000	0.974	0.946	0.925	0.909	0.895	0.883	0.873	0.863	0.855	0.848
27	1.000	0.968	0.941	0.920	0.903	0.890	0.878	0.868	0.858	0.850	0.843
28-1/2	1.000	0.963	0.936	0.915	0.899	0.885	0.873	0.863	0.854	0.846	0.838
30	0.998	0.958	0.931	0.910	0.894	0.880	0.869	0.858	0.849	0.841	0.834
31-1/2	0.993	0.954	0.926	0.906	0.890	0.876	0.864	0.854	0.845	0.837	0.830
33	0.988	0.949	0.922	0.902	0.886	0.872	0.860	0.850	0.841	0.833	0.826
34-1/2	0.984	0.945	0.918	0.898	0.882	0.868	0.857	0.847	0.838	0.830	0.823
36	0.980	0.941	0.914	0.894	0.878	0.864	0.853	0.843	0.834	0.826	0.819

Table 4.5 Volume Factor for Bending about X-X Axis Western Species Glued Laminated Timber (Cont.)

Depth d (in.)	C _v when Span (ft.) is										
	10	14	18	22	26	30	34	38	42	46	50
6-3/4 in. Width											
7-1/2	1.000	1.000	1.000	--	--	--	--	--	--	--	--
9	1.000	1.000	1.000	0.997	--	--	--	--	--	--	--
10-1/2	1.000	1.000	1.000	0.981	0.965	--	--	--	--	--	--
12	1.000	1.000	0.988	0.968	0.952	0.939	--	--	--	--	--
13-1/2	1.000	1.000	0.976	0.957	0.941	0.928	--	--	--	--	--
15	1.000	0.991	0.966	0.947	0.931	0.918	0.907	--	--	--	--
16-1/2	1.000	0.981	0.957	0.938	0.922	0.909	0.898	0.888	--	--	--
18	1.000	0.973	0.949	0.930	0.914	0.901	0.890	0.880	0.872	--	--
19-1/2	0.998	0.965	0.941	0.922	0.907	0.894	0.883	0.873	0.865	0.857	--
21	0.991	0.958	0.934	0.916	0.900	0.888	0.877	0.867	0.858	0.851	0.843
22-1/2	0.984	0.951	0.928	0.909	0.894	0.882	0.871	0.861	0.852	0.845	0.838
24	0.978	0.945	0.922	0.903	0.889	0.876	0.865	0.855	0.847	0.839	0.832
25-1/2	0.972	0.940	0.916	0.898	0.883	0.871	0.860	0.850	0.842	0.834	0.827
27	0.966	0.934	0.911	0.893	0.878	0.866	0.855	0.845	0.837	0.829	0.823
28-1/2	0.961	0.929	0.906	0.888	0.873	0.861	0.850	0.841	0.832	0.825	0.818
30	0.956	0.924	0.901	0.884	0.869	0.857	0.846	0.837	0.828	0.821	0.814
31-1/2	0.951	0.920	0.897	0.879	0.865	0.852	0.842	0.832	0.824	0.817	0.810
33	0.947	0.916	0.893	0.875	0.861	0.848	0.838	0.829	0.820	0.813	0.806
34-1/2	0.943	0.912	0.889	0.871	0.857	0.845	0.834	0.825	0.817	0.809	0.803
36	0.939	0.908	0.885	0.868	0.853	0.841	0.831	0.821	0.813	0.806	0.799
37-1/2	0.935	0.904	0.882	0.864	0.850	0.838	0.827	0.818	0.810	0.803	0.796
39	0.931	0.900	0.878	0.861	0.846	0.834	0.824	0.815	0.807	0.799	0.793
40-1/2	0.928	0.897	0.875	0.857	0.843	0.831	0.821	0.812	0.804	0.796	0.790
42	0.924	0.894	0.872	0.854	0.840	0.828	0.818	0.809	0.801	0.794	0.787
43-1/2	0.921	0.891	0.869	0.851	0.837	0.825	0.815	0.806	0.798	0.791	0.784
45	0.918	0.888	0.866	0.848	0.834	0.823	0.812	0.803	0.795	0.788	0.782
46-1/2	0.915	0.885	0.863	0.846	0.832	0.820	0.810	0.801	0.793	0.786	0.779
48	0.912	0.882	0.860	0.843	0.829	0.817	0.807	0.798	0.790	0.783	0.777
49-1/2	0.909	0.879	0.857	0.840	0.826	0.815	0.805	0.796	0.788	0.781	0.774
51	0.907	0.877	0.855	0.838	0.824	0.812	0.802	0.793	0.785	0.778	0.772
52-1/2	0.904	0.874	0.852	0.835	0.822	0.810	0.800	0.791	0.783	0.776	0.770
54	0.901	0.872	0.850	0.833	0.819	0.808	0.798	0.789	0.781	0.774	0.767
55-1/2	0.899	0.869	0.848	0.831	0.817	0.805	0.795	0.787	0.779	0.772	0.765
57	0.897	0.867	0.845	0.829	0.815	0.803	0.793	0.785	0.777	0.770	0.763
58-1/2	0.894	0.865	0.843	0.826	0.813	0.801	0.791	0.783	0.775	0.768	0.761
60	0.892	0.862	0.841	0.824	0.811	0.799	0.789	0.781	0.773	0.766	0.759

Table 4.5 Volume Factor for Bending about X-X Axis Western Species Glued Laminated Timber (Cont.)

Depth d (in.)	C _v when Span (ft.) is										
	10	14	18	22	26	30	34	38	42	46	50
8-3/4 in. Width											
9	1.000	1.000	0.991	0.971	--	--	--	--	--	--	--
10-1/2	1.000	1.000	0.976	0.956	0.940	--	--	--	--	--	--
12	1.000	0.987	0.963	0.944	0.928	0.915	--	--	--	--	--
13-1/2	1.000	0.976	0.951	0.932	0.917	0.904	--	--	--	--	--
15	0.998	0.965	0.941	0.923	0.907	0.895	0.883	--	--	--	--
16-1/2	0.989	0.956	0.932	0.914	0.899	0.886	0.875	0.865	--	--	--
18	0.980	0.948	0.924	0.906	0.891	0.878	0.867	0.858	0.849	--	--
19-1/2	0.973	0.940	0.917	0.899	0.884	0.871	0.861	0.851	0.843	0.835	--
21	0.965	0.933	0.910	0.892	0.877	0.865	0.854	0.845	0.836	0.829	0.822
22-1/2	0.959	0.927	0.904	0.886	0.871	0.859	0.848	0.839	0.831	0.823	0.816
24	0.953	0.921	0.898	0.880	0.866	0.853	0.843	0.834	0.825	0.818	0.811
25-1/2	0.947	0.915	0.893	0.875	0.861	0.848	0.838	0.828	0.820	0.813	0.806
27	0.941	0.910	0.888	0.870	0.856	0.843	0.833	0.824	0.816	0.808	0.801
28-1/2	0.936	0.905	0.883	0.865	0.851	0.839	0.828	0.819	0.811	0.804	0.797
30	0.932	0.901	0.878	0.861	0.847	0.835	0.824	0.815	0.807	0.800	0.793
31-1/2	0.927	0.896	0.874	0.857	0.843	0.831	0.820	0.811	0.803	0.796	0.789
33	0.923	0.892	0.870	0.853	0.839	0.827	0.816	0.807	0.799	0.792	0.786
34-1/2	0.919	0.888	0.866	0.849	0.835	0.823	0.813	0.804	0.796	0.789	0.782
36	0.915	0.884	0.862	0.845	0.831	0.820	0.809	0.800	0.792	0.785	0.779
37-1/2	0.911	0.881	0.859	0.842	0.828	0.816	0.806	0.797	0.789	0.782	0.776
39	0.907	0.877	0.856	0.839	0.825	0.813	0.803	0.794	0.786	0.779	0.773
40-1/2	0.904	0.874	0.852	0.835	0.822	0.810	0.800	0.791	0.783	0.776	0.770
42	0.901	0.871	0.849	0.832	0.819	0.807	0.797	0.788	0.780	0.773	0.767
43-1/2	0.898	0.868	0.846	0.830	0.816	0.804	0.794	0.785	0.778	0.771	0.764
45	0.895	0.865	0.843	0.827	0.813	0.801	0.791	0.783	0.775	0.768	0.762
46-1/2	0.892	0.862	0.841	0.824	0.810	0.799	0.789	0.780	0.772	0.765	0.759
48	0.889	0.859	0.838	0.821	0.808	0.796	0.786	0.778	0.770	0.763	0.757
49-1/2	0.886	0.857	0.835	0.819	0.805	0.794	0.784	0.775	0.768	0.761	0.754
51	0.883	0.854	0.833	0.816	0.803	0.791	0.782	0.773	0.765	0.758	0.752
52-1/2	0.881	0.852	0.831	0.814	0.801	0.789	0.779	0.771	0.763	0.756	0.750
54	0.878	0.849	0.828	0.812	0.798	0.787	0.777	0.769	0.761	0.754	0.748
55-1/2	0.876	0.847	0.826	0.810	0.796	0.785	0.775	0.766	0.759	0.752	0.746
57	0.874	0.845	0.824	0.807	0.794	0.783	0.773	0.764	0.757	0.750	0.744
58-1/2	0.871	0.843	0.822	0.805	0.792	0.781	0.771	0.762	0.755	0.748	0.742
60	0.869	0.840	0.820	0.803	0.790	0.779	0.769	0.761	0.753	0.746	0.740

Table 4.5 Volume Factor for Bending about X-X Axis Western Species Glued Laminated Timber (Cont.)

Depth d (in.)	C _v when Span (ft.) is										
	12	16	20	24	28	32	36	40	44	48	52
10-3/4 in. Width											
12	0.982	0.954	0.933	0.916	0.902	--	--	--	--	--	--
13-1/2	0.971	0.943	0.922	0.906	0.892	0.880	--	--	--	--	--
15	0.960	0.933	0.913	0.896	0.882	0.871	0.860	--	--	--	--
16-1/2	0.951	0.924	0.904	0.888	0.874	0.862	0.852	0.843	--	--	--
18	0.943	0.916	0.896	0.880	0.866	0.855	0.845	0.836	0.828	--	--
19-1/2	0.936	0.909	0.889	0.873	0.860	0.848	0.838	0.829	0.822	0.814	--
21	0.929	0.902	0.882	0.866	0.853	0.842	0.832	0.823	0.815	0.808	0.802
22-1/2	0.922	0.896	0.876	0.860	0.847	0.836	0.826	0.818	0.810	0.803	0.796
24	0.916	0.890	0.871	0.855	0.842	0.831	0.821	0.812	0.805	0.798	0.791
25-1/2	0.911	0.885	0.865	0.850	0.837	0.826	0.816	0.807	0.800	0.793	0.787
27	0.906	0.880	0.860	0.845	0.832	0.821	0.811	0.803	0.795	0.788	0.782
28-1/2	0.901	0.875	0.856	0.840	0.828	0.817	0.807	0.799	0.791	0.784	0.778
30	0.896	0.871	0.851	0.836	0.823	0.812	0.803	0.794	0.787	0.780	0.774
31-1/2	0.892	0.866	0.847	0.832	0.819	0.808	0.799	0.791	0.783	0.776	0.770
33	0.888	0.862	0.843	0.828	0.815	0.805	0.795	0.787	0.779	0.773	0.767
34-1/2	0.884	0.859	0.840	0.824	0.812	0.801	0.792	0.783	0.776	0.769	0.763
36	0.880	0.855	0.836	0.821	0.808	0.798	0.788	0.780	0.773	0.766	0.760
37-1/2	0.876	0.851	0.833	0.818	0.805	0.794	0.785	0.777	0.770	0.763	0.757
39	0.873	0.848	0.829	0.814	0.802	0.791	0.782	0.774	0.767	0.760	0.754
40-1/2	0.870	0.845	0.826	0.811	0.799	0.788	0.779	0.771	0.764	0.757	0.751
42	0.866	0.842	0.823	0.808	0.796	0.785	0.776	0.768	0.761	0.754	0.748
43-1/2	0.863	0.839	0.820	0.806	0.793	0.783	0.774	0.765	0.758	0.752	0.746
45	0.860	0.836	0.818	0.803	0.791	0.780	0.771	0.763	0.756	0.749	0.743
46-1/2	0.858	0.833	0.815	0.800	0.788	0.778	0.768	0.760	0.753	0.747	0.741
48	0.855	0.831	0.812	0.798	0.785	0.775	0.766	0.758	0.751	0.744	0.738
49-1/2	0.852	0.828	0.810	0.795	0.783	0.773	0.764	0.756	0.748	0.742	0.736
51	0.850	0.826	0.807	0.793	0.781	0.770	0.761	0.753	0.746	0.740	0.734
52-1/2	0.847	0.823	0.805	0.791	0.778	0.768	0.759	0.751	0.744	0.738	0.732
54	0.845	0.821	0.803	0.788	0.776	0.766	0.757	0.749	0.742	0.736	0.730
55-1/2	0.843	0.819	0.801	0.786	0.774	0.764	0.755	0.747	0.740	0.734	0.728
57	0.840	0.817	0.799	0.784	0.772	0.762	0.753	0.745	0.738	0.732	0.726
58-1/2	0.838	0.814	0.796	0.782	0.770	0.760	0.751	0.743	0.736	0.730	0.724
60	0.836	0.812	0.794	0.780	0.768	0.758	0.749	0.741	0.734	0.728	0.722

Table 4.5 Volume Factor for Bending about X-X Axis Western Species Glued Laminated Timber (Cont.)

Depth d (in.)	C _v when Span (ft.) is										
	12	16	20	24	28	32	36	40	44	48	52
12-1/4 in. Width											
13-1/2	0.958	0.931	0.910	0.894	0.880	0.868	--	--	--	--	--
15	0.948	0.921	0.901	0.884	0.871	0.859	0.849	--	--	--	--
16-1/2	0.939	0.912	0.892	0.876	0.863	0.851	0.841	0.832	--	--	--
18	0.931	0.904	0.884	0.868	0.855	0.844	0.834	0.825	0.817	--	--
19-1/2	0.923	0.897	0.877	0.862	0.848	0.837	0.827	0.819	0.811	0.804	--
21	0.917	0.891	0.871	0.855	0.842	0.831	0.821	0.813	0.805	0.798	0.792
22-1/2	0.910	0.884	0.865	0.849	0.836	0.825	0.816	0.807	0.799	0.792	0.786
24	0.904	0.879	0.859	0.844	0.831	0.820	0.810	0.802	0.794	0.787	0.781
25-1/2	0.899	0.873	0.854	0.839	0.826	0.815	0.805	0.797	0.789	0.783	0.776
27	0.894	0.868	0.849	0.834	0.821	0.810	0.801	0.792	0.785	0.778	0.772
28-1/2	0.889	0.864	0.845	0.829	0.817	0.806	0.796	0.788	0.781	0.774	0.768
30	0.884	0.859	0.840	0.825	0.813	0.802	0.792	0.784	0.777	0.770	0.764
31-1/2	0.880	0.855	0.836	0.821	0.809	0.798	0.789	0.780	0.773	0.766	0.760
33	0.876	0.851	0.832	0.817	0.805	0.794	0.785	0.777	0.769	0.763	0.757
34-1/2	0.872	0.847	0.829	0.814	0.801	0.791	0.781	0.773	0.766	0.759	0.753
36	0.868	0.844	0.825	0.810	0.798	0.787	0.778	0.770	0.763	0.756	0.750
37-1/2	0.865	0.840	0.822	0.807	0.795	0.784	0.775	0.767	0.760	0.753	0.747
39	0.862	0.837	0.819	0.804	0.792	0.781	0.772	0.764	0.757	0.750	0.744
40-1/2	0.858	0.834	0.816	0.801	0.789	0.778	0.769	0.761	0.754	0.747	0.741
42	0.855	0.831	0.813	0.798	0.786	0.775	0.766	0.758	0.751	0.744	0.739
43-1/2	0.852	0.828	0.810	0.795	0.783	0.773	0.764	0.756	0.748	0.742	0.736
45	0.849	0.825	0.807	0.792	0.780	0.770	0.761	0.753	0.746	0.739	0.733
46-1/2	0.847	0.823	0.804	0.790	0.778	0.767	0.758	0.750	0.743	0.737	0.731
48	0.844	0.820	0.802	0.787	0.775	0.765	0.756	0.748	0.741	0.735	0.729
49-1/2	0.841	0.817	0.799	0.785	0.773	0.763	0.754	0.746	0.739	0.732	0.726
51	0.839	0.815	0.797	0.783	0.771	0.760	0.751	0.744	0.737	0.730	0.724
52-1/2	0.836	0.813	0.795	0.780	0.768	0.758	0.749	0.741	0.734	0.728	0.722
54	0.834	0.810	0.792	0.778	0.766	0.756	0.747	0.739	0.732	0.726	0.720
55-1/2	0.832	0.808	0.790	0.776	0.764	0.754	0.745	0.737	0.730	0.724	0.718
57	0.829	0.806	0.788	0.774	0.762	0.752	0.743	0.735	0.728	0.722	0.716
58-1/2	0.827	0.804	0.786	0.772	0.760	0.750	0.741	0.733	0.726	0.720	0.714
60	0.825	0.802	0.784	0.770	0.758	0.748	0.739	0.732	0.725	0.718	0.713

Table 4.6 Volume Factor for Bending about X-X Axis Southern Pine Glued Laminated Timber

Depth d (in.)	C _v when Span (ft.) is										
	8	12	16	20	24	28	32	36	40	44	48
2-1/2 in. Width											
5-1/2	1.000	1.000	--	--	--	--	--	--	--	--	--
6-7/8	1.000	1.000	1.000	--	--	--	--	--	--	--	--
8-1/4	1.000	1.000	1.000	1.000	--	--	--	--	--	--	--
9-5/8	1.000	1.000	1.000	1.000	1.000	--	--	--	--	--	--
11	1.000	1.000	1.000	1.000	1.000	--	--	--	--	--	--
12-3/8	1.000	1.000	1.000	1.000	1.000	1.000	--	--	--	--	--
13-3/4	1.000	1.000	1.000	1.000	1.000	1.000	1.000	--	--	--	--
15-1/8	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.997	--	--	--
16-1/2	1.000	1.000	1.000	1.000	1.000	1.000	0.999	0.993	0.988	--	--
17-7/8	1.000	1.000	1.000	1.000	1.000	1.000	0.995	0.989	0.984	0.979	--
19-1/4	1.000	1.000	1.000	1.000	1.000	0.998	0.991	0.985	0.980	0.976	0.971
20-5/8	1.000	1.000	1.000	1.000	1.000	0.994	0.988	0.982	0.977	0.972	0.968
22	1.000	1.000	1.000	1.000	0.999	0.991	0.985	0.979	0.974	0.969	0.965
23-3/8	1.000	1.000	1.000	1.000	0.996	0.988	0.982	0.976	0.971	0.966	0.962
3 in. Width											
5-1/2	1.000	1.000	--	--	--	--	--	--	--	--	--
6-7/8	1.000	1.000	1.000	--	--	--	--	--	--	--	--
8-1/4	1.000	1.000	1.000	1.000	--	--	--	--	--	--	--
9-5/8	1.000	1.000	1.000	1.000	1.000	--	--	--	--	--	--
11	1.000	1.000	1.000	1.000	1.000	--	--	--	--	--	--
12-3/8	1.000	1.000	1.000	1.000	1.000	1.000	--	--	--	--	--
13-3/4	1.000	1.000	1.000	1.000	1.000	1.000	0.999	--	--	--	--
15-1/8	1.000	1.000	1.000	1.000	1.000	1.000	0.994	0.988	--	--	--
16-1/2	1.000	1.000	1.000	1.000	1.000	0.996	0.990	0.984	0.979	--	--
17-7/8	1.000	1.000	1.000	1.000	1.000	0.992	0.986	0.980	0.975	0.970	--
19-1/4	1.000	1.000	1.000	1.000	0.996	0.989	0.982	0.976	0.971	0.967	0.963
20-5/8	1.000	1.000	1.000	1.000	0.993	0.985	0.979	0.973	0.968	0.963	0.959
22	1.000	1.000	1.000	0.999	0.990	0.982	0.976	0.970	0.965	0.960	0.956
23-3/8	1.000	1.000	1.000	0.996	0.987	0.979	0.973	0.967	0.962	0.957	0.953
3-1/8 in. Width											
5-1/2	1.000	1.000	--	--	--	--	--	--	--	--	--
6-7/8	1.000	1.000	1.000	--	--	--	--	--	--	--	--
8-1/4	1.000	1.000	1.000	1.000	--	--	--	--	--	--	--
9-5/8	1.000	1.000	1.000	1.000	1.000	--	--	--	--	--	--
11	1.000	1.000	1.000	1.000	1.000	--	--	--	--	--	--
12-3/8	1.000	1.000	1.000	1.000	1.000	1.000	--	--	--	--	--
13-3/4	1.000	1.000	1.000	1.000	1.000	1.000	0.997	--	--	--	--
15-1/8	1.000	1.000	1.000	1.000	1.000	0.999	0.992	0.986	--	--	--
16-1/2	1.000	1.000	1.000	1.000	1.000	0.994	0.988	0.982	0.977	--	--
17-7/8	1.000	1.000	1.000	1.000	0.998	0.990	0.984	0.978	0.973	0.968	--
19-1/4	1.000	1.000	1.000	1.000	0.994	0.987	0.980	0.974	0.969	0.965	0.961
20-5/8	1.000	1.000	1.000	1.000	0.991	0.983	0.977	0.971	0.966	0.961	0.957
22	1.000	1.000	1.000	0.997	0.988	0.980	0.974	0.968	0.963	0.958	0.954
23-3/8	1.000	1.000	1.000	0.994	0.985	0.977	0.971	0.965	0.960	0.955	0.951

Table 4.6 Volume Factor for Bending about X-X Axis Southern Pine Glued Laminated Timber (Cont.)

Depth d (in.)	C _v when Span (ft.) is										
	8	12	16	20	24	28	32	36	40	44	48
3-1/2 in. Width											
5-1/2	1.000	1.000	--	--	--	--	--	--	--	--	--
6-7/8	1.000	1.000	1.000	--	--	--	--	--	--	--	--
8-1/4	1.000	1.000	1.000	1.000	--	--	--	--	--	--	--
9-5/8	1.000	1.000	1.000	1.000	1.000	--	--	--	--	--	--
11	1.000	1.000	1.000	1.000	1.000	--	--	--	--	--	--
12-3/8	1.000	1.000	1.000	1.000	1.000	1.000	--	--	--	--	--
13-3/4	1.000	1.000	1.000	1.000	1.000	0.998	0.991	--	--	--	--
15-1/8	1.000	1.000	1.000	1.000	1.000	0.993	0.987	0.981	--	--	--
16-1/2	1.000	1.000	1.000	1.000	0.996	0.989	0.982	0.976	0.971	--	--
17-7/8	1.000	1.000	1.000	1.000	0.992	0.985	0.978	0.973	0.967	0.963	--
19-1/4	1.000	1.000	1.000	0.998	0.989	0.981	0.975	0.969	0.964	0.959	0.955
20-5/8	1.000	1.000	1.000	0.994	0.985	0.978	0.971	0.966	0.961	0.956	0.952
22	1.000	1.000	1.000	0.991	0.982	0.975	0.968	0.963	0.957	0.953	0.949
23-3/8	1.000	1.000	0.999	0.988	0.979	0.972	0.965	0.960	0.955	0.950	0.946
5 in. Width											
6-7/8	1.000	1.000	1.000	--	--	--	--	--	--	--	--
8-1/4	1.000	1.000	1.000	1.000	--	--	--	--	--	--	--
9-5/8	1.000	1.000	1.000	1.000	1.000	--	--	--	--	--	--
11	1.000	1.000	1.000	1.000	0.999	--	--	--	--	--	--
12-3/8	1.000	1.000	1.000	1.000	0.993	0.985	--	--	--	--	--
13-3/4	1.000	1.000	1.000	0.997	0.988	0.980	0.974	--	--	--	--
15-1/8	1.000	1.000	1.000	0.992	0.983	0.976	0.969	0.963	--	--	--
16-1/2	1.000	1.000	0.999	0.988	0.979	0.971	0.965	0.959	0.954	--	--
17-7/8	1.000	1.000	0.995	0.984	0.975	0.967	0.961	0.955	0.950	0.946	--
19-1/4	1.000	1.000	0.991	0.980	0.971	0.964	0.957	0.952	0.947	0.942	0.938
20-5/8	1.000	1.000	0.988	0.977	0.968	0.961	0.954	0.949	0.944	0.939	0.935
22	1.000	0.999	0.985	0.974	0.965	0.957	0.951	0.946	0.941	0.936	0.932
23-3/8	1.000	0.996	0.982	0.971	0.962	0.955	0.948	0.943	0.938	0.933	0.929
24-3/4	1.000	0.993	0.979	0.968	0.959	0.952	0.946	0.940	0.935	0.931	0.927
26-1/8	1.000	0.990	0.976	0.965	0.957	0.949	0.943	0.937	0.933	0.928	0.924
27-1/2	1.000	0.988	0.974	0.963	0.954	0.947	0.941	0.935	0.930	0.926	0.922
28-7/8	1.000	0.985	0.971	0.961	0.952	0.945	0.938	0.933	0.928	0.923	0.919
30-1/4	1.000	0.983	0.969	0.958	0.950	0.942	0.936	0.931	0.926	0.921	0.917
31-5/8	1.000	0.981	0.967	0.956	0.948	0.940	0.934	0.929	0.924	0.919	0.915
33	0.999	0.979	0.965	0.954	0.946	0.938	0.932	0.927	0.922	0.917	0.913
34-3/8	0.997	0.977	0.963	0.952	0.944	0.936	0.930	0.925	0.920	0.915	0.911
35-3/4	0.995	0.975	0.961	0.950	0.942	0.935	0.928	0.923	0.918	0.914	0.910

Table 4.6 Volume Factor for Bending about X-X Axis Southern Pine Glued Laminated Timber (Cont.)

Depth d (in.)	C _v when Span (ft.) is										
	8	12	16	20	24	28	32	36	40	44	48
5-1/8 in. Width											
6-7/8	1.000	1.000	1.000	--	--	--	--	--	--	--	--
8-1/4	1.000	1.000	1.000	1.000	--	--	--	--	--	--	--
9-5/8	1.000	1.000	1.000	1.000	1.000	--	--	--	--	--	--
11	1.000	1.000	1.000	1.000	0.998	--	--	--	--	--	--
12-3/8	1.000	1.000	1.000	1.000	0.992	0.984	--	--	--	--	--
13-3/4	1.000	1.000	1.000	0.996	0.987	0.979	0.973	--	--	--	--
15-1/8	1.000	1.000	1.000	0.991	0.982	0.974	0.968	0.962	--	--	--
16-1/2	1.000	1.000	0.998	0.987	0.978	0.970	0.964	0.958	0.953	--	--
17-7/8	1.000	1.000	0.994	0.983	0.974	0.966	0.960	0.954	0.949	0.945	--
19-1/4	1.000	1.000	0.990	0.979	0.970	0.963	0.956	0.951	0.946	0.941	0.937
20-5/8	1.000	1.000	0.987	0.976	0.967	0.959	0.953	0.947	0.942	0.938	0.934
22	1.000	0.998	0.983	0.973	0.964	0.956	0.950	0.944	0.939	0.935	0.931
23-3/8	1.000	0.995	0.980	0.970	0.961	0.953	0.947	0.941	0.937	0.932	0.928
24-3/4	1.000	0.992	0.978	0.967	0.958	0.951	0.944	0.939	0.934	0.929	0.925
26-1/8	1.000	0.989	0.975	0.964	0.955	0.948	0.942	0.936	0.931	0.927	0.923
27-1/2	1.000	0.987	0.973	0.962	0.953	0.946	0.939	0.934	0.929	0.925	0.921
28-7/8	1.000	0.984	0.970	0.959	0.951	0.943	0.937	0.932	0.927	0.922	0.918
30-1/4	1.000	0.982	0.968	0.957	0.948	0.941	0.935	0.929	0.925	0.920	0.916
31-5/8	1.000	0.980	0.966	0.955	0.946	0.939	0.933	0.927	0.922	0.918	0.914
33	0.998	0.978	0.964	0.953	0.944	0.937	0.931	0.925	0.921	0.916	0.912
34-3/8	0.996	0.976	0.962	0.951	0.942	0.935	0.929	0.924	0.919	0.914	0.910
35-3/4	0.994	0.974	0.960	0.949	0.941	0.933	0.927	0.922	0.917	0.913	0.909
5-1/2 in. Width											
6-7/8	1.000	1.000	1.000	--	--	--	--	--	--	--	--
8-1/4	1.000	1.000	1.000	1.000	--	--	--	--	--	--	--
9-5/8	1.000	1.000	1.000	1.000	1.000	--	--	--	--	--	--
11	1.000	1.000	1.000	1.000	0.994	--	--	--	--	--	--
12-3/8	1.000	1.000	1.000	0.997	0.988	0.981	--	--	--	--	--
13-3/4	1.000	1.000	1.000	0.992	0.983	0.976	0.969	--	--	--	--
15-1/8	1.000	1.000	0.998	0.987	0.978	0.971	0.964	0.959	--	--	--
16-1/2	1.000	1.000	0.994	0.983	0.974	0.967	0.960	0.955	0.950	--	--
17-7/8	1.000	1.000	0.990	0.979	0.970	0.963	0.956	0.951	0.946	0.941	--
19-1/4	1.000	1.000	0.987	0.976	0.967	0.959	0.953	0.947	0.942	0.938	0.934
20-5/8	1.000	0.997	0.983	0.972	0.963	0.956	0.950	0.944	0.939	0.935	0.931
22	1.000	0.994	0.980	0.969	0.960	0.953	0.947	0.941	0.936	0.932	0.928
23-3/8	1.000	0.991	0.977	0.966	0.957	0.950	0.944	0.938	0.933	0.929	0.925
24-3/4	1.000	0.988	0.974	0.963	0.955	0.947	0.941	0.935	0.931	0.926	0.922
26-1/8	1.000	0.986	0.972	0.961	0.952	0.945	0.938	0.933	0.928	0.924	0.920
27-1/2	1.000	0.983	0.969	0.958	0.950	0.942	0.936	0.931	0.926	0.921	0.917
28-7/8	1.000	0.981	0.967	0.956	0.947	0.940	0.934	0.928	0.923	0.919	0.915
30-1/4	0.998	0.978	0.964	0.954	0.945	0.938	0.932	0.926	0.921	0.917	0.913
31-5/8	0.996	0.976	0.962	0.952	0.943	0.936	0.930	0.924	0.919	0.915	0.911
33	0.994	0.974	0.960	0.950	0.941	0.934	0.928	0.922	0.917	0.913	0.909
34-3/8	0.992	0.972	0.958	0.948	0.939	0.932	0.926	0.920	0.915	0.911	0.907
35-3/4	0.990	0.970	0.956	0.946	0.937	0.930	0.924	0.918	0.914	0.909	0.905

4
DESIGN ADJUSTMENT FACTORS

Table 4.6 Volume Factor for Bending about X-X Axis Southern Pine Glued Laminated Timber (Cont.)

Depth d (in.)	C _v when Span (ft.) is										
	10	14	18	22	26	30	34	38	42	46	50
6-3/4 in. Width											
6-7/8	1.000	1.000	--	--	--	--	--	--	--	--	--
8-1/4	1.000	1.000	1.000	--	--	--	--	--	--	--	--
9-5/8	1.000	1.000	1.000	0.995	--	--	--	--	--	--	--
11	1.000	1.000	0.998	0.988	0.980	--	--	--	--	--	--
12-3/8	1.000	1.000	0.992	0.983	0.974	0.967	--	--	--	--	--
13-3/4	1.000	1.000	0.987	0.977	0.969	0.962	0.956	--	--	--	--
15-1/8	1.000	0.995	0.983	0.973	0.965	0.958	0.952	--	--	--	--
16-1/2	1.000	0.991	0.978	0.968	0.960	0.954	0.948	0.942	--	--	--
17-7/8	1.000	0.987	0.974	0.965	0.957	0.950	0.944	0.939	0.934	--	--
19-1/4	1.000	0.983	0.971	0.961	0.953	0.946	0.940	0.935	0.930	0.926	--
20-5/8	0.996	0.980	0.967	0.958	0.950	0.943	0.937	0.932	0.927	0.923	0.919
22	0.993	0.976	0.964	0.955	0.947	0.940	0.934	0.929	0.924	0.920	0.916
23-3/8	0.990	0.974	0.961	0.952	0.944	0.937	0.931	0.926	0.921	0.917	0.913
24-3/4	0.987	0.971	0.959	0.949	0.941	0.934	0.929	0.923	0.919	0.915	0.911
26-1/8	0.985	0.968	0.956	0.946	0.939	0.932	0.926	0.921	0.916	0.912	0.908
27-1/2	0.982	0.966	0.954	0.944	0.936	0.930	0.924	0.919	0.914	0.910	0.906
28-7/8	0.980	0.963	0.951	0.942	0.934	0.927	0.921	0.916	0.912	0.908	0.904
30-1/4	0.977	0.961	0.949	0.940	0.932	0.925	0.919	0.914	0.910	0.906	0.902
31-5/8	0.975	0.959	0.947	0.937	0.930	0.923	0.917	0.912	0.908	0.904	0.900
33	0.973	0.957	0.945	0.935	0.928	0.921	0.915	0.910	0.906	0.902	0.898
34-3/8	0.971	0.955	0.943	0.934	0.926	0.919	0.913	0.908	0.904	0.900	0.896
35-3/4	0.969	0.953	0.941	0.932	0.924	0.917	0.912	0.907	0.902	0.898	0.894
37-1/8	0.967	0.951	0.939	0.930	0.922	0.916	0.910	0.905	0.900	0.896	0.893
38-1/2	0.966	0.950	0.938	0.928	0.921	0.914	0.908	0.903	0.899	0.895	0.891
39-7/8	0.964	0.948	0.936	0.927	0.919	0.912	0.907	0.902	0.897	0.893	0.889
41-1/4	0.962	0.946	0.934	0.925	0.917	0.911	0.905	0.900	0.896	0.892	0.888
42-5/8	0.961	0.945	0.933	0.924	0.916	0.909	0.904	0.899	0.894	0.890	0.886
44	0.959	0.943	0.931	0.922	0.914	0.908	0.902	0.897	0.893	0.889	0.885
45-3/8	0.958	0.942	0.930	0.921	0.913	0.907	0.901	0.896	0.891	0.887	0.884
46-3/4	0.956	0.940	0.929	0.919	0.912	0.905	0.900	0.895	0.890	0.886	0.882
48-1/8	0.955	0.939	0.927	0.918	0.910	0.904	0.898	0.893	0.889	0.885	0.881
49-1/2	0.954	0.938	0.926	0.917	0.909	0.903	0.897	0.892	0.888	0.884	0.880
50-7/8	0.952	0.936	0.925	0.915	0.908	0.901	0.896	0.891	0.886	0.882	0.879
52-1/4	0.951	0.935	0.923	0.914	0.907	0.900	0.895	0.890	0.885	0.881	0.877
53-5/8	0.950	0.934	0.922	0.913	0.905	0.899	0.893	0.888	0.884	0.880	0.876
55	0.949	0.933	0.921	0.912	0.904	0.898	0.892	0.887	0.883	0.879	0.875
56-3/8	0.947	0.932	0.920	0.911	0.903	0.897	0.891	0.886	0.882	0.878	0.874
57-3/4	0.946	0.930	0.919	0.910	0.902	0.896	0.890	0.885	0.881	0.877	0.873
59-1/8	0.945	0.929	0.918	0.909	0.901	0.895	0.889	0.884	0.880	0.876	0.872
60-1/2	0.944	0.928	0.917	0.908	0.900	0.894	0.888	0.883	0.879	0.875	0.871

Table 4.6 Volume Factor for Bending about X-X Axis Southern Pine Glued Laminated Timber (Cont.)

Depth d (in.)	C_v when Span (ft.) is										
	10	14	18	22	26	30	34	38	42	46	50
8-1/2 in. Width											
9-5/8	1.000	1.000	0.993	0.984	--	--	--	--	--	--	--
11	1.000	0.999	0.987	0.977	0.969	--	--	--	--	--	--
12-3/8	1.000	0.993	0.981	0.971	0.963	0.956	--	--	--	--	--
13-3/4	1.000	0.988	0.976	0.966	0.958	0.951	0.945	--	--	--	--
15-1/8	1.000	0.984	0.971	0.962	0.954	0.947	0.941	--	--	--	--
16-1/2	0.996	0.979	0.967	0.957	0.949	0.943	0.937	0.932	--	--	--
17-7/8	0.992	0.975	0.963	0.954	0.946	0.939	0.933	0.928	0.923	--	--
19-1/4	0.988	0.972	0.960	0.950	0.942	0.935	0.930	0.924	0.920	0.916	--
20-5/8	0.985	0.968	0.956	0.947	0.939	0.932	0.926	0.921	0.917	0.912	0.909
22	0.982	0.965	0.953	0.944	0.936	0.929	0.923	0.918	0.914	0.910	0.906
23-3/8	0.979	0.962	0.950	0.941	0.933	0.926	0.921	0.915	0.911	0.907	0.903
24-3/4	0.976	0.960	0.948	0.938	0.930	0.924	0.918	0.913	0.908	0.904	0.900
26-1/8	0.973	0.957	0.945	0.936	0.928	0.921	0.915	0.910	0.906	0.902	0.898
27-1/2	0.971	0.955	0.943	0.933	0.925	0.919	0.913	0.908	0.904	0.899	0.896
28-7/8	0.968	0.952	0.940	0.931	0.923	0.917	0.911	0.906	0.901	0.897	0.894
30-1/4	0.966	0.950	0.938	0.929	0.921	0.915	0.909	0.904	0.899	0.895	0.891
31-5/8	0.964	0.948	0.936	0.927	0.919	0.912	0.907	0.902	0.897	0.893	0.889
33	0.962	0.946	0.934	0.925	0.917	0.911	0.905	0.900	0.895	0.891	0.888
34-3/8	0.960	0.944	0.932	0.923	0.915	0.909	0.903	0.898	0.894	0.889	0.886
35-3/4	0.958	0.942	0.930	0.921	0.913	0.907	0.901	0.896	0.892	0.888	0.884
37-1/8	0.956	0.940	0.929	0.919	0.912	0.905	0.900	0.895	0.890	0.886	0.882
38-1/2	0.955	0.939	0.927	0.918	0.910	0.904	0.898	0.893	0.888	0.884	0.881
39-7/8	0.953	0.937	0.925	0.916	0.908	0.902	0.896	0.891	0.887	0.883	0.879
41-1/4	0.951	0.935	0.924	0.915	0.907	0.900	0.895	0.890	0.885	0.881	0.878
42-5/8	0.950	0.934	0.922	0.913	0.905	0.899	0.893	0.888	0.884	0.880	0.876
44	0.948	0.932	0.921	0.912	0.904	0.898	0.892	0.887	0.883	0.879	0.875
45-3/8	0.947	0.931	0.919	0.910	0.903	0.896	0.891	0.886	0.881	0.877	0.874
46-3/4	0.945	0.930	0.918	0.909	0.901	0.895	0.889	0.884	0.880	0.876	0.872
48-1/8	0.944	0.928	0.917	0.907	0.900	0.894	0.888	0.883	0.879	0.875	0.871
49-1/2	0.943	0.927	0.915	0.906	0.899	0.892	0.887	0.882	0.877	0.873	0.870
50-7/8	0.941	0.926	0.914	0.905	0.897	0.891	0.885	0.881	0.876	0.872	0.869
52-1/4	0.940	0.924	0.913	0.904	0.896	0.890	0.884	0.879	0.875	0.871	0.867
53-5/8	0.939	0.923	0.912	0.903	0.895	0.889	0.883	0.878	0.874	0.870	0.866
55	0.938	0.922	0.911	0.901	0.894	0.888	0.882	0.877	0.873	0.869	0.865
56-3/8	0.937	0.921	0.909	0.900	0.893	0.886	0.881	0.876	0.872	0.868	0.864
57-3/4	0.935	0.920	0.908	0.899	0.892	0.885	0.880	0.875	0.871	0.867	0.863
59-1/8	0.934	0.919	0.907	0.898	0.891	0.884	0.879	0.874	0.870	0.866	0.862
60-1/2	0.933	0.918	0.906	0.897	0.890	0.883	0.878	0.873	0.869	0.865	0.861

Table 4.6 Volume Factor for Bending about X-X Axis Southern Pine Glued Laminated Timber (Cont.)

Depth d (in.)	C _v when Span (ft.) is										
	12	16	20	24	28	32	36	40	44	48	52
10-1/2 in. Width											
11	0.996	0.982	0.971	0.963	--	--	--	--	--	--	--
12-3/8	0.991	0.976	0.966	0.957	0.950	--	--	--	--	--	--
13-3/4	0.985	0.971	0.961	0.952	0.945	0.938	--	--	--	--	--
15-1/8	0.981	0.967	0.956	0.947	0.940	0.934	0.928	--	--	--	--
16-1/2	0.976	0.963	0.952	0.943	0.936	0.930	0.924	0.919	--	--	--
17-7/8	0.973	0.959	0.948	0.939	0.932	0.926	0.921	0.916	0.911	--	--
19-1/4	0.969	0.955	0.945	0.936	0.929	0.923	0.917	0.912	0.908	0.904	--
20-5/8	0.966	0.952	0.941	0.933	0.926	0.919	0.914	0.909	0.905	0.901	--
22	0.963	0.949	0.938	0.930	0.923	0.916	0.911	0.906	0.902	0.898	0.894
23-3/8	0.960	0.946	0.935	0.927	0.920	0.914	0.908	0.904	0.899	0.895	0.892
24-3/4	0.957	0.943	0.933	0.924	0.917	0.911	0.906	0.901	0.897	0.893	0.889
26-1/8	0.954	0.941	0.930	0.922	0.915	0.909	0.903	0.899	0.894	0.890	0.887
27-1/2	0.952	0.938	0.928	0.919	0.912	0.906	0.901	0.896	0.892	0.888	0.885
28-7/8	0.950	0.936	0.926	0.917	0.910	0.904	0.899	0.894	0.890	0.886	0.882
30-1/4	0.947	0.934	0.923	0.915	0.908	0.902	0.897	0.892	0.888	0.884	0.880
31-5/8	0.945	0.932	0.921	0.913	0.906	0.900	0.895	0.890	0.886	0.882	0.878
33	0.943	0.930	0.919	0.911	0.904	0.898	0.893	0.888	0.884	0.880	0.877
34-3/8	0.941	0.928	0.918	0.909	0.902	0.896	0.891	0.886	0.882	0.878	0.875
35-3/4	0.939	0.926	0.916	0.907	0.900	0.894	0.889	0.885	0.880	0.877	0.873
37-1/8	0.938	0.924	0.914	0.906	0.899	0.893	0.888	0.883	0.879	0.875	0.871
38-1/2	0.936	0.923	0.912	0.904	0.897	0.891	0.886	0.881	0.877	0.873	0.870
39-7/8	0.934	0.921	0.911	0.903	0.896	0.890	0.884	0.880	0.876	0.872	0.868
41-1/4	0.933	0.919	0.909	0.901	0.894	0.888	0.883	0.878	0.874	0.870	0.867
42-5/8	0.931	0.918	0.908	0.900	0.893	0.887	0.881	0.877	0.873	0.869	0.865
44	0.930	0.916	0.906	0.898	0.891	0.885	0.880	0.875	0.871	0.867	0.864
45-3/8	0.928	0.915	0.905	0.897	0.890	0.884	0.879	0.874	0.870	0.866	0.863
46-3/4	0.927	0.914	0.904	0.895	0.888	0.883	0.877	0.873	0.869	0.865	0.861
48-1/8	0.926	0.912	0.902	0.894	0.887	0.881	0.876	0.872	0.867	0.864	0.860
49-1/2	0.924	0.911	0.901	0.893	0.886	0.880	0.875	0.870	0.866	0.862	0.859
50-7/8	0.923	0.910	0.900	0.892	0.885	0.879	0.874	0.869	0.865	0.861	0.858
52-1/4	0.922	0.909	0.899	0.890	0.884	0.878	0.873	0.868	0.864	0.860	0.857
53-5/8	0.921	0.907	0.897	0.889	0.882	0.877	0.871	0.867	0.863	0.859	0.856
55	0.919	0.906	0.896	0.888	0.881	0.875	0.870	0.866	0.862	0.858	0.854
56-3/8	0.918	0.905	0.895	0.887	0.880	0.874	0.869	0.865	0.861	0.857	0.853
57-3/4	0.917	0.904	0.894	0.886	0.879	0.873	0.868	0.864	0.859	0.856	0.852
59-1/8	0.916	0.903	0.893	0.885	0.878	0.872	0.867	0.863	0.858	0.855	0.851
60-1/2	0.915	0.902	0.892	0.884	0.877	0.871	0.866	0.862	0.858	0.854	0.850

CAPACITY SELECTION TABLES

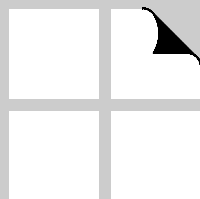
5.1	General	GL-30
5.2	Bending Capacity, M, and Shear Capacity, V	GL-30
5.3	Bending Stiffness, EI	GL-30
5.4	Tension Parallel to Grain Capacity, T	GL-30
5.5	Compression Parallel to Grain Capacity, P	GL-30

Table 5.1 Moment and Shear Capacities for Bending about X-X Axis ($C_D = 1.0$, $C_V = 1.0$) *Western Species* Glued Laminated Timber GL-31

Table 5.2 Moment and Shear Capacities for Bending about X-X Axis ($C_D = 1.0$, $C_V = 1.0$) *Southern Pine* Glued Laminated Timber GL-37

Table 5.3 Stiffness for Bending about X-X Axis *Western Species* Glued Laminated Timber GL-43

Table 5.4 Stiffness for Bending about X-X Axis *Southern Pine* Glued Laminated Timber GL-49



5.1 General

Capacity and stiffness values for structural glued laminated timber are provided in this section. The capacity value is based on a normal load duration (10 years). For other load durations, the tabulated capacities should be multiplied by the appropriate load duration factor (see Section 4.2).

5.2 Bending Capacity, M , and Shear Capacity, V

Bending capacity, M , and shear capacity, V , are given for various allowable stress levels in Table 5.1 for Western species glued laminated timber and Table 5.2 for Southern Pine glued laminated timber. These capacities shall be further multiplied by applicable design adjustment factors given in Section 4 of this Supplement. Note that the **tabulated values for bending capacity, M , have NOT been adjusted for volume factor** (see Section 4.9 of this Supplement) as the length of the glued laminated timber member is not specified in the tables.

The bending capacities in Tables 5.1 and 5.2 are based on fully laterally supported members. When members are not laterally supported, see the *NDS* for design details.

As noted in Section 3.2, tabulated horizontal shear values have been arbitrarily reduced by 10% to allow for in-service checking. The designer may increase the tabulated shear capacity values by 10% if allowance for checking is not a design concern.

5.3 Bending Stiffness, EI

Tables 5.3 (Western species) and 5.4 (Southern Pine) provides the bending stiffness for various glued laminated timber sizes at different E levels. The EI values may be used for deflection computations.

5.4 Tension Parallel to Grain Capacity, T

Tension parallel to grain capacity, T , can be calculated by multiplying the tensile strength parallel to grain (given in Tables 3.1 and 3.2) by the cross sectional area (given in Tables 9.1 and 9.2). This capacity shall be further multiplied by applicable design adjustment factors given in Section 4 of this Supplement.

5.5 Compression Parallel to Grain Capacity, P

Capacity for compression parallel-to-grain, P , (crushing) can be calculated by multiplying the allowable compressive stress parallel to grain (given in Tables 3.1 and 3.2) by the cross sectional area (given in Tables 9.1 and 9.2). This capacity shall be further multiplied by ap-

plicable design adjustment factors, especially the column stability factor when appropriate, given in Section 4 of this Supplement.

Table 5.1 Moment and Shear Capacities^a for Bending about X-X Axis ($C_D = 1.0$, $C_V = 1.0$) Western Species Glued Laminated Timber

Depth d (in.)	M (lb-ft.) when F_{bx} (psi) is			V (lb) when F_{vx} (psi) is		
	2,400	2,000	1,600	240	190	175
2-1/2 in. Width						
6	3,000	2,500	2,000	2,400	1,900	1,750
7-1/2	4,688	3,906	3,125	3,000	2,375	2,188
9	6,750	5,625	4,500	3,600	2,850	2,625
10-1/2	9,188	7,656	6,125	4,200	3,325	3,063
12	12,000	10,000	8,000	4,800	3,800	3,500
13-1/2	15,188	12,656	10,125	5,400	4,275	3,938
15	18,750	15,625	12,500	6,000	4,750	4,375
16-1/2	22,688	18,906	15,125	6,600	5,225	4,813
18	27,000	22,500	18,000	7,200	5,700	5,250
19-1/2	31,688	26,406	21,125	7,800	6,175	5,688
21	36,750	30,625	24,500	8,400	6,650	6,125
3-1/8 in. Width						
6	3,750	3,125	2,500	3,000	2,375	2,188
7-1/2	5,859	4,883	3,906	3,750	2,969	2,734
9	8,438	7,031	5,625	4,500	3,563	3,281
10-1/2	11,484	9,570	7,656	5,250	4,156	3,828
12	15,000	12,500	10,000	6,000	4,750	4,375
13-1/2	18,984	15,820	12,656	6,750	5,344	4,922
15	23,438	19,531	15,625	7,500	5,938	5,469
16-1/2	28,359	23,633	18,906	8,250	6,531	6,016
18	33,750	28,125	22,500	9,000	7,125	6,563
19-1/2	39,609	33,008	26,406	9,750	7,719	7,109
21	45,938	38,281	30,625	10,500	8,313	7,656
22-1/2	52,734	43,945	35,156	11,250	8,906	8,203
24	60,000	50,000	40,000	12,000	9,500	8,750
3-1/2 in. Width						
6	4,200	3,500	2,800	3,360	2,660	2,450
7-1/2	6,563	5,469	4,375	4,200	3,325	3,063
9	9,450	7,875	6,300	5,040	3,990	3,675
10-1/2	12,863	10,719	8,575	5,880	4,655	4,288
12	16,800	14,000	11,200	6,720	5,320	4,900
13-1/2	21,263	17,719	14,175	7,560	5,985	5,513
15	26,250	21,875	17,500	8,400	6,650	6,125
16-1/2	31,763	26,469	21,175	9,240	7,315	6,738
18	37,800	31,500	25,200	10,080	7,980	7,350
19-1/2	44,363	36,969	29,575	10,920	8,645	7,963
21	51,450	42,875	34,300	11,760	9,310	8,575
22-1/2	59,063	49,219	39,375	12,600	9,975	9,188
24	67,200	56,000	44,800	13,440	10,640	9,800

^a Applicable to fully laterally supported members. For other conditions of lateral support, see NDS-2001. For other load durations, multiply the tabulated values by an appropriate load duration factor (see Section 4.2).

Table 5.1 Moment and Shear Capacities^a for Bending about X-X Axis ($C_D = 1.0$, $C_V = 1.0$) Western Species Glued Laminated Timber

Depth d (in.)	M (lb-ft.) when F_{bx} (psi) is			V (lb) when F_{vx} (psi) is		
	2,400	2,000	1,600	240	190	175
5-1/8 in. Width						
6	6,150	5,125	4,100	4,920	3,895	3,588
7-1/2	9,609	8,008	6,406	6,150	4,869	4,484
9	13,838	11,531	9,225	7,380	5,843	5,381
10-1/2	18,834	15,695	12,556	8,610	6,816	6,278
12	24,600	20,500	16,400	9,840	7,790	7,175
13-1/2	31,134	25,945	20,756	11,070	8,764	8,072
15	38,438	32,031	25,625	12,300	9,738	8,969
16-1/2	46,509	38,758	31,006	13,530	10,711	9,866
18	55,350	46,125	36,900	14,760	11,685	10,763
19-1/2	64,959	54,133	43,306	15,990	12,659	11,659
21	75,338	62,781	50,225	17,220	13,633	12,556
22-1/2	86,484	72,070	57,656	18,450	14,606	13,453
24	98,400	82,000	65,600	19,680	15,580	14,350
25-1/2	111,084	92,570	74,056	20,910	16,554	15,247
27	124,538	103,781	83,025	22,140	17,528	16,144
28-1/2	138,759	115,633	92,506	23,370	18,501	17,041
30	153,750	128,125	102,500	24,600	19,475	17,938
31-1/2	169,509	141,258	113,006	25,830	20,449	18,834
33	186,038	155,031	124,025	27,060	21,423	19,731
34-1/2	203,334	169,445	135,556	28,290	22,396	20,628
36	221,400	184,500	147,600	29,520	23,370	21,525
5-1/2 in. Width						
6	6,600	5,500	4,400	5,280	4,180	3,850
7-1/2	10,313	8,594	6,875	6,600	5,225	4,813
9	14,850	12,375	9,900	7,920	6,270	5,775
10-1/2	20,213	16,844	13,475	9,240	7,315	6,738
12	26,400	22,000	17,600	10,560	8,360	7,700
13-1/2	33,413	27,844	22,275	11,880	9,405	8,663
15	41,250	34,375	27,500	13,200	10,450	9,625
16-1/2	49,913	41,594	33,275	14,520	11,495	10,588
18	59,400	49,500	39,600	15,840	12,540	11,550
19-1/2	69,713	58,094	46,475	17,160	13,585	12,513
21	80,850	67,375	53,900	18,480	14,630	13,475
22-1/2	92,813	77,344	61,875	19,800	15,675	14,438
24	105,600	88,000	70,400	21,120	16,720	15,400
25-1/2	119,213	99,344	79,475	22,440	17,765	16,363
27	133,650	111,375	89,100	23,760	18,810	17,325
28-1/2	148,913	124,094	99,275	25,080	19,855	18,288
30	165,000	137,500	110,000	26,400	20,900	19,250
31-1/2	181,913	151,594	121,275	27,720	21,945	20,213
33	199,650	166,375	133,100	29,040	22,990	21,175
34-1/2	218,213	181,844	145,475	30,360	24,035	22,138
36	237,600	198,000	158,400	31,680	25,080	23,100

^a Applicable to fully laterally supported members. For other conditions of lateral support, see NDS-2001. For other load durations, multiply the tabulated values by an appropriate load duration factor (see Section 4.2).

Table 5.1 Moment and Shear Capacities^a for Bending about X-X Axis ($C_D = 1.0$, $C_V = 1.0$) Western Species Glued Laminated Timber

Depth d (in.)	M (lb-ft.) when F_{bx} (psi) is			V (lb) when F_{vx} (psi) is		
	2,400	2,000	1,600	240	190	175
6-3/4 in. Width						
7-1/2	12,656	10,547	8,438	8,100	6,413	5,906
9	18,225	15,188	12,150	9,720	7,695	7,088
10-1/2	24,806	20,672	16,538	11,340	8,978	8,269
12	32,400	27,000	21,600	12,960	10,260	9,450
13-1/2	41,006	34,172	27,338	14,580	11,543	10,631
15	50,625	42,188	33,750	16,200	12,825	11,813
16-1/2	61,256	51,047	40,838	17,820	14,108	12,994
18	72,900	60,750	48,600	19,440	15,390	14,175
19-1/2	85,556	71,297	57,038	21,060	16,673	15,356
21	99,225	82,688	66,150	22,680	17,955	16,538
22-1/2	113,906	94,922	75,938	24,300	19,238	17,719
24	129,600	108,000	86,400	25,920	20,520	18,900
25-1/2	146,306	121,922	97,538	27,540	21,803	20,081
27	164,025	136,688	109,350	29,160	23,085	21,263
28-1/2	182,756	152,297	121,838	30,780	24,368	22,444
30	202,500	168,750	135,000	32,400	25,650	23,625
31-1/2	223,256	186,047	148,838	34,020	26,933	24,806
33	245,025	204,188	163,350	35,640	28,215	25,988
34-1/2	267,806	223,172	178,538	37,260	29,498	27,169
36	291,600	243,000	194,400	38,880	30,780	28,350
37-1/2	316,406	263,672	210,938	40,500	32,063	29,531
39	342,225	285,188	228,150	42,120	33,345	30,713
40-1/2	369,056	307,547	246,038	43,740	34,628	31,894
42	396,900	330,750	264,600	45,360	35,910	33,075
43-1/2	425,756	354,797	283,838	46,980	37,193	34,256
45	455,625	379,688	303,750	48,600	38,475	35,438
46-1/2	486,506	405,422	324,338	50,220	39,758	36,619
48	518,400	432,000	345,600	51,840	41,040	37,800
49-1/2	551,306	459,422	367,538	53,460	42,323	38,981
51	585,225	487,688	390,150	55,080	43,605	40,163
52-1/2	620,156	516,797	413,438	56,700	44,888	41,344
54	656,100	546,750	437,400	58,320	46,170	42,525
55-1/2	693,056	577,547	462,038	59,940	47,453	43,706
57	731,025	609,188	487,350	61,560	48,735	44,888
58-1/2	770,006	641,672	513,338	63,180	50,018	46,069
60	810,000	675,000	540,000	64,800	51,300	47,250

^a Applicable to fully laterally supported members. For other conditions of lateral support, see NDS-2001. For other load durations, multiply the tabulated values by an appropriate load duration factor (see Section 4.2).

Table 5.1 Moment and Shear Capacities^a for Bending about X-X Axis ($C_D = 1.0$, $C_V = 1.0$) Western Species Glued Laminated Timber

Depth d (in.)	M (lb-ft.) when F_{bx} (psi) is			V (lb) when F_{vx} (psi) is		
	2,400	2,000	1,600	240	190	175
8-3/4 in. Width						
9	23,625	19,688	15,750	12,600	9,975	9,188
10-1/2	32,156	26,797	21,438	14,700	11,638	10,719
12	42,000	35,000	28,000	16,800	13,300	12,250
13-1/2	53,156	44,297	35,438	18,900	14,963	13,781
15	65,625	54,688	43,750	21,000	16,625	15,313
16-1/2	79,406	66,172	52,938	23,100	18,288	16,844
18	94,500	78,750	63,000	25,200	19,950	18,375
19-1/2	110,906	92,422	73,938	27,300	21,613	19,906
21	128,625	107,188	85,750	29,400	23,275	21,438
22-1/2	147,656	123,047	98,438	31,500	24,938	22,969
24	168,000	140,000	112,000	33,600	26,600	24,500
25-1/2	189,656	158,047	126,438	35,700	28,263	26,031
27	212,625	177,188	141,750	37,800	29,925	27,563
28-1/2	236,906	197,422	157,938	39,900	31,588	29,094
30	262,500	218,750	175,000	42,000	33,250	30,625
31-1/2	289,406	241,172	192,938	44,100	34,913	32,156
33	317,625	264,688	211,750	46,200	36,575	33,688
34-1/2	347,156	289,297	231,438	48,300	38,238	35,219
36	378,000	315,000	252,000	50,400	39,900	36,750
37-1/2	410,156	341,797	273,438	52,500	41,563	38,281
39	443,625	369,688	295,750	54,600	43,225	39,813
40-1/2	478,406	398,672	318,938	56,700	44,888	41,344
42	514,500	428,750	343,000	58,800	46,550	42,875
43-1/2	551,906	459,922	367,938	60,900	48,213	44,406
45	590,625	492,188	393,750	63,000	49,875	45,938
46-1/2	630,656	525,547	420,438	65,100	51,538	47,469
48	672,000	560,000	448,000	67,200	53,200	49,000
49-1/2	714,656	595,547	476,438	69,300	54,863	50,531
51	758,625	632,188	505,750	71,400	56,525	52,063
52-1/2	803,906	669,922	535,938	73,500	58,188	53,594
54	850,500	708,750	567,000	75,600	59,850	55,125
55-1/2	898,406	748,672	598,938	77,700	61,513	56,656
57	947,625	789,688	631,750	79,800	63,175	58,188
58-1/2	998,156	831,797	665,438	81,900	64,838	59,719
60	1,050,000	875,000	700,000	84,000	66,500	61,250

^a Applicable to fully laterally supported members. For other conditions of lateral support, see NDS-2001. For other load durations, multiply the tabulated values by an appropriate load duration factor (see Section 4.2).

Table 5.1 Moment and Shear Capacities^a for Bending about X-X Axis ($C_D = 1.0$, $C_V = 1.0$) Western Species Glued Laminated Timber

Depth d (in.)	M (lb-ft.) when F_{bx} (psi) is			V (lbf) when F_{vx} (psi) is		
	2,400	2,000	1,600	240	190	175
10-3/4 in. Width						
12	51,600	43,000	34,400	20,640	16,340	15,050
13-1/2	65,306	54,422	43,538	23,220	18,383	16,931
15	80,625	67,188	53,750	25,800	20,425	18,813
16-1/2	97,556	81,297	65,038	28,380	22,468	20,694
18	116,100	96,750	77,400	30,960	24,510	22,575
19-1/2	136,256	113,547	90,838	33,540	26,553	24,456
21	158,025	131,688	105,350	36,120	28,595	26,338
22-1/2	181,406	151,172	120,938	38,700	30,638	28,219
24	206,400	172,000	137,600	41,280	32,680	30,100
25-1/2	233,006	194,172	155,338	43,860	34,723	31,981
27	261,225	217,688	174,150	46,440	36,765	33,863
28-1/2	291,056	242,547	194,038	49,020	38,808	35,744
30	322,500	268,750	215,000	51,600	40,850	37,625
31-1/2	355,556	296,297	237,038	54,180	42,893	39,506
33	390,225	325,188	260,150	56,760	44,935	41,388
34-1/2	426,506	355,422	284,338	59,340	46,978	43,269
36	464,400	387,000	309,600	61,920	49,020	45,150
37-1/2	503,906	419,922	335,938	64,500	51,063	47,031
39	545,025	454,188	363,350	67,080	53,105	48,913
40-1/2	587,756	489,797	391,838	69,660	55,148	50,794
42	632,100	526,750	421,400	72,240	57,190	52,675
43-1/2	678,056	565,047	452,038	74,820	59,233	54,556
45	725,625	604,688	483,750	77,400	61,275	56,438
46-1/2	774,806	645,672	516,538	79,980	63,318	58,319
48	825,600	688,000	550,400	82,560	65,360	60,200
49-1/2	878,006	731,672	585,338	85,140	67,403	62,081
51	932,025	776,688	621,350	87,720	69,445	63,963
52-1/2	987,656	823,047	658,438	90,300	71,488	65,844
54	1,044,900	870,750	696,600	92,880	73,530	67,725
55-1/2	1,103,756	919,797	735,838	95,460	75,573	69,606
57	1,164,225	970,188	776,150	98,040	77,615	71,488
58-1/2	1,226,306	1,021,922	817,538	100,620	79,658	73,369
60	1,290,000	1,075,000	860,000	103,200	81,700	75,250

^a Applicable to fully laterally supported members. For other conditions of lateral support, see NDS-2001. For other load durations, multiply the tabulated values by an appropriate load duration factor (see Section 4.2).

Table 5.1 Moment and Shear Capacities^a for Bending about X-X Axis ($C_D = 1.0$, $C_V = 1.0$) Western Species Glued Laminated Timber

Depth d (in.)	M (lb-ft.) when F_{bx} (psi) is			V (lbf) when F_{vx} (psi) is		
	2,400	2,000	1,600	240	190	175
12-1/4 in. Width						
13-1/2	74,419	62,016	49,613	26,460	20,948	19,294
15	91,875	76,563	61,250	29,400	23,275	21,438
16-1/2	111,169	92,641	74,113	32,340	25,603	23,581
18	132,300	110,250	88,200	35,280	27,930	25,725
19-1/2	155,269	129,391	103,513	38,220	30,258	27,869
21	180,075	150,063	120,050	41,160	32,585	30,013
22-1/2	206,719	172,266	137,813	44,100	34,913	32,156
24	235,200	196,000	156,800	47,040	37,240	34,300
25-1/2	265,519	221,266	177,013	49,980	39,568	36,444
27	297,675	248,063	198,450	52,920	41,895	38,588
28-1/2	331,669	276,391	221,113	55,860	44,223	40,731
30	367,500	306,250	245,000	58,800	46,550	42,875
31-1/2	405,169	337,641	270,113	61,740	48,878	45,019
33	444,675	370,563	296,450	64,680	51,205	47,163
34-1/2	486,019	405,016	324,013	67,620	53,533	49,306
36	529,200	441,000	352,800	70,560	55,860	51,450
37-1/2	574,219	478,516	382,813	73,500	58,188	53,594
39	621,075	517,563	414,050	76,440	60,515	55,738
40-1/2	669,769	558,141	446,513	79,380	62,843	57,881
42	720,300	600,250	480,200	82,320	65,170	60,025
43-1/2	772,669	643,891	515,113	85,260	67,498	62,169
45	826,875	689,063	551,250	88,200	69,825	64,313
46-1/2	882,919	735,766	588,613	91,140	72,153	66,456
48	940,800	784,000	627,200	94,080	74,480	68,600
49-1/2	1,000,519	833,766	667,013	97,020	76,808	70,744
51	1,062,075	885,063	708,050	99,960	79,135	72,888
52-1/2	1,125,469	937,891	750,313	102,900	81,463	75,031
54	1,190,700	992,250	793,800	105,840	83,790	77,175
55-1/2	1,257,769	1,048,141	838,513	108,780	86,118	79,319
57	1,326,675	1,105,563	884,450	111,720	88,445	81,463
58-1/2	1,397,419	1,164,516	931,613	114,660	90,773	83,606
60	1,470,000	1,225,000	980,000	117,600	93,100	85,750

^a Applicable to fully laterally supported members. For other conditions of lateral support, see NDS-2001. For other load durations, multiply the tabulated values by an appropriate load duration factor (see Section 4.2).

Table 5.2 Moment and Shear Capacities^a for Bending about X-X Axis ($C_D = 1.0$, $C_V = 1.0$) Southern Pine Glued Laminated Timber

Depth d (in.)	M (lb-ft.) when F_{bx} (psi) is					V (lb) when F_{vx} (psi) is
	3,000	2,800	2,600	2,400	2,000	270
2-1/2 in. Width						
5-1/2	3,151	2,941	2,731	2,521	2,101	2,475
6-7/8	4,924	4,595	4,267	3,939	3,282	3,094
8-1/4	7,090	6,617	6,145	5,672	4,727	3,713
9-5/8	9,650	9,007	8,363	7,720	6,433	4,331
11	12,604	11,764	10,924	10,083	8,403	4,950
12-3/8	15,952	14,889	13,825	12,762	10,635	5,569
13-3/4	19,694	18,381	17,068	15,755	13,129	6,188
15-1/8	23,830	22,241	20,652	19,064	15,887	6,806
16-1/2	28,359	26,469	24,578	22,688	18,906	7,425
17-7/8	33,283	31,064	28,845	26,626	22,189	8,044
19-1/4	38,600	36,027	33,454	30,880	25,734	8,663
20-5/8	44,312	41,357	38,403	35,449	29,541	9,281
22	50,417	47,056	43,694	40,333	33,611	9,900
23-3/8	56,916	53,121	49,327	45,533	37,944	10,519
3 in. Width						
5-1/2	3,781	3,529	3,277	3,025	2,521	2,970
6-7/8	5,908	5,514	5,120	4,727	3,939	3,713
8-1/4	8,508	7,941	7,373	6,806	5,672	4,455
9-5/8	11,580	10,808	10,036	9,264	7,720	5,198
11	15,125	14,117	13,108	12,100	10,083	5,940
12-3/8	19,143	17,866	16,590	15,314	12,762	6,683
13-3/4	23,633	22,057	20,482	18,906	15,755	7,425
15-1/8	28,596	26,689	24,783	22,877	19,064	8,168
16-1/2	34,031	31,763	29,494	27,225	22,688	8,910
17-7/8	39,939	37,277	34,614	31,952	26,626	9,653
19-1/4	46,320	43,232	40,144	37,056	30,880	10,395
20-5/8	53,174	49,629	46,084	42,539	35,449	11,138
22	60,500	56,467	52,433	48,400	40,333	11,880
23-3/8	68,299	63,746	59,192	54,639	45,533	12,623
3-1/8 in. Width						
5-1/2	3,939	3,676	3,414	3,151	2,626	3,094
6-7/8	6,154	5,744	5,334	4,924	4,103	3,867
8-1/4	8,862	8,271	7,681	7,090	5,908	4,641
9-5/8	12,063	11,258	10,454	9,650	8,042	5,414
11	15,755	14,705	13,655	12,604	10,503	6,188
12-3/8	19,940	18,611	17,281	15,952	13,293	6,961
13-3/4	24,618	22,976	21,335	19,694	16,412	7,734
15-1/8	29,787	27,801	25,816	23,830	19,858	8,508
16-1/2	35,449	33,086	30,723	28,359	23,633	9,281
17-7/8	41,604	38,830	36,056	33,283	27,736	10,055
19-1/4	48,250	45,034	41,817	38,600	32,167	10,828
20-5/8	55,389	51,697	48,004	44,312	36,926	11,602
22	63,021	58,819	54,618	50,417	42,014	12,375
23-3/8	71,145	66,402	61,659	56,916	47,430	13,148

^a Applicable to fully laterally supported members. For other conditions of lateral support, see NDS-2001. For other load durations, multiply the tabulated values by an appropriate load duration factor (see Section 4.2).

**Table 5.2 Moment and Shear Capacities^a for Bending about X-X Axis ($C_D = 1.0$,
(Cont.) $C_V = 1.0$) Southern Pine Glued Laminated Timber**

Depth d (in.)	M (lb-ft.) when F_{bx} (psi) is					V (lb) when F_{vx} (psi) is
	3,000	2,800	2,600	2,400	2,000	270
3-1/2 in. Width						
5-1/2	4,411	4,117	3,823	3,529	2,941	3,465
6-7/8	6,893	6,433	5,974	5,514	4,595	4,331
8-1/4	9,926	9,264	8,602	7,941	6,617	5,198
9-5/8	13,510	12,609	11,709	10,808	9,007	6,064
11	17,646	16,469	15,293	14,117	11,764	6,930
12-3/8	22,333	20,844	19,355	17,866	14,889	7,796
13-3/4	27,572	25,734	23,895	22,057	18,381	8,663
15-1/8	33,362	31,138	28,913	26,689	22,241	9,529
16-1/2	39,703	37,056	34,409	31,763	26,469	10,395
17-7/8	46,596	43,490	40,383	37,277	31,064	11,261
19-1/4	54,040	50,438	46,835	43,232	36,027	12,128
20-5/8	62,036	57,900	53,765	49,629	41,357	12,994
22	70,583	65,878	61,172	56,467	47,056	13,860
23-3/8	79,682	74,370	69,058	63,746	53,121	14,726
5 in. Width						
6-7/8	9,847	9,191	8,534	7,878	6,565	6,188
8-1/4	14,180	13,234	12,289	11,344	9,453	7,425
9-5/8	19,300	18,013	16,727	15,440	12,867	8,663
11	25,208	23,528	21,847	20,167	16,806	9,900
12-3/8	31,904	29,777	27,650	25,523	21,270	11,138
13-3/4	39,388	36,762	34,136	31,510	26,259	12,375
15-1/8	47,660	44,482	41,305	38,128	31,773	13,613
16-1/2	56,719	52,938	49,156	45,375	37,813	14,850
17-7/8	66,566	62,128	57,690	53,253	44,377	16,088
19-1/4	77,201	72,054	66,907	61,760	51,467	17,325
20-5/8	88,623	82,715	76,807	70,898	59,082	18,563
22	100,833	94,111	87,389	80,667	67,222	19,800
23-3/8	113,831	106,243	98,654	91,065	75,888	21,038
24-3/4	127,617	119,109	110,602	102,094	85,078	22,275
26-1/8	142,191	132,711	123,232	113,753	94,794	23,513
27-1/2	157,552	147,049	136,545	126,042	105,035	24,750
28-7/8	173,701	162,121	150,541	138,961	115,801	25,988
30-1/4	190,638	177,929	165,220	152,510	127,092	27,225
31-5/8	208,363	194,472	180,581	166,690	138,908	28,463
33	226,875	211,750	196,625	181,500	151,250	29,700
34-3/8	246,175	229,763	213,352	196,940	164,117	30,938
35-3/4	266,263	248,512	230,761	213,010	177,509	32,175

^a Applicable to fully laterally supported members. For other conditions of lateral support, see NDS-2001. For other load durations, multiply the tabulated values by an appropriate load duration factor (see Section 4.2).

**Table 5.2 Moment and Shear Capacities^a for Bending about X-X Axis ($C_D = 1.0$,
(Cont.) $C_V = 1.0$) Southern Pine Glued Laminated Timber**

Depth d (in.)	M (lb-ft) when F_{bx} (psi) is					V (lb) when F_{vx} (psi) is
	3,000	2,800	2,600	2,400	2,000	270
5-1/8 in. Width						
6-7/8	10,093	9,420	8,747	8,075	6,729	6,342
8-1/4	14,534	13,565	12,596	11,627	9,689	7,611
9-5/8	19,783	18,464	17,145	15,826	13,188	8,879
11	25,839	24,116	22,393	20,671	17,226	10,148
12-3/8	32,702	30,522	28,342	26,162	21,801	11,416
13-3/4	40,373	37,681	34,990	32,298	26,915	12,684
15-1/8	48,851	45,594	42,338	39,081	32,567	13,953
16-1/2	58,137	54,261	50,385	46,509	38,758	15,221
17-7/8	68,230	63,681	59,133	54,584	45,487	16,490
19-1/4	79,131	73,855	68,580	63,304	52,754	17,758
20-5/8	90,839	84,783	78,727	72,671	60,559	19,027
22	103,354	96,464	89,574	82,683	68,903	20,295
23-3/8	116,677	108,899	101,120	93,342	77,785	21,563
24-3/4	130,808	122,087	113,367	104,646	87,205	22,832
26-1/8	145,746	136,029	126,313	116,596	97,164	24,100
27-1/2	161,491	150,725	139,959	129,193	107,661	25,369
28-7/8	178,044	166,174	154,305	142,435	118,696	26,637
30-1/4	195,404	182,377	169,350	156,323	130,269	27,906
31-5/8	213,572	199,334	185,095	170,857	142,381	29,174
33	232,547	217,044	201,541	186,038	155,031	30,443
34-3/8	252,330	235,508	218,686	201,864	168,220	31,711
35-3/4	272,920	254,725	236,530	218,336	181,946	32,979
5-1/2 in. Width						
6-7/8	10,832	10,110	9,387	8,665	7,221	6,806
8-1/4	15,598	14,558	13,518	12,478	10,398	8,168
9-5/8	21,230	19,815	18,399	16,984	14,153	9,529
11	27,729	25,881	24,032	22,183	18,486	10,890
12-3/8	35,095	32,755	30,415	28,076	23,396	12,251
13-3/4	43,327	40,438	37,550	34,661	28,885	13,613
15-1/8	52,425	48,930	45,435	41,940	34,950	14,974
16-1/2	62,391	58,231	54,072	49,913	41,594	16,335
17-7/8	73,222	68,341	63,459	58,578	48,815	17,696
19-1/4	84,921	79,259	73,598	67,936	56,614	19,058
20-5/8	97,485	90,986	84,487	77,988	64,990	20,419
22	110,917	103,522	96,128	88,733	73,944	21,780
23-3/8	125,215	116,867	108,519	100,172	83,476	23,141
24-3/4	140,379	131,020	121,662	112,303	93,586	24,503
26-1/8	156,410	145,983	135,555	125,128	104,273	25,864
27-1/2	173,307	161,753	150,200	138,646	115,538	27,225
28-7/8	191,071	178,333	165,595	152,857	127,381	28,586
30-1/4	209,702	195,722	181,742	167,761	139,801	29,948
31-5/8	229,199	213,919	198,639	183,359	152,799	31,309
33	249,563	232,925	216,288	199,650	166,375	32,670
34-3/8	270,793	252,740	234,687	216,634	180,528	34,031
35-3/4	292,889	273,363	253,837	234,311	195,260	35,393

^a Applicable to fully laterally supported members. For other conditions of lateral support, see NDS-2001. For other load durations, multiply the tabulated values by an appropriate load duration factor (see Section 4.2).

**Table 5.2 Moment and Shear Capacities^a for Bending about X-X Axis ($C_D = 1.0$,
(Cont.) $C_V = 1.0$) Southern Pine Glued Laminated Timber**

Depth d (in.)	M (lb-ft.) when F_{bx} (psi) is					V (lbf) when F_{vx} (psi) is
	3,000	2,800	2,600	2,400	2,000	270
6-3/4 in. Width						
6-7/8	NA	12,407	11,521	10,635	8,862	8,353
8-1/4	NA	17,866	16,590	15,314	12,762	10,024
9-5/8	NA	24,318	22,581	20,844	17,370	11,694
11	NA	31,763	29,494	27,225	22,688	13,365
12-3/8	NA	40,199	37,328	34,457	28,714	15,036
13-3/4	NA	49,629	46,084	42,539	35,449	16,706
15-1/8	NA	60,051	55,762	51,472	42,894	18,377
16-1/2	NA	71,466	66,361	61,256	51,047	20,048
17-7/8	NA	83,873	77,882	71,891	59,909	21,718
19-1/4	NA	97,273	90,325	83,377	69,480	23,389
20-5/8	NA	111,665	103,689	95,713	79,761	25,059
22	NA	127,050	117,975	108,900	90,750	26,730
23-3/8	NA	143,428	133,183	122,938	102,448	28,401
24-3/4	NA	160,798	149,312	137,827	114,855	30,071
26-1/8	NA	179,160	166,363	153,566	127,972	31,742
27-1/2	NA	198,516	184,336	170,156	141,797	33,413
28-7/8	NA	218,863	203,230	187,597	156,331	35,083
30-1/4	NA	240,204	223,046	205,889	171,574	36,754
31-5/8	NA	262,537	243,784	225,032	187,526	38,424
33	NA	285,863	265,444	245,025	204,188	40,095
34-3/8	NA	310,181	288,025	265,869	221,558	41,766
35-3/4	NA	335,491	311,528	287,564	239,637	43,436
37-1/8	NA	361,795	335,952	310,110	258,425	45,107
38-1/2	NA	389,091	361,298	333,506	277,922	46,778
39-7/8	NA	417,379	387,566	357,754	298,128	48,448
41-1/4	NA	446,660	414,756	382,852	319,043	50,119
42-5/8	NA	476,934	442,867	408,800	340,667	51,789
44	NA	508,200	471,900	435,600	363,000	53,460
45-3/8	NA	540,459	501,855	463,250	386,042	55,131
46-3/4	NA	573,710	532,731	491,752	409,793	56,801
48-1/8	NA	607,954	564,529	521,104	434,253	58,472
49-1/2	NA	643,191	597,248	551,306	459,422	60,143
50-7/8	NA	679,420	630,890	582,360	485,300	61,813
52-1/4	NA	716,641	665,453	614,264	511,887	63,484
53-5/8	NA	754,856	700,937	647,019	539,183	65,154
55	NA	794,063	737,344	680,625	567,188	66,825
56-3/8	NA	834,262	774,672	715,082	595,901	68,496
57-3/4	NA	875,454	812,921	750,389	625,324	70,166
59-1/8	NA	917,638	852,093	786,547	655,456	71,837
60-1/2	NA	960,816	892,186	823,556	686,297	73,508

^a Applicable to fully laterally supported members. For other conditions of lateral support, see NDS-2001. For other load durations, multiply the tabulated values by an appropriate load duration factor (see Section 4.2).

Table 5.2 Moment and Shear Capacities^a for Bending about X-X Axis ($C_D = 1.0$, $C_V = 1.0$) Southern Pine Glued Laminated Timber

Depth d (in.)	M (lbf-ft.) when F_{bx} (psi) is					V (lbf) when F_{vx} (psi) is
	3,000	2,800	2,600	2,400	2,000	270
8-1/2 in. Width						
9-5/8	NA	30,623	28,436	26,248	21,873	14,726
11	NA	39,997	37,140	34,283	28,569	16,830
12-3/8	NA	50,621	47,006	43,390	36,158	18,934
13-3/4	NA	62,496	58,032	53,568	44,640	21,038
15-1/8	NA	75,620	70,218	64,817	54,014	23,141
16-1/2	NA	89,994	83,566	77,138	64,281	25,245
17-7/8	NA	105,618	98,074	90,529	75,441	27,349
19-1/4	NA	122,491	113,742	104,993	87,494	29,453
20-5/8	NA	140,615	130,571	120,527	100,439	31,556
22	NA	159,989	148,561	137,133	114,278	33,660
23-3/8	NA	180,612	167,712	154,811	129,009	35,764
24-3/4	NA	202,486	188,023	173,559	144,633	37,868
26-1/8	NA	225,609	209,494	193,379	161,150	39,971
27-1/2	NA	249,983	232,127	214,271	178,559	42,075
28-7/8	NA	275,606	255,920	236,234	196,861	44,179
30-1/4	NA	302,479	280,873	259,268	216,056	46,283
31-5/8	NA	330,602	306,988	283,373	236,144	48,386
33	NA	359,975	334,263	308,550	257,125	50,490
34-3/8	NA	390,598	362,698	334,798	278,998	52,594
35-3/4	NA	422,471	392,294	362,118	301,765	54,698
37-1/8	NA	455,593	423,051	390,509	325,424	56,801
38-1/2	NA	489,966	454,968	419,971	349,976	58,905
39-7/8	NA	525,588	488,046	450,504	375,420	61,009
41-1/4	NA	562,461	522,285	482,109	401,758	63,113
42-5/8	NA	600,583	557,684	514,786	428,988	65,216
44	NA	639,956	594,244	548,533	457,111	67,320
45-3/8	NA	680,578	631,965	583,352	486,127	69,424
46-3/4	NA	722,450	670,846	619,243	516,036	71,528
48-1/8	NA	765,572	710,888	656,204	546,837	73,631
49-1/2	NA	809,944	752,091	694,238	578,531	75,735
50-7/8	NA	855,566	794,454	733,342	611,118	77,839
52-1/4	NA	902,437	837,978	773,518	644,598	79,943
53-5/8	NA	950,559	882,662	814,765	678,971	82,046
55	NA	999,931	928,507	857,083	714,236	84,150
56-3/8	NA	1,050,552	975,513	900,473	750,394	86,254
57-3/4	NA	1,102,423	1,023,679	944,934	787,445	88,358
59-1/8	NA	1,155,545	1,073,006	990,467	825,389	90,461
60-1/2	NA	1,209,916	1,123,493	1,037,071	864,226	92,565

^a Applicable to fully laterally supported members. For other conditions of lateral support, see NDS-2001. For other load durations, multiply the tabulated values by an appropriate load duration factor (see Section 4.2).

**Table 5.2 Moment and Shear Capacities^a for Bending about X-X Axis ($C_D = 1.0$,
(Cont.) $C_V = 1.0$) Southern Pine Glued Laminated Timber**

Depth d (in.)	M (lb-ft.) when F_{bx} (psi) is					V (lb) when F_{vx} (psi) is
	3,000	2,800	2,600	2,400	2,000	270
10-1/2 in. Width						
11	NA	49,408	45,879	42,350	35,292	20,790
12-3/8	NA	62,532	58,066	53,599	44,666	23,389
13-3/4	NA	77,201	71,686	66,172	55,143	25,988
15-1/8	NA	93,413	86,740	80,068	66,723	28,586
16-1/2	NA	111,169	103,228	95,288	79,406	31,185
17-7/8	NA	130,469	121,150	111,830	93,192	33,784
19-1/4	NA	151,313	140,505	129,697	108,081	36,383
20-5/8	NA	173,701	161,294	148,887	124,072	38,981
22	NA	197,633	183,517	169,400	141,167	41,580
23-3/8	NA	223,110	207,173	191,237	159,364	44,179
24-3/4	NA	250,130	232,263	214,397	178,664	46,778
26-1/8	NA	278,694	258,787	238,880	199,067	49,376
27-1/2	NA	308,802	286,745	264,688	220,573	51,975
28-7/8	NA	340,454	316,136	291,818	243,182	54,574
30-1/4	NA	373,651	346,961	320,272	266,893	57,173
31-5/8	NA	408,391	379,220	350,049	291,708	59,771
33	NA	444,675	412,913	381,150	317,625	62,370
34-3/8	NA	482,503	448,039	413,574	344,645	64,969
35-3/4	NA	521,876	484,599	447,322	372,768	67,568
37-1/8	NA	562,792	522,592	482,393	401,994	70,166
38-1/2	NA	605,252	562,020	518,788	432,323	72,765
39-7/8	NA	649,256	602,881	556,505	463,755	75,364
41-1/4	NA	694,805	645,176	595,547	496,289	77,963
42-5/8	NA	741,897	688,904	635,912	529,926	80,561
44	NA	790,533	734,067	677,600	564,667	83,160
45-3/8	NA	840,714	780,663	720,612	600,510	85,759
46-3/4	NA	892,438	828,692	764,947	637,456	88,358
48-1/8	NA	945,706	878,156	810,605	675,505	90,956
49-1/2	NA	1,000,519	929,053	857,588	714,656	93,555
50-7/8	NA	1,056,875	981,384	905,893	754,911	96,154
52-1/4	NA	1,114,776	1,035,149	955,522	796,268	98,753
53-5/8	NA	1,174,220	1,090,347	1,006,474	838,729	101,351
55	NA	1,235,208	1,146,979	1,058,750	882,292	103,950
56-3/8	NA	1,297,741	1,205,045	1,112,349	926,958	106,549
57-3/4	NA	1,361,817	1,264,545	1,167,272	972,727	109,148
59-1/8	NA	1,427,438	1,325,478	1,223,518	1,019,598	111,746
60-1/2	NA	1,494,602	1,387,845	1,281,088	1,067,573	114,345

^a Applicable to fully laterally supported members. For other conditions of lateral support, see NDS-2001. For other load durations, multiply the tabulated values by an appropriate load duration factor (see Section 4.2).

Table 5.3 Stiffness for Bending about X-X Axis Western Species Glued Laminated Timber

Depth d (in.)	EI (10 ⁶ lbf-in. ²) when E (10 ⁶ psi) is					
	2.1	1.9	1.8	1.7	1.5	1.3
2-1/2 in. Width						
6	95	86	81	77	68	59
7-1/2	185	167	158	149	132	114
9	319	289	273	258	228	197
10-1/2	506	458	434	410	362	314
12	756	684	648	612	540	468
13-1/2	1,076	974	923	871	769	666
15	1,477	1,336	1,266	1,195	1,055	914
16-1/2	1,965	1,778	1,685	1,591	1,404	1,217
18	2,552	2,309	2,187	2,066	1,823	1,580
19-1/2	3,244	2,935	2,781	2,626	2,317	2,008
21	4,052	3,666	3,473	3,280	2,894	2,508
3-1/8 in. Width						
6	118	107	101	96	84	73
7-1/2	231	209	198	187	165	143
9	399	361	342	323	285	247
10-1/2	633	573	543	512	452	392
12	945	855	810	765	675	585
13-1/2	1,346	1,217	1,153	1,089	961	833
15	1,846	1,670	1,582	1,494	1,318	1,143
16-1/2	2,457	2,223	2,106	1,989	1,755	1,521
18	3,189	2,886	2,734	2,582	2,278	1,974
19-1/2	4,055	3,669	3,476	3,283	2,896	2,510
21	5,065	4,582	4,341	4,100	3,618	3,135
22-1/2	6,229	5,636	5,339	5,043	4,449	3,856
24	7,560	6,840	6,480	6,120	5,400	4,680
3-1/2 in. Width						
6	132	120	113	107	95	82
7-1/2	258	234	221	209	185	160
9	447	404	383	361	319	276
10-1/2	709	642	608	574	506	439
12	1,058	958	907	857	756	655
13-1/2	1,507	1,363	1,292	1,220	1,076	933
15	2,067	1,870	1,772	1,673	1,477	1,280
16-1/2	2,751	2,489	2,358	2,227	1,965	1,703
18	3,572	3,232	3,062	2,892	2,552	2,211
19-1/2	4,542	4,109	3,893	3,677	3,244	2,811
21	5,672	5,132	4,862	4,592	4,052	3,511
22-1/2	6,977	6,312	5,980	5,648	4,983	4,319
24	8,467	7,661	7,258	6,854	6,048	5,242

Table 5.3 Stiffness for Bending about X-X Axis Western Species Glued (Cont.) Laminated Timber

Depth d (in.)	EI (10 ⁶ lbf-in. ²) when E (10 ⁶ psi) is					
	2.1	1.9	1.8	1.7	1.5	1.3
5-1/8 in. Width						
6	194	175	166	157	138	120
7-1/2	378	342	324	306	270	234
9	654	592	560	529	467	405
10-1/2	1,038	939	890	840	742	643
12	1,550	1,402	1,328	1,255	1,107	959
13-1/2	2,207	1,996	1,891	1,786	1,576	1,366
15	3,027	2,739	2,595	2,450	2,162	1,874
16-1/2	4,029	3,645	3,453	3,261	2,878	2,494
18	5,231	4,732	4,483	4,234	3,736	3,238
19-1/2	6,650	6,017	5,700	5,384	4,750	4,117
21	8,306	7,515	7,119	6,724	5,933	5,142
22-1/2	10,216	9,243	8,757	8,270	7,297	6,324
24	12,398	11,218	10,627	10,037	8,856	7,675
25-1/2	14,871	13,455	12,747	12,039	10,622	9,206
27	17,653	15,972	15,131	14,291	12,609	10,928
28-1/2	20,762	18,785	17,796	16,807	14,830	12,853
30	24,216	21,909	20,756	19,603	17,297	14,991
31-1/2	28,033	25,363	24,028	22,693	20,023	17,354
33	32,231	29,161	27,627	26,092	23,022	19,953
34-1/2	36,829	33,321	31,568	29,814	26,306	22,799
36	41,845	37,859	35,867	33,874	29,889	25,904
5-1/2 in. Width						
6	208	188	178	168	149	129
7-1/2	406	367	348	329	290	251
9	702	635	601	568	501	434
10-1/2	1,114	1,008	955	902	796	690
12	1,663	1,505	1,426	1,346	1,188	1,030
13-1/2	2,368	2,143	2,030	1,917	1,692	1,466
15	3,248	2,939	2,784	2,630	2,320	2,011
16-1/2	4,324	3,912	3,706	3,500	3,088	2,677
18	5,613	5,079	4,811	4,544	4,010	3,475
19-1/2	7,137	6,457	6,117	5,777	5,098	4,418
21	8,914	8,065	7,640	7,216	6,367	5,518
22-1/2	10,963	9,919	9,397	8,875	7,831	6,787
24	13,306	12,038	11,405	10,771	9,504	8,237
25-1/2	15,960	14,440	13,680	12,920	11,400	9,880
27	18,945	17,141	16,238	15,336	13,532	11,728
28-1/2	22,281	20,159	19,098	18,037	15,915	13,793
30	25,988	23,513	22,275	21,038	18,563	16,088
31-1/2	30,084	27,219	25,786	24,354	21,488	18,623
33	34,589	31,295	29,648	28,001	24,707	21,412
34-1/2	39,524	35,760	33,877	31,995	28,231	24,467
36	44,906	40,630	38,491	36,353	32,076	27,799

Table 5.3 Stiffness for Bending about X-X Axis Western Species Glued Laminated Timber (Cont.)

Depth d (in.)	EI (10 ⁶ lbf-in. ²) when E (10 ⁶ psi) is					
	2.1	1.9	1.8	1.7	1.5	1.3
6-3/4 in. Width						
7-1/2	498	451	427	403	356	308
9	861	779	738	697	615	533
10-1/2	1,367	1,237	1,172	1,107	977	847
12	2,041	1,847	1,750	1,652	1,458	1,264
13-1/2	2,906	2,630	2,491	2,353	2,076	1,799
15	3,987	3,607	3,417	3,227	2,848	2,468
16-1/2	5,306	4,801	4,548	4,296	3,790	3,285
18	6,889	6,233	5,905	5,577	4,921	4,265
19-1/2	8,759	7,925	7,508	7,090	6,256	5,422
21	10,940	9,898	9,377	8,856	7,814	6,772
22-1/2	13,455	12,174	11,533	10,892	9,611	8,329
24	16,330	14,774	13,997	13,219	11,664	10,109
25-1/2	19,587	17,721	16,789	15,856	13,991	12,125
27	23,251	21,036	19,929	18,822	16,608	14,393
28-1/2	27,345	24,741	23,438	22,136	19,532	16,928
30	31,894	28,856	27,338	25,819	22,781	19,744
31-1/2	36,921	33,405	31,647	29,888	26,372	22,856
33	42,451	38,408	36,386	34,365	30,322	26,279
34-1/2	48,506	43,887	41,577	39,267	34,647	30,028
36	55,112	49,864	47,239	44,615	39,366	34,117
37-1/2	62,292	56,360	53,394	50,427	44,495	38,562
39	70,071	63,397	60,060	56,724	50,050	43,377
40-1/2	78,471	70,997	67,261	63,524	56,050	48,577
42	87,516	79,182	75,014	70,847	62,512	54,177
43-1/2	97,232	87,972	83,342	78,712	69,451	60,191
45	107,641	97,390	92,264	87,138	76,887	66,635
46-1/2	118,768	107,457	101,801	96,146	84,835	73,523
48	130,637	118,195	111,974	105,754	93,312	80,870
49-1/2	143,271	129,626	122,803	115,981	102,336	88,691
51	156,694	141,771	134,309	126,848	111,924	97,001
52-1/2	170,931	154,651	146,512	138,372	122,093	105,814
54	186,004	168,290	159,432	150,575	132,860	115,146
55-1/2	201,939	182,707	173,091	163,475	144,242	125,010
57	218,759	197,925	187,508	177,091	156,257	135,422
58-1/2	236,488	213,965	202,704	191,443	168,920	146,397
60	255,150	230,850	218,700	206,550	182,250	157,950

Table 5.3 Stiffness for Bending about X-X Axis Western Species Glued (Cont.) Laminated Timber

Depth d (in.)	EI (10 ⁶ lbf-in. ²) when E (10 ⁶ psi) is					
	2.1	1.9	1.8	1.7	1.5	1.3
8-3/4 in. Width						
9	1,116	1,010	957	904	797	691
10-1/2	1,773	1,604	1,519	1,435	1,266	1,097
12	2,646	2,394	2,268	2,142	1,890	1,638
13-1/2	3,767	3,409	3,229	3,050	2,691	2,332
15	5,168	4,676	4,430	4,184	3,691	3,199
16-1/2	6,879	6,223	5,896	5,568	4,913	4,258
18	8,930	8,080	7,655	7,229	6,379	5,528
19-1/2	11,354	10,273	9,732	9,191	8,110	7,029
21	14,181	12,830	12,155	11,480	10,129	8,779
22-1/2	17,442	15,781	14,950	14,120	12,458	10,797
24	21,168	19,152	18,144	17,136	15,120	13,104
25-1/2	25,390	22,972	21,763	20,554	18,136	15,718
27	30,140	27,269	25,834	24,399	21,528	18,658
28-1/2	35,447	32,071	30,383	28,695	25,319	21,943
30	41,344	37,406	35,438	33,469	29,531	25,594
31-1/2	47,861	43,302	41,023	38,744	34,186	29,628
33	55,029	49,788	47,167	44,547	39,306	34,065
34-1/2	62,879	56,890	53,896	50,902	44,913	38,925
36	71,442	64,638	61,236	57,834	51,030	44,226
37-1/2	80,750	73,059	69,214	65,369	57,678	49,988
39	90,832	82,182	77,856	73,531	64,880	56,229
40-1/2	101,721	92,033	87,190	82,346	72,658	62,970
42	113,447	102,643	97,241	91,838	81,034	70,229
43-1/2	126,042	114,038	108,036	102,034	90,030	78,026
45	139,535	126,246	119,602	112,957	99,668	86,379
46-1/2	153,959	139,296	131,965	124,633	109,971	95,308
48	169,344	153,216	145,152	137,088	120,960	104,832
49-1/2	185,721	168,034	159,190	150,346	132,658	114,970
51	203,122	183,777	174,104	164,432	145,087	125,742
52-1/2	221,577	200,474	189,923	179,372	158,269	137,167
54	241,117	218,153	206,672	195,190	172,226	149,263
55-1/2	261,773	236,842	224,377	211,912	186,981	162,050
57	283,577	256,569	243,066	229,562	202,555	175,548
58-1/2	306,559	277,363	262,765	248,167	218,971	189,774
60	330,750	299,250	283,500	267,750	236,250	204,750

Table 5.3 Stiffness for Bending about X-X Axis Western Species Glued Laminated Timber (Cont.)

Depth d (in.)	EI (10 ⁶ lbf-in. ²) when E (10 ⁶ psi) is					
	2.1	1.9	1.8	1.7	1.5	1.3
10-3/4 in. Width						
12	3,251	2,941	2,786	2,632	2,322	2,012
13-1/2	4,629	4,188	3,967	3,747	3,306	2,865
15	6,349	5,745	5,442	5,140	4,535	3,930
16-1/2	8,451	7,646	7,244	6,841	6,036	5,231
18	10,971	9,927	9,404	8,882	7,837	6,792
19-1/2	13,949	12,621	11,956	11,292	9,964	8,635
21	17,422	15,763	14,933	14,104	12,444	10,785
22-1/2	21,429	19,388	18,367	17,347	15,306	13,265
24	26,006	23,530	22,291	21,053	18,576	16,099
25-1/2	31,194	28,223	26,737	25,252	22,281	19,310
27	37,029	33,502	31,739	29,976	26,449	22,922
28-1/2	43,549	39,402	37,328	35,254	31,107	26,959
30	50,794	45,956	43,538	41,119	36,281	31,444
31-1/2	58,800	53,200	50,400	47,600	42,000	36,400
33	67,606	61,168	57,948	54,729	48,290	41,852
34-1/2	77,251	69,894	66,215	62,536	55,179	47,822
36	87,772	79,412	75,233	71,053	62,694	54,335
37-1/2	99,207	89,758	85,034	80,310	70,862	61,414
39	111,594	100,966	95,652	90,338	79,710	69,082
40-1/2	124,972	113,070	107,119	101,168	89,265	77,363
42	139,378	126,104	119,467	112,830	99,556	86,282
43-1/2	154,851	140,103	132,730	125,356	110,608	95,860
45	171,429	155,102	146,939	138,776	122,449	106,123
46-1/2	189,150	171,135	162,128	153,121	135,107	117,093
48	208,051	188,237	178,330	168,422	148,608	128,794
49-1/2	228,172	206,441	195,576	184,711	162,980	141,249
51	249,550	225,783	213,900	202,016	178,250	154,483
52-1/2	272,223	246,297	233,334	220,371	194,445	168,519
54	296,229	268,017	253,911	239,805	211,592	183,380
55-1/2	321,607	290,978	275,663	260,349	229,719	199,090
57	348,394	315,214	298,624	282,034	248,853	215,673
58-1/2	376,629	340,760	322,825	304,890	269,021	233,151
60	406,350	367,650	348,300	328,950	290,250	251,550

Table 5.3 Stiffness for Bending about X-X Axis Western Species Glued Laminated Timber (Cont.)

Depth d (in.)	EI (10 ⁶ lbf-in. ²) when E (10 ⁶ psi) is					
	2.1	1.9	1.8	1.7	1.5	1.3
12-1/4 in. Width						
13-1/2	5,274	4,772	4,521	4,270	3,767	3,265
15	7,235	6,546	6,202	5,857	5,168	4,479
16-1/2	9,630	8,713	8,254	7,796	6,879	5,961
18	12,502	11,312	10,716	10,121	8,930	7,740
19-1/2	15,896	14,382	13,625	12,868	11,354	9,840
21	19,853	17,962	17,017	16,072	14,181	12,290
22-1/2	24,419	22,093	20,930	19,767	17,442	15,116
24	29,635	26,813	25,402	23,990	21,168	18,346
25-1/2	35,546	32,161	30,468	28,776	25,390	22,005
27	42,195	38,177	36,168	34,158	30,140	26,121
28-1/2	49,626	44,900	42,537	40,173	35,447	30,721
30	57,881	52,369	49,613	46,856	41,344	35,831
31-1/2	67,005	60,623	57,433	54,242	47,861	41,479
33	77,040	69,703	66,034	62,366	55,029	47,691
34-1/2	88,030	79,646	75,454	71,262	62,879	54,495
36	100,019	90,493	85,730	80,968	71,442	61,916
37-1/2	113,049	102,283	96,899	91,516	80,750	69,983
39	127,165	115,054	108,999	102,943	90,832	78,721
40-1/2	142,410	128,847	122,065	115,284	101,721	88,158
42	158,826	143,700	136,137	128,574	113,447	98,321
43-1/2	176,458	159,653	151,250	142,847	126,042	109,236
45	195,349	176,745	167,442	158,140	139,535	120,930
46-1/2	215,543	195,015	184,751	174,487	153,959	133,431
48	237,082	214,502	203,213	191,923	169,344	146,765
49-1/2	260,010	235,247	222,866	210,484	185,721	160,958
51	284,371	257,288	243,746	230,205	203,122	176,039
52-1/2	310,207	280,664	265,892	251,120	221,577	192,033
54	337,563	305,415	289,340	273,266	241,117	208,968
55-1/2	366,482	331,579	314,128	296,676	261,773	226,870
57	397,007	359,197	340,292	321,387	283,577	245,767
58-1/2	429,182	388,308	367,870	347,433	306,559	265,684
60	463,050	418,950	396,900	374,850	330,750	286,650

Table 5.4 Stiffness for Bending about X-X Axis Southern Pine Glued Laminated Timber

Depth d (in.)	EI (10 ⁶ lbf-in. ²) when E (10 ⁶ psi) is					
	2.1	2.0	1.9	1.8	1.7	1.5
2-1/2 in. Width						
5-1/2	73	69	66	62	59	52
6-7/8	142	135	129	122	115	102
8-1/4	246	234	222	211	199	175
9-5/8	390	372	353	334	316	279
11	582	555	527	499	471	416
12-3/8	829	790	750	711	671	592
13-3/4	1,137	1,083	1,029	975	921	812
15-1/8	1,514	1,442	1,370	1,298	1,225	1,081
16-1/2	1,965	1,872	1,778	1,685	1,591	1,404
17-7/8	2,499	2,380	2,261	2,142	2,023	1,785
19-1/4	3,121	2,972	2,824	2,675	2,526	2,229
20-5/8	3,838	3,656	3,473	3,290	3,107	2,742
22	4,659	4,437	4,215	3,993	3,771	3,328
23-3/8	5,588	5,322	5,056	4,789	4,523	3,991
3 in. Width						
5-1/2	87	83	79	75	71	62
6-7/8	171	162	154	146	138	122
8-1/4	295	281	267	253	239	211
9-5/8	468	446	424	401	379	334
11	699	666	632	599	566	499
12-3/8	995	948	900	853	805	711
13-3/4	1,365	1,300	1,235	1,170	1,105	975
15-1/8	1,817	1,730	1,644	1,557	1,471	1,298
16-1/2	2,358	2,246	2,134	2,021	1,909	1,685
17-7/8	2,998	2,856	2,713	2,570	2,427	2,142
19-1/4	3,745	3,567	3,388	3,210	3,032	2,675
20-5/8	4,606	4,387	4,167	3,948	3,729	3,290
22	5,590	5,324	5,058	4,792	4,525	3,993
23-3/8	6,705	6,386	6,067	5,747	5,428	4,789
3-1/8 in. Width						
5-1/2	91	87	82	78	74	65
6-7/8	178	169	161	152	144	127
8-1/4	307	292	278	263	249	219
9-5/8	488	464	441	418	395	348
11	728	693	659	624	589	520
12-3/8	1,036	987	938	888	839	740
13-3/4	1,422	1,354	1,286	1,219	1,151	1,015
15-1/8	1,892	1,802	1,712	1,622	1,532	1,352
16-1/2	2,457	2,340	2,223	2,106	1,989	1,755
17-7/8	3,123	2,975	2,826	2,677	2,528	2,231
19-1/4	3,901	3,715	3,530	3,344	3,158	2,786
20-5/8	4,798	4,570	4,341	4,113	3,884	3,427
22	5,823	5,546	5,269	4,991	4,714	4,159
23-3/8	6,985	6,652	6,319	5,987	5,654	4,989

Table 5.4 Stiffness for Bending about X-X Axis Southern Pine Glued Laminated Timber (Cont.)

Depth d (in.)	EI (10 ⁶ lbf-in. ²) when E (10 ⁶ psi) is					
	2.1	2.0	1.9	1.8	1.7	1.5
3-1/2 in. Width						
5-1/2	102	97	92	87	82	73
6-7/8	199	190	180	171	161	142
8-1/4	344	328	311	295	278	246
9-5/8	546	520	494	468	442	390
11	815	776	738	699	660	582
12-3/8	1,161	1,105	1,050	995	940	829
13-3/4	1,592	1,516	1,441	1,365	1,289	1,137
15-1/8	2,119	2,018	1,917	1,817	1,716	1,514
16-1/2	2,751	2,620	2,489	2,358	2,227	1,965
17-7/8	3,498	3,332	3,165	2,998	2,832	2,499
19-1/4	4,369	4,161	3,953	3,745	3,537	3,121
20-5/8	5,374	5,118	4,862	4,606	4,350	3,838
22	6,522	6,211	5,901	5,590	5,280	4,659
23-3/8	7,823	7,450	7,078	6,705	6,333	5,588
5 in. Width						
6-7/8	284	271	257	244	230	203
8-1/4	491	468	445	421	398	351
9-5/8	780	743	706	669	632	557
11	1,165	1,109	1,054	998	943	832
12-3/8	1,658	1,579	1,500	1,421	1,342	1,184
13-3/4	2,275	2,166	2,058	1,950	1,841	1,625
15-1/8	3,028	2,883	2,739	2,595	2,451	2,163
16-1/2	3,931	3,743	3,556	3,369	3,182	2,808
17-7/8	4,997	4,759	4,521	4,284	4,046	3,570
19-1/4	6,242	5,944	5,647	5,350	5,053	4,458
20-5/8	7,677	7,311	6,946	6,580	6,215	5,484
22	9,317	8,873	8,430	7,986	7,542	6,655
23-3/8	11,175	10,643	10,111	9,579	9,047	7,982
24-3/4	13,266	12,634	12,002	11,371	10,739	9,476
26-1/8	15,602	14,859	14,116	13,373	12,630	11,144
27-1/2	18,197	17,331	16,464	15,598	14,731	12,998
28-7/8	21,066	20,062	19,059	18,056	17,053	15,047
30-1/4	24,221	23,067	21,914	20,760	19,607	17,300
31-5/8	27,676	26,358	25,040	23,722	22,404	19,768
33	31,445	29,948	28,450	26,953	25,455	22,461
34-3/8	35,542	33,849	32,157	30,464	28,772	25,387
35-3/4	39,979	38,076	36,172	34,268	32,364	28,557

Table 5.4 Stiffness for Bending about X-X Axis Southern Pine Glued Laminated Timber (Cont.)

Depth d (in.)	EI (10 ⁶ lbf-in. ²) when E (10 ⁶ psi) is					
	2.1	2.0	1.9	1.8	1.7	1.5
5-1/8 in. Width						
6-7/8	291	278	264	250	236	208
8-1/4	504	480	456	432	408	360
9-5/8	800	762	724	685	647	571
11	1,194	1,137	1,080	1,023	966	853
12-3/8	1,700	1,619	1,538	1,457	1,376	1,214
13-3/4	2,332	2,220	2,109	1,998	1,887	1,665
15-1/8	3,103	2,955	2,808	2,660	2,512	2,217
16-1/2	4,029	3,837	3,645	3,453	3,261	2,878
17-7/8	5,122	4,878	4,635	4,391	4,147	3,659
19-1/4	6,398	6,093	5,788	5,484	5,179	4,570
20-5/8	7,869	7,494	7,119	6,745	6,370	5,621
22	9,550	9,095	8,640	8,186	7,731	6,821
23-3/8	11,455	10,909	10,364	9,818	9,273	8,182
24-3/4	13,597	12,950	12,302	11,655	11,007	9,712
26-1/8	15,992	15,230	14,469	13,707	12,946	11,423
27-1/2	18,652	17,764	16,876	15,988	15,099	13,323
28-7/8	21,592	20,564	19,536	18,508	17,479	15,423
30-1/4	24,826	23,644	22,462	21,279	20,097	17,733
31-5/8	28,368	27,017	25,666	24,315	22,964	20,263
33	32,231	30,696	29,161	27,627	26,092	23,022
34-3/8	36,430	34,695	32,961	31,226	29,491	26,021
35-3/4	40,979	39,028	37,076	35,125	33,173	29,271
5-1/2 in. Width						
6-7/8	313	298	283	268	253	223
8-1/4	540	515	489	463	438	386
9-5/8	858	817	776	736	695	613
11	1,281	1,220	1,159	1,098	1,037	915
12-3/8	1,824	1,737	1,650	1,563	1,477	1,303
13-3/4	2,502	2,383	2,264	2,145	2,026	1,787
15-1/8	3,330	3,172	3,013	2,855	2,696	2,379
16-1/2	4,324	4,118	3,912	3,706	3,500	3,088
17-7/8	5,497	5,235	4,974	4,712	4,450	3,927
19-1/4	6,866	6,539	6,212	5,885	5,558	4,904
20-5/8	8,445	8,043	7,640	7,238	6,836	6,032
22	10,249	9,761	9,273	8,785	8,297	7,321
23-3/8	12,293	11,708	11,122	10,537	9,951	8,781
24-3/4	14,592	13,898	13,203	12,508	11,813	10,423
26-1/8	17,162	16,345	15,528	14,710	13,893	12,259
27-1/2	20,017	19,064	18,111	17,157	16,204	14,298
28-7/8	23,172	22,069	20,965	19,862	18,758	16,552
30-1/4	26,643	25,374	24,105	22,837	21,568	19,030
31-5/8	30,443	28,994	27,544	26,094	24,645	21,745
33	34,589	32,942	31,295	29,648	28,001	24,707
34-3/8	39,096	37,234	35,372	33,511	31,649	27,925
35-3/4	43,977	41,883	39,789	37,695	35,601	31,412

Table 5.4 Stiffness for Bending about X-X Axis Southern Pine Glued (Cont.) Laminated Timber

Depth d (in.)	EI (10 ⁶ lbf-in. ²) when E (10 ⁶ psi) is					
	2.1	2.0	1.9	1.8	1.7	1.5
6-3/4 in. Width						
6-7/8	384	366	347	329	311	274
8-1/4	663	632	600	569	537	474
9-5/8	1,053	1,003	953	903	853	752
11	1,572	1,497	1,423	1,348	1,273	1,123
12-3/8	2,239	2,132	2,025	1,919	1,812	1,599
13-3/4	3,071	2,925	2,778	2,632	2,486	2,193
15-1/8	4,087	3,893	3,698	3,503	3,309	2,919
16-1/2	5,306	5,054	4,801	4,548	4,296	3,790
17-7/8	6,747	6,425	6,104	5,783	5,461	4,819
19-1/4	8,426	8,025	7,624	7,222	6,821	6,019
20-5/8	10,364	9,870	9,377	8,883	8,390	7,403
22	12,578	11,979	11,380	10,781	10,182	8,984
23-3/8	15,087	14,368	13,650	12,932	12,213	10,776
24-3/4	17,909	17,056	16,203	15,350	14,498	12,792
26-1/8	21,063	20,060	19,057	18,054	17,051	15,045
27-1/2	24,566	23,396	22,227	21,057	19,887	17,547
28-7/8	28,439	27,084	25,730	24,376	23,022	20,313
30-1/4	32,698	31,141	29,584	28,027	26,470	23,356
31-5/8	37,362	35,583	33,804	32,025	30,246	26,687
33	42,451	40,429	38,408	36,386	34,365	30,322
34-3/8	47,981	45,696	43,411	41,127	38,842	34,272
35-3/4	53,972	51,402	48,832	46,262	43,692	38,552
37-1/8	60,442	57,564	54,686	51,808	48,930	43,173
38-1/2	67,410	64,200	60,990	57,780	54,570	48,150
39-7/8	74,893	71,327	67,761	64,194	60,628	53,495
41-1/4	82,911	78,963	75,015	71,067	67,119	59,222
42-5/8	91,482	87,126	82,769	78,413	74,057	65,344
44	100,624	95,832	91,040	86,249	81,457	71,874
45-3/8	110,355	105,100	99,845	94,590	89,335	78,825
46-3/4	120,694	114,947	109,200	103,452	97,705	86,210
48-1/8	131,660	125,391	119,121	112,851	106,582	94,043
49-1/2	143,271	136,448	129,626	122,803	115,981	102,336
50-7/8	155,545	148,138	140,731	133,324	125,917	111,103
52-1/4	168,500	160,476	152,453	144,429	136,405	120,357
53-5/8	182,156	173,482	164,808	156,134	147,460	130,112
55	196,530	187,172	177,813	168,455	159,096	140,379
56-3/8	211,642	201,564	191,485	181,407	171,329	151,173
57-3/4	227,509	216,675	205,841	195,007	184,174	162,506
59-1/8	244,149	232,523	220,897	209,271	197,645	174,392
60-1/2	261,582	249,126	236,669	224,213	211,757	186,844

Table 5.4 Stiffness for Bending about X-X Axis Southern Pine Glued Laminated Timber (Cont.)

Depth d (in.)	EI (10 ⁶ lbf-in. ²) when E (10 ⁶ psi) is					
	2.1	2.0	1.9	1.8	1.7	1.5
8-1/2 in. Width						
9-5/8	1,326	1,263	1,200	1,137	1,074	947
11	1,980	1,886	1,791	1,697	1,603	1,414
12-3/8	2,819	2,685	2,551	2,416	2,282	2,014
13-3/4	3,867	3,683	3,499	3,315	3,130	2,762
15-1/8	5,147	4,902	4,657	4,412	4,167	3,676
16-1/2	6,682	6,364	6,046	5,727	5,409	4,773
17-7/8	8,496	8,091	7,687	7,282	6,877	6,068
19-1/4	10,611	10,106	9,600	9,095	8,590	7,579
20-5/8	13,051	12,429	11,808	11,186	10,565	9,322
22	15,839	15,085	14,330	13,576	12,822	11,314
23-3/8	18,998	18,093	17,189	16,284	15,379	13,570
24-3/4	22,552	21,478	20,404	19,330	18,256	16,108
26-1/8	26,523	25,260	23,997	22,734	21,471	18,945
27-1/2	30,935	29,462	27,989	26,516	25,043	22,097
28-7/8	35,812	34,106	32,401	30,696	28,990	25,580
30-1/4	41,175	39,214	37,254	35,293	33,332	29,411
31-5/8	47,049	44,808	42,568	40,328	38,087	33,606
33	53,456	50,911	48,365	45,820	43,274	38,183
34-3/8	60,421	57,543	54,666	51,789	48,912	43,158
35-3/4	67,965	64,729	61,492	58,256	55,019	48,546
37-1/8	76,113	72,488	68,864	65,239	61,615	54,366
38-1/2	84,887	80,844	76,802	72,760	68,718	60,633
39-7/8	94,310	89,819	85,328	80,837	76,346	67,364
41-1/4	104,407	99,435	94,463	89,492	84,520	74,576
42-5/8	115,199	109,714	104,228	98,742	93,257	82,285
44	126,711	120,677	114,643	108,610	102,576	90,508
45-3/8	138,965	132,348	125,731	119,113	112,496	99,261
46-3/4	151,985	144,748	137,511	130,273	123,036	108,561
48-1/8	165,794	157,899	150,004	142,109	134,214	118,424
49-1/2	180,415	171,824	163,233	154,641	146,050	128,868
50-7/8	195,871	186,544	177,217	167,889	158,562	139,908
52-1/4	212,186	202,082	191,977	181,873	171,769	151,561
53-5/8	229,382	218,459	207,536	196,613	185,690	163,844
55	247,483	235,698	223,913	212,128	200,343	176,773
56-3/8	266,512	253,821	241,130	228,439	215,748	190,366
57-3/4	286,492	272,850	259,207	245,565	231,922	204,637
59-1/8	307,447	292,807	278,166	263,526	248,886	219,605
60-1/2	329,400	313,714	298,028	282,343	266,657	235,285

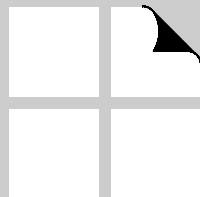
Table 5.4 Stiffness for Bending about X-X Axis Southern Pine Glued Laminated Timber (Cont.)

Depth d (in.)	EI (10 ⁶ lbf-in. ²) when E (10 ⁶ psi) is					
	2.1	2.0	1.9	1.8	1.7	1.5
10-1/2 in. Width						
11	2,446	2,329	2,213	2,096	1,980	1,747
12-3/8	3,482	3,316	3,151	2,985	2,819	2,487
13-3/4	4,777	4,549	4,322	4,094	3,867	3,412
15-1/8	6,358	6,055	5,752	5,450	5,147	4,541
16-1/2	8,254	7,861	7,468	7,075	6,682	5,896
17-7/8	10,495	9,995	9,495	8,995	8,496	7,496
19-1/4	13,107	12,483	11,859	11,235	10,611	9,362
20-5/8	16,122	15,354	14,586	13,819	13,051	11,515
22	19,566	18,634	17,702	16,771	15,839	13,976
23-3/8	23,468	22,351	21,233	20,116	18,998	16,763
24-3/4	27,858	26,532	25,205	23,878	22,552	19,899
26-1/8	32,764	31,204	29,644	28,083	26,523	23,403
27-1/2	38,214	36,395	34,575	32,755	30,935	27,296
28-7/8	44,238	42,131	40,025	37,918	35,812	31,598
30-1/4	50,863	48,441	46,019	43,597	41,175	36,331
31-5/8	58,119	55,352	52,584	49,816	47,049	41,514
33	66,034	62,890	59,745	56,601	53,456	47,167
34-3/8	74,637	71,083	67,529	63,975	60,421	53,312
35-3/4	83,957	79,959	75,961	71,963	67,965	59,969
37-1/8	94,021	89,544	85,067	80,590	76,113	67,158
38-1/2	104,860	99,867	94,873	89,880	84,887	74,900
39-7/8	116,501	110,953	105,406	99,858	94,310	83,215
41-1/4	128,973	122,832	116,690	110,548	104,407	92,124
42-5/8	142,305	135,529	128,752	121,976	115,199	101,647
44	156,526	149,072	141,618	134,165	126,711	111,804
45-3/8	171,663	163,489	155,314	147,140	138,965	122,617
46-3/4	187,747	178,806	169,866	160,926	151,985	134,105
48-1/8	204,805	195,052	185,299	175,547	165,794	146,289
49-1/2	222,866	212,253	201,640	191,028	180,415	159,190
50-7/8	241,958	230,437	218,915	207,393	195,871	172,827
52-1/4	262,112	249,630	237,149	224,667	212,186	187,223
53-5/8	283,354	269,861	256,368	242,875	229,382	202,396
55	305,714	291,156	276,598	262,041	247,483	218,367
56-3/8	329,221	313,543	297,866	282,189	266,512	235,158
57-3/4	353,902	337,050	320,197	303,345	286,492	252,787
59-1/8	379,788	361,702	343,617	325,532	307,447	271,277
60-1/2	406,905	387,529	368,153	348,776	329,400	290,647

OTHER CONSIDERATIONS

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6.1 General

The section contains information concerning physical properties of glued laminated timber members. Other design considerations, such as fire protection, are also given.

6.2 Specific Gravity

Table 6.1 provides specific gravity values for some of the most common wood species used for glued laminated timber. These values are used in determining various physical and connection properties. Further, weight factors are provided at four moisture contents. When the cross-sectional area (in.²) is multiplied by the appropriate weight factor, it provides the weight of the glued laminated timber member per linear foot of length. For other

moisture contents, the tabulated weight factors can be interpolated or extrapolated.

Glued laminated timber members often are manufactured using different species at different portions of the cross section. In this case the weight of the glued laminated timber may be computed by the sum of the products of the cross-sectional area and the weight factor for each species.

Table 6.1 Average Specific Gravity and Weight Factor

Species Combination	Specific Gravity ^a	Weight Factor ^b			
		12%	15%	19%	25%
California Redwood (Close Grain)	0.44	0.195	0.198	0.202	0.208
Douglas Fir-Larch	0.50	0.235	0.238	0.242	0.248
Douglas Fir (South)	0.46	0.221	0.225	0.229	0.235
Eastern Spruce	0.41	0.191	0.194	0.198	0.203
Hem-Fir	0.43	0.195	0.198	0.202	0.208
Red Maple	0.58	0.261	0.264	0.268	0.274
Red Oak	0.67	0.307	0.310	0.314	0.319
Southern Pine	0.55	0.252	0.255	0.259	0.265
Spruce-Pine-Fir (North)	0.42	0.195	0.198	0.202	0.208
Yellow Poplar	0.43	0.213	0.216	0.220	0.226

^a Specific gravity is based on weight and volume when oven-dry.

^b Weight factor shall be multiplied by net cross-sectional area in in.² to obtain weight in pounds per lineal foot.

6.3 Dimensional Changes Due to Moisture

Due to the hygroscopic nature of wood, it changes dimensions as its moisture content is altered below the fiber saturation point. For most species the longitudinal shrinkage of normal wood drying from fiber saturation point to oven-dry condition is approximately 0.1 to 0.2 percent. However, certain atypical types of wood may exhibit excessive longitudinal shrinkage and these types should be avoided in use where longitudinal stability is important.

The change in radial (R), tangential (T) and volumetric (V) dimensions are computed as:

$$X = X_o (\Delta MC) e_{ME} \quad [6.1]$$

where:

X_o = initial dimension or volume

X = new dimension or volume

e_{ME} = coefficient of moisture expansion (in./in./%MC for linear expansion, in.³/in.³/%MC for volumetric expansion), as given in Table 6.2

ΔMC = moisture content change (%), as defined as follows:

$$\Delta MC = M - M_o \quad [6.2]$$

where:

M_o = initial moisture content % ($M_o \leq \text{FSP}$)

M = new moisture content % ($M \leq \text{FSP}$)

FSP = fiber saturation point, as given in Table 6.2 for selected species

For more information concerning the effects of moisture changes on glued laminated timber, refer to APA EWS Technical Note Y260.

Table 6.2 Coefficient of Moisture Expansion, e_{ME} , and Fiber Saturation Point, FSP, for Solid Woods

Species	e_{ME}			FSP (%)
	Radial (in./in./%)	Tangential (in./in./%)	Volumetric (in. ³ /in. ³ /%)	
Alaska Cedar	0.0010	0.0021	0.0033	28
Douglas Fir-Larch	0.0018	0.0033	0.0050	28
Englemann Spruce	0.0013	0.0024	0.0037	30
Redwood	0.0012	0.0022	0.0032	22
Red Oak	0.0017	0.0038	0.0063	30
Southern Pine	0.0020	0.0030	0.0047	26
Western Hemlock	0.0015	0.0028	0.0044	28
Yellow Poplar	0.0015	0.0026	0.0041	31

6.4 Dimensional Changes Due to Temperature

The thermal expansion of solid wood, including glued laminated timber, is computed by the relationship:

$$X = X_o(\Delta T)e_{TE} \quad [6.3]$$

where:

X_o = reference dimension at T_o

X = computed dimension at T

e_{TE} = coefficient of thermal expansion (in./in./°F), see Table 6.3

ΔT = temperature change (°F), as defined as follows:

$$\Delta T = T - T_o \quad [6.4]$$

where:

T_o = reference temperature (°F), $-60^\circ\text{F} \leq T_o \leq 130^\circ\text{F}$

T = new temperature (°F), $-60^\circ\text{F} \leq T \leq 130^\circ\text{F}$.

The coefficient of thermal expansion of oven-dry wood parallel to grain appears to be independent of specific gravity and species. In tests of both hardwoods and

softwoods, the parallel-to-grain values have ranged from about 1.7×10^{-6} to 2.5×10^{-6} per °F.

The linear expansion coefficients across the grain (radial and tangential) are proportional to the density of wood. These coefficients are about 5 to 10 times greater than the parallel-to-grain coefficients. The radial and tangential thermal expansion coefficients for oven-dry wood in the oven-dry specific gravity (SG) range of about 0.1 to 0.8 can be approximated by the following equations.

Radial:

$$e_{TE} = [18(\text{SG}) + 5.5] (10^{-6} \text{ in./in./}^\circ\text{F}) \quad [6.5]$$

Tangential:

$$e_{TE} = [18(\text{SG}) + 10.2] (10^{-6} \text{ in./in./}^\circ\text{F}) \quad [6.6]$$

where:

SG = specific gravity provided in Table 6.1

Table 6.3 provides the numerical values for e_{TE} for the most commonly used commercial species or species groups.

Wood that contains moisture reacts to varying temperature differently than does dry wood. When moist wood is heated, it tends to expand because of normal thermal expansion and to shrink because of loss in moisture content. Unless the wood is very dry initially (perhaps 3 or 4 percent MC or less), the shrinkage due to moisture loss on heating will be greater than the thermal expansion, so the net dimensional change on heating will be negative. Wood at intermediate moisture levels (about 8 to 20 percent) will expand when first heated, then gradually shrink to a volume smaller than the initial volume, as the wood gradually loses water while in the heated condition.

Even in the longitudinal (grain) direction, where dimensional change due to moisture change is very small, such changes will still predominate over corresponding dimensional changes due to thermal expansion unless the wood is very dry initially. For wood at usual moisture levels, net dimensional changes will generally be negative after prolonged heating.

Computation of actual changes in dimensions can be accomplished by determining the equilibrium moisture content of wood at the temperature value and relative humidity of interest. Then the relative dimensional changes due to temperature change alone and moisture content change alone are computed. By combining these two changes the final dimension of lumber and timber can be established.

Table 6.3 Coefficient of Thermal Expansion, e_{TE} , for Solid Woods

Species	e_{TE}	
	Radial (10^{-6} in./in./°F)	Tangential (10^{-6} in./in./°F)
California Redwood	13	18
Douglas Fir-Larch ^a	15	19
Douglas Fir, <i>South</i>	14	19
Eastern Spruce	13	18
Hem-Fir ^a	13	18
Red Oak	18	22
Southern Pine	15	20
Spruce-Pine-Fir	13	18
Yellow Poplar	14	18

^a Also applies when species name includes the designation "North."

6.5 Fire Considerations

Fires do not normally start in structural framing, but rather in the building's contents. These fires generally reach temperatures of between 1,290°F and 1,650°F. Glued laminated timber members perform very well under these conditions. Unprotected steel members typically suffer severe buckling and twisting during fires, often collapsing catastrophically.

Wood ignites at about 480°F, but charring may begin as low as 300°F. Wood typically chars at 1/40 in. per minute. Thus, after half an hour's fire exposure, only the outer 3/4 in. of the glued laminated timber will be damaged. Char insulates a wood member and hence raises the temperature it can withstand. Most of the cross section will remain intact, and the member will continue supporting loads during a typical building fire.

It is important to note that neither building materials alone, nor building features alone, nor detection and fire

extinguishing equipment alone can provide adequate safety from fire in buildings. To ensure a safe structure in the event of fire, authorities base fire and building code requirements on research and testing, as well as fire histories. The model building codes classify Heavy Timber as a specific type of construction and give minimum sizes for roof and floor beams.

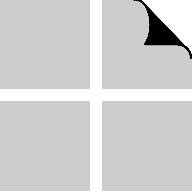
The requirements set out for Heavy Timber construction in model building codes do not constitute one-hour fire resistance. However, procedures are available to calculate the glued laminated timber size required for projects in which one-hour fire resistance is required (see Section 16.2 of *NDS* and AF&PA Technical Report 10 available at www.awc.org). The minimum depths for selected glued laminated timber sizes that can be adopted for one-hour fire ratings are given in Table 6.4 for glued laminated timber beams.

To achieve a one-hour fire rating for beams whose dimensions qualify them for this rating, the basic layup must be modified - one core lamination must be removed from the center and the tension face augmented with the addition of a tension lamination. For more information concerning the effects of fire on glued laminated timber, refer to APA EWS Technical Note Y245 or AITC Technical Note 7. For determining fire resistance other than one hour, see Section 16.2 of *NDS* and AF&PA Technical Report 10 available at www.awc.org.

Table 6.4 Minimum Depths at Which Selected Beam Sizes Can Be Adopted for One-Hour Fire Ratings^a

Beam Width (in.)	Beam Depth (in.)	
	3 Sides Exposed	4 Sides Exposed
6-3/4	13-1/2 or 13-3/4	27 or 27-1/2
8-1/2	7-1/2 or 8-1/4	15 or 15-1/8
8-3/4	6-7/8 or 7-1/2	13-1/2 or 13-3/4
10-1/2	6 or 6-7/8	12 or 12-3/8
10-3/4	6 or 6-7/8	12 or 12-3/8

^a Assuming a load factor of 1.0 (design loads are equal to the capacity of the member). The minimum depths may be reduced when the design loads are less than the member capacity.



LOAD AND SPAN TABLES

7.1	General	GL-62
7.2	Load-Span Tables for Selected Bending Members	GL-64

Table 7.1 Allowable Loads in Pounds per Lineal Foot for Simple Span *Western Species* 24F-1.8E Glulam Roof Beams — Non-Snow Loads .. GL-64

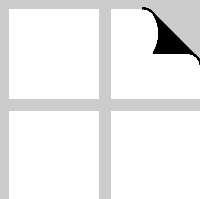
Table 7.2 Allowable Loads in Pounds per Lineal Foot for Simple Span *Western Species* Glulam 24F-1.8E Roof Beams — Snow Loads GL-66

Table 7.3 Allowable Loads in Pounds per Lineal Foot for Simple Span *Western Species* 24F-1.8E Glulam Floor Beams..... GL-68

Table 7.4 Allowable Loads in Pounds per Lineal Foot for Simple Span *Southern Pine* 24F-1.8E Glulam Roof Beams — Non-Snow Loads GL-70

Table 7.5 Allowable Loads in Pounds per Lineal Foot for Simple Span *Southern Pine* 24F-1.8E Glulam Roof Beams — Snow Loads GL-72

Table 7.6 Allowable Loads in Pounds per Lineal Foot for Simple Span *Southern Pine* 24F-1.8E Glulam Floor Beams..... GL-74



7.1 General

The section contains load-span tables for selected glued laminated timber bending members made of 24F-1.8E Douglas fir-Larch (such as 24F-V4/WS) or Southern Pine (such as 24F-V3/SP) when subjected to uniform loads in simple-span applications. These tables can be used to size such members for preliminary design. ***Final design should include a complete analysis, including bearing stress and lateral stability.***

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7.2 Load-Span Tables for Selected Bending Members

Table 7.1 Allowable Loads in Pounds per Lineal Foot for Simple Span Western Species 24F-1.8E Glulam Roof Beams – Non-Snow Loads

Load Duration Factor = 1.25, $F_b = 2,400$ psi, $F_v = 240$ psi, $E_x = 1,800,000$ psi

3-1/8 Inch Width

Depth (in)	Span (ft.)																				
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
6	581	295	169	105	69	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7-1/2	910	580	333	208	137	95	68	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9	1312	837	579	362	240	167	120	88	66	51	—	—	—	—	—	—	—	—	—	—	—
10-1/2	1786	1140	790	578	385	268	193	143	108	84	65	52	—	—	—	—	—	—	—	—	—
12	2335	1491	1033	756	577	402	291	216	164	127	100	80	64	52	—	—	—	—	—	—	—
13-1/2	2925	1888	1308	958	731	576	417	311	237	184	145	116	94	77	63	52	—	—	—	—	—
15	3398	2332	1616	1184	904	712	575	429	328	255	202	162	132	108	89	74	62	52	—	—	—
16-1/2	3916	2823	1957	1434	1095	863	696	573	439	342	272	219	178	146	121	101	85	72	61	52	—
18	4486	3201	2330	1708	1305	1028	830	684	570	447	355	286	234	192	160	134	113	96	81	70	60
19-1/2	5117	3596	2736	2006	1532	1208	975	801	664	559	454	367	299	247	206	173	146	124	106	91	78
21	5817	4023	3072	2328	1778	1402	1131	923	766	645	550	460	377	311	260	218	185	158	135	116	100
22-1/2	6601	4483	3392	2673	2043	1611	1290	1053	874	736	628	541	466	385	322	271	230	196	169	145	126
24	7482	4982	3732	2982	2326	1825	1459	1191	989	834	711	612	533	467	393	332	282	241	207	179	155
25-1/2	8481	5524	4094	3250	2627	2049	1639	1338	1111	936	799	688	599	525	463	400	340	291	251	217	189
27	9622	6116	4479	3532	2914	2286	1828	1493	1240	1045	891	768	668	586	517	460	407	348	300	260	227

3-1/2 Inch Width

Depth (in)	Span (ft.)																				
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
6	651	331	189	117	77	53	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7-1/2	1019	650	373	233	154	106	76	55	—	—	—	—	—	—	—	—	—	—	—	—	—
9	1469	937	649	406	269	187	134	99	74	57	—	—	—	—	—	—	—	—	—	—	—
10-1/2	2001	1277	884	647	431	300	216	160	121	94	73	58	—	—	—	—	—	—	—	—	—
12	2615	1670	1156	847	646	451	326	242	184	143	112	89	72	58	—	—	—	—	—	—	—
13-1/2	3275	2115	1465	1073	819	645	467	348	265	206	163	130	105	86	71	58	—	—	—	—	—
15	3805	2612	1810	1327	1013	797	643	480	367	286	226	182	147	121	100	83	69	58	—	—	—
16-1/2	4386	3162	2192	1606	1227	966	780	642	491	384	304	245	199	164	136	113	95	80	68	58	—
18	5025	3585	2610	1913	1461	1151	930	760	631	501	398	321	262	216	179	150	126	107	91	78	67
19-1/2	5731	4028	3064	2247	1716	1353	1086	886	736	619	509	411	335	277	231	194	164	139	119	102	88
21	6515	4505	3441	2607	1992	1566	1252	1022	848	714	609	516	422	349	291	245	207	177	151	130	112
22-1/2	7393	5021	3799	2994	2288	1787	1428	1166	968	815	695	599	520	432	361	304	258	220	189	163	141
24	8380	5580	4180	3340	2594	2021	1616	1319	1095	923	787	678	589	517	440	371	316	270	232	201	174
25-1/2	9498	6187	4585	3640	2912	2269	1814	1481	1230	1037	884	762	663	581	513	448	381	326	281	243	212
27	10777	6850	5017	3956	3247	2531	2024	1653	1373	1157	987	851	740	649	573	509	454	390	336	292	254

5-1/8 Inch Width

Depth (in)	Span (ft.)																				
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
12	3829	2445	1693	1240	946	660	477	355	270	209	164	131	105	85	69	57	—	—	—	—	—
13-1/2	4796	3097	2145	1572	1199	944	684	509	389	302	238	191	154	126	103	85	71	59	—	—	—
15	5572	3825	2651	1942	1483	1160	926	703	537	419	332	266	216	177	146	121	101	85	72	60	51
16-1/2	6422	4630	3209	2352	1788	1392	1111	906	720	562	446	358	292	240	199	166	139	118	100	85	72
18	7358	5249	3821	2802	2111	1644	1313	1071	888	733	583	470	383	316	262	220	185	157	134	114	98
19-1/2	8391	5898	4487	3264	2460	1915	1530	1248	1036	872	743	601	491	405	338	284	240	204	174	149	128
21	9541	6597	5039	3759	2833	2207	1763	1439	1194	1005	857	738	618	511	426	358	303	259	221	191	165
22-1/2	10825	7352	5563	4287	3232	2518	2012	1642	1363	1148	979	843	732	632	528	445	377	322	277	239	207
24	12270	8170	6120	4848	3655	2848	2277	1858	1543	1300	1108	954	830	727	641	544	462	395	340	294	255
25-1/2	13908	9060	6713	5330	4103	3197	2556	2087	1733	1460	1245	1073	933	817	721	641	558	478	412	356	310
27	15781	10030	7346	5793	4576	3566	2851	2328	1934	1629	1390	1198	1042	913	806	716	639	572	493	427	372
28-1/2	17941	11093	8023	6281	5073	3953	3162	2582	2145	1807	1542	1329	1156	1014	895	795	710	638	575	506	441
30	20463	12263	8748	6796	5554	4360	3487	2848	2366	1994	1701	1467	1276	1119	988	878	785	705	636	576	519
31-1/2	23443	13555	9527	7341	5968	4785	3827	3126	2597	2189	1868	1611	1402	1230	1086	965	863	775	699	633	576
33	27019	14992	10367	7918	6402	5229	4183	3417	2839	2394	2043	1762	1533	1345	1188	1056	944	848	765	694	631

Table 7.1 Allowable Loads in Pounds per Lineal Foot for Simple Span Western Species 24F-1.8E Glulam Roof Beams – Non-Snow Loads

Load Duration Factor = 1.25, $F_b = 2,400$ psi, $F_v = 240$ psi, $E_x = 1,800,000$ psi

5-1/2 Inch Width

Depth (in)	Span (ft.)																				
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
12	4109	2624	1817	1331	1015	708	512	381	290	224	176	140	113	91	74	61	—	—	—	—	—
13-1/2	5147	3323	2302	1687	1287	1010	734	547	417	324	256	205	165	135	111	92	76	63	53	—	—
15	5980	4105	2845	2085	1588	1235	986	755	577	449	356	286	232	190	157	130	109	91	77	65	55
16-1/2	6892	4969	3444	2524	1905	1483	1184	965	772	603	478	385	313	257	213	178	150	126	107	91	77
18	7896	5633	4101	2985	2249	1751	1399	1141	946	787	625	504	411	339	281	236	199	168	143	122	105
19-1/2	9006	6329	4815	3478	2621	2041	1631	1330	1104	929	791	645	527	435	362	304	257	219	187	160	138
21	10239	7080	5407	4005	3019	2351	1879	1533	1272	1071	913	786	663	548	457	384	326	277	238	205	177
22-1/2	11617	7890	5970	4568	3444	2683	2144	1750	1453	1223	1043	898	780	678	567	477	405	346	297	256	222
24	13168	8768	6568	5166	3895	3034	2426	1980	1644	1385	1180	1017	884	774	683	584	496	424	365	315	273
25-1/2	14926	9722	7205	5720	4372	3407	2724	2224	1847	1556	1326	1143	994	871	769	682	599	513	442	382	332
27	16935	10764	7884	6217	4876	3800	3038	2481	2060	1736	1481	1276	1110	973	859	763	681	611	529	458	399
28-1/2	19254	11905	8610	6740	5405	4212	3369	2751	2285	1926	1643	1416	1232	1080	953	847	757	679	612	543	474
30	21960	13160	9388	7293	5960	4646	3716	3034	2521	2125	1813	1563	1360	1192	1053	936	836	751	677	613	557
31-1/2	25158	14547	10225	7878	6404	5099	4078	3331	2768	2333	1991	1716	1494	1310	1157	1028	919	825	745	675	613
33	28996	16089	11125	8497	6870	5572	4457	3641	3025	2550	2176	1877	1633	1433	1266	1125	1006	904	815	739	672

6-3/4 Inch Width

Depth (in)	Span (ft.)																				
	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
18	6913	4972	3589	2704	2105	1681	1371	1137	957	767	618	504	416	345	289	244	207	176	150	129	110
19-1/2	7768	5791	4181	3151	2453	1960	1599	1326	1116	951	792	647	534	445	373	316	268	229	197	169	146
21	8689	6636	4815	3629	2826	2259	1843	1529	1287	1097	944	813	672	561	472	400	341	292	251	217	188
22-1/2	9683	7327	5492	4140	3225	2577	2103	1746	1470	1253	1079	937	821	696	586	497	424	364	314	272	236
24	10761	8061	6211	4682	3648	2916	2380	1976	1664	1419	1222	1062	930	821	716	609	520	447	387	336	292
25-1/2	11932	8842	6971	5256	4095	3274	2673	2219	1870	1594	1373	1194	1046	923	820	732	630	542	469	408	356
27	13210	9676	7629	5862	4568	3652	2982	2476	2086	1779	1533	1333	1169	1031	916	818	734	649	562	490	428
28-1/2	14610	10567	8272	6498	5064	4050	3307	2747	2314	1974	1702	1480	1297	1145	1017	909	816	735	666	581	509
30	16151	11522	8951	7166	5585	4467	3647	3030	2554	2178	1878	1634	1433	1265	1124	1004	902	813	736	669	599
31-1/2	17854	12548	9668	7860	6130	4903	4004	3327	2804	2392	2063	1795	1574	1390	1235	1104	991	894	810	736	672
33	19746	13654	10428	8432	6698	5358	4376	3636	3065	2616	2256	1963	1722	1521	1352	1208	1085	979	887	807	736
34-1/2	21861	14847	11234	9031	7291	5833	4764	3959	3338	2849	2457	2138	1876	1657	1473	1317	1183	1068	968	880	803
36	24241	16141	12091	9661	7907	6326	5168	4295	3621	3091	2666	2321	2036	1799	1600	1430	1285	1160	1052	957	873
37-1/2	26938	17547	13003	10323	8547	6839	5587	4644	3916	3342	2883	2510	2203	1947	1731	1548	1391	1256	1139	1036	946
39	30022	19081	13976	11020	9093	7370	6022	5005	4221	3603	3109	2707	2375	2099	1867	1670	1501	1356	1229	1118	1021

8-3/4 Inch width

Depth (in)	Span (ft.)																				
	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
24	13949	10449	7844	5913	4606	3682	3005	2494	2101	1790	1542	1340	1174	1035	919	789	675	580	501	435	379
25-1/2	15468	11462	8804	6638	5172	4134	3375	2802	2360	2012	1733	1507	1320	1165	1034	923	816	703	608	529	462
27	17124	12543	9817	7403	5768	4612	3765	3126	2634	2246	1935	1683	1475	1301	1156	1032	926	834	729	635	555
28-1/2	18939	13698	10723	8206	6395	5114	4175	3468	2922	2492	2148	1868	1637	1445	1284	1146	1029	927	839	753	660
30	20936	14936	11603	9049	7052	5640	4605	3826	3224	2750	2370	2062	1808	1596	1418	1267	1137	1025	928	843	769
31-1/2	23144	16266	12533	9931	7741	6191	5056	4200	3540	3020	2604	2265	1986	1754	1559	1393	1251	1128	1021	928	847
33	25596	17699	13518	10852	8459	6766	5526	4591	3870	3302	2847	2478	2173	1919	1706	1524	1369	1235	1119	1017	928
34-1/2	28338	19247	14563	11707	9207	7365	6016	4999	4214	3596	3101	2699	2368	2091	1859	1662	1493	1347	1220	1110	1013
36	31423	20923	15673	12523	9986	7988	6526	5423	4572	3902	3365	2929	2570	2271	2019	1805	1621	1463	1326	1206	1101
37-1/2	34920	22746	16856	13382	10794	8636	7055	5863	4944	4220	3640	3168	2780	2457	2184	1953	1755	1584	1436	1307	1193
39	38917	24735	18117	14285	11632	9307	7604	6320	5329	4549	3924	3417	2998	2650	2356	2107	1894	1710	1550	1411	1288
40-1/2	43161	26914	19466	15238	12500	10002	8172	6793	5728	4890	4219	3673	3224	2850	2535	2267	2038	1840	1668	1518	1387
42	46252	29311	20911	16244	13274	10720	8759	7282	6141	5243	4524	3939	3458	3056	2719	2432	2187	1975	1791	1630	1489
43-1/2	49444	31960	22463	17307	14070	11462	9366	7787	6568	5608	4839	4214	3699	3270	2909	2603	2340	2114	1917	1745	1594
45	52737	34904	24135	18434	14904	12228	9992	8308	7008	5984	5164	4497	3948	3491	3106	2779	2499	2257	2048	1864	1703

Notes:

- Span = simply supported beam.
- Maximum deflection = $L/180$ under total load. Other deflection limits may apply.
- Service condition = dry.
- Tabulated values represent total loads and have taken the dead weight of the beam (assumed 35 pcf) into account.
- Sufficient bearing length shall be provided at supports.
- Maximum beam shear is located at a distance from the supports equal to the depth of the beam.

Table 7.2 Allowable Loads in Pounds per Lineal Foot for Simple Span Western Species 24F-1.8E Glulam Roof Beams – Snow LoadsLoad Duration Factor = 1.15, $F_b = 2,400$ psi, $F_v = 240$ psi, $E_x = 1,800,000$ psi**3-1/8 Inch Width**

Depth (in)	Span (ft.)																				
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
6	535	295	169	105	69	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7-1/2	837	533	333	208	137	95	68	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9	1206	769	532	362	240	167	120	88	66	51	—	—	—	—	—	—	—	—	—	—	—
10-1/2	1643	1049	726	531	385	268	193	143	108	84	65	52	—	—	—	—	—	—	—	—	—
12	2147	1371	949	695	530	402	291	216	164	127	100	80	64	52	—	—	—	—	—	—	—
13-1/2	2690	1736	1203	881	672	529	417	311	237	184	145	116	94	77	63	52	—	—	—	—	—
15	3125	2145	1486	1089	831	654	528	429	328	255	202	162	132	108	89	74	62	52	—	—	—
16-1/2	3602	2597	1799	1319	1007	793	640	527	439	342	272	219	178	146	121	101	85	72	61	52	—
18	4126	2943	2143	1571	1199	945	763	628	523	440	355	286	234	192	160	134	113	96	81	70	60
19-1/2	4706	3307	2516	1844	1409	1110	896	735	610	513	437	367	299	247	206	173	146	124	106	91	78
21	5351	3699	2825	2140	1635	1288	1039	848	703	592	504	434	377	311	260	218	185	158	135	116	100
22-1/2	6071	4123	3119	2458	1878	1480	1186	967	803	676	576	496	431	378	322	271	230	196	169	145	126
24	6882	4582	3432	2742	2138	1678	1341	1095	909	765	652	562	488	428	377	332	282	241	207	179	155
25-1/2	7801	5081	3765	2988	2415	1884	1506	1229	1021	860	733	632	549	481	425	377	336	291	251	217	189
27	8851	5625	4119	3248	2679	2101	1680	1372	1139	960	818	705	613	537	474	421	376	338	300	260	227

3-1/2 Inch Width

Depth (in)	Span (ft.)																				
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
6	599	331	189	117	77	53	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7-1/2	937	597	373	233	154	106	76	55	—	—	—	—	—	—	—	—	—	—	—	—	—
9	1351	862	596	406	269	187	134	99	74	57	—	—	—	—	—	—	—	—	—	—	—
10-1/2	1840	1174	813	595	431	300	216	160	121	94	73	58	—	—	—	—	—	—	—	—	—
12	2405	1535	1063	778	594	451	326	242	184	143	112	89	72	58	—	—	—	—	—	—	—
13-1/2	3013	1945	1347	987	753	592	467	348	265	206	163	130	105	86	71	58	—	—	—	—	—
15	3500	2402	1664	1219	931	733	591	480	367	286	226	182	147	121	100	83	69	58	—	—	—
16-1/2	4034	2908	2015	1477	1127	888	717	590	490	384	304	245	199	164	136	113	95	80	68	58	—
18	4621	3297	2400	1759	1343	1058	854	698	579	487	398	321	262	216	179	150	126	107	91	78	67
19-1/2	5271	3704	2818	2066	1578	1243	998	814	675	568	484	411	335	277	231	194	164	139	119	102	88
21	5993	4143	3164	2397	1831	1440	1150	938	779	655	558	481	417	349	291	245	207	177	151	130	112
22-1/2	6800	4618	3494	2753	2103	1642	1313	1071	889	748	638	549	477	418	361	304	258	220	189	163	141
24	7708	5132	3844	3071	2385	1858	1485	1212	1006	847	722	622	541	474	418	371	316	270	232	201	174
25-1/2	8737	5690	4216	3347	2677	2086	1668	1361	1130	952	812	699	608	533	470	417	372	326	281	243	212
27	9913	6300	4614	3638	2986	2326	1860	1519	1261	1062	906	781	679	595	525	466	416	373	336	292	254

5-1/8 Inch Width

Depth (in)	Span (ft.)																				
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
12	3521	2248	1557	1140	869	660	477	355	270	209	164	131	105	85	69	57	—	—	—	—	—
13-1/2	4411	2848	1972	1445	1102	867	684	509	389	302	238	191	154	126	103	85	71	59	—	—	—
15	5125	3518	2437	1786	1363	1065	850	693	537	419	332	266	216	177	146	121	101	85	72	60	51
16-1/2	5907	4258	2951	2163	1643	1279	1021	832	689	562	446	358	292	240	199	166	139	118	100	85	72
18	6767	4827	3514	2576	1940	1510	1206	983	815	686	583	470	383	316	262	220	185	157	134	114	98
19-1/2	7718	5424	4126	3001	2261	1760	1406	1146	951	800	681	586	491	405	338	284	240	204	174	149	128
21	8775	6067	4633	3456	2605	2028	1620	1322	1097	923	786	677	587	511	426	358	303	259	221	191	165
22-1/2	9957	6762	5116	3942	2971	2314	1849	1509	1252	1054	898	773	672	588	518	445	377	322	277	239	207
24	11286	7514	5628	4458	3360	2618	2092	1707	1417	1193	1017	876	761	666	588	521	462	395	340	294	255
25-1/2	12793	8332	6174	4901	3773	2939	2349	1917	1592	1341	1143	984	856	750	661	587	524	470	412	356	310
27	14516	9225	6756	5327	4207	3278	2621	2139	1776	1496	1276	1099	956	837	739	656	585	525	473	427	372
28-1/2	16503	10203	7378	5775	4664	3634	2906	2372	1970	1660	1416	1220	1061	930	820	729	651	584	526	476	432
30	18823	11279	8045	6249	5106	4008	3205	2617	2174	1832	1562	1346	1171	1027	906	805	719	645	582	527	478
31-1/2	21564	12468	8762	6750	5487	4399	3518	2873	2387	2011	1716	1479	1287	1128	996	885	791	710	640	579	527
33	24854	13790	9534	7281	5886	4807	3845	3140	2609	2199	1876	1617	1407	1234	1090	968	865	777	701	635	577

Table 7.2 Allowable Loads in Pounds per Lineal Foot for Simple Span Western Species 24F-1.8E Glulam Roof Beams – Snow Loads

Load Duration Factor = 1.15, $F_b = 2,400$ psi, $F_v = 240$ psi, $E_x = 1,800,000$ psi

5-1/2 Inch Width

Depth (in)	Span (ft.)																				
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
12	3779	2413	1671	1223	933	708	512	381	290	224	176	140	113	91	74	61	—	—	—	—	—
13-1/2	4734	3056	2117	1550	1183	927	734	547	417	324	256	205	165	135	111	92	76	63	53	—	—
15	5500	3775	2615	1916	1459	1135	906	738	577	449	356	286	232	190	157	130	109	91	77	65	55
16-1/2	6339	4570	3167	2321	1751	1362	1088	886	735	603	478	385	313	257	213	178	150	126	107	91	77
18	7262	5181	3771	2744	2067	1609	1285	1048	869	730	622	504	411	339	281	236	199	168	143	122	105
19-1/2	8283	5821	4428	3197	2409	1875	1498	1222	1013	852	726	624	527	435	362	304	257	219	187	160	138
21	9417	6511	4972	3683	2775	2161	1726	1408	1168	983	837	721	626	548	457	384	326	277	238	205	177
22-1/2	10685	7256	5490	4200	3166	2466	1970	1607	1334	1123	957	824	715	626	552	477	405	346	297	256	222
24	12112	8064	6040	4750	3581	2789	2229	1819	1510	1271	1083	933	811	710	626	555	495	424	365	315	273
25-1/2	13729	8942	6626	5259	4020	3132	2503	2043	1696	1428	1218	1049	912	798	704	625	558	500	442	382	332
27	15578	9900	7250	5716	4483	3493	2792	2279	1893	1594	1359	1171	1018	892	787	699	624	559	504	456	399
28-1/2	17711	10949	7918	6198	4970	3872	3096	2528	2099	1769	1508	1300	1130	990	874	776	693	622	560	507	460
30	20200	12104	8634	6707	5480	4271	3415	2788	2316	1951	1664	1435	1248	1094	965	858	766	687	620	561	509
31-1/2	23142	13380	9403	7244	5889	4687	3749	3061	2543	2143	1828	1576	1371	1202	1061	943	842	756	682	617	561
33	26673	14799	10232	7814	6317	5123	4097	3346	2780	2343	1999	1723	1499	1315	1161	1032	922	828	747	676	615

6-3/4 Inch Width

Depth (in)	Span (ft.)																				
	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
18	6358	4572	3299	2485	1934	1544	1259	1044	878	747	618	504	416	345	289	244	207	176	150	129	110
19-1/2	7144	5325	3844	2896	2254	1801	1468	1218	1024	872	750	647	534	445	373	316	268	229	197	169	146
21	7991	6102	4427	3336	2598	2075	1692	1404	1182	1006	866	752	658	561	472	400	341	292	251	217	188
22-1/2	8905	6738	5050	3806	2964	2368	1932	1603	1349	1150	990	859	752	663	586	497	424	364	314	272	236
24	9897	7413	5711	4305	3353	2679	2186	1815	1528	1302	1121	974	853	752	667	595	520	447	387	336	292
25-1/2	10974	8131	6410	4833	3764	3009	2456	2038	1717	1463	1260	1095	959	846	751	670	600	541	469	408	356
27	12150	8898	7015	5389	4199	3356	2740	2275	1916	1633	1407	1223	1072	945	839	749	672	605	547	490	428
28-1/2	13438	9718	7607	5975	4655	3722	3038	2523	2125	1812	1562	1358	1190	1050	932	832	747	673	609	553	503
30	14855	10596	8231	6589	5134	4105	3352	2784	2345	2000	1724	1499	1314	1160	1030	920	825	744	673	612	557
31-1/2	16421	11540	8891	7227	5635	4506	3680	3056	2576	2197	1894	1647	1444	1275	1132	1012	908	819	741	673	614
33	18162	12557	9590	7753	6158	4925	4022	3341	2816	2402	2071	1802	1580	1395	1239	1107	994	897	812	738	673
34-1/2	20108	13655	10331	8304	6703	5361	4379	3638	3066	2616	2256	1963	1721	1520	1351	1207	1084	978	886	805	734
36	22297	14845	11119	8883	7270	5815	4750	3947	3327	2839	2448	2130	1869	1651	1467	1311	1178	1063	963	875	799
37-1/2	24778	16138	11958	9492	7859	6287	5135	4267	3597	3070	2648	2304	2022	1786	1588	1419	1275	1151	1043	948	865
39	27615	17550	12853	10133	8360	6775	5535	4600	3878	3310	2855	2485	2180	1926	1713	1531	1376	1242	1126	1024	934

8-3/4 Inch Width

Depth (in)	Span (ft.)																				
	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
24	12829	9609	7212	5436	4234	3383	2760	2291	1928	1643	1415	1229	1076	948	841	750	672	580	501	435	379
25-1/2	14226	10541	8095	6103	4753	3799	3100	2573	2167	1847	1590	1382	1210	1067	947	845	757	682	608	529	462
27	15750	11535	9027	6806	5302	4238	3459	2872	2418	2062	1776	1543	1352	1193	1058	945	847	763	690	626	555
28-1/2	17419	12597	9860	7545	5878	4700	3836	3185	2683	2288	1971	1713	1501	1325	1176	1050	942	848	767	697	634
30	19256	13736	10670	8320	6483	5184	4232	3514	2961	2525	2176	1892	1658	1463	1299	1160	1041	938	849	771	702
31-1/2	21287	14960	11525	9132	7116	5690	4646	3859	3251	2773	2390	2079	1822	1608	1429	1276	1145	1032	934	849	774
33	23543	16278	12431	9978	7777	6219	5078	4218	3555	3032	2614	2274	1994	1760	1564	1397	1254	1131	1024	930	848
34-1/2	26065	17701	13392	10765	8465	6770	5529	4593	3871	3303	2847	2477	2172	1918	1704	1523	1367	1233	1117	1015	926
36	28903	19243	14413	11515	9181	7343	5997	4983	4200	3584	3090	2689	2358	2083	1851	1654	1486	1340	1214	1104	1007
37-1/2	32120	20920	15501	12305	9924	7938	6484	5388	4542	3876	3342	2909	2551	2254	2003	1791	1608	1451	1315	1196	1091
39	35797	22750	16661	13136	10695	8556	6989	5808	4896	4179	3604	3137	2752	2431	2161	1932	1736	1567	1420	1291	1178
40-1/2	39701	24754	17901	14012	11493	9195	7511	6242	5263	4492	3875	3373	2959	2615	2325	2079	1868	1686	1528	1390	1269
42	42545	26959	19231	14937	12205	9855	8052	6692	5643	4817	4155	3617	3174	2805	2494	2230	2004	1810	1640	1492	1363
43-1/2	45481	29396	20659	15915	12937	10538	8610	7156	6035	5152	4444	3869	3396	3001	2669	2387	2146	1937	1756	1598	1459
45	48510	32104	22197	16951	13704	11242	9185	7635	6439	5497	4743	4130	3625	3204	2850	2549	2291	2069	1876	1708	1559

Notes:

- Span = simply supported beam.
- Maximum deflection = L/180 under total load. Other deflection limits may apply.
- Service condition = dry.
- Tabulated values represent total loads and have taken the dead weight of the beam (assumed 35 pcf) into account.
- Sufficient bearing length shall be provided at supports.
- Maximum beam shear is located at a distance from the supports equal to the depth of the beam.

Table 7.3 Allowable Loads in Pounds per Lineal Foot for Simple Span Western Species 24F-1.8E Glulam Floor Beams

Load Duration Factor = 1.00, $F_b = 2,400$ psi, $F_v = 240$ psi, $E_x = 1,800,000$ psi

3-1/8 Inch Width

Depth (in)	Span (ft.)																				
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
6	362	183	104	64	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7-1/2	710	361	206	128	84	57	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9	1048	626	359	224	148	102	72	53	—	—	—	—	—	—	—	—	—	—	—	—	—
10-1/2	1428	911	574	358	237	164	118	86	65	—	—	—	—	—	—	—	—	—	—	—	—
12	1866	1191	824	538	357	248	178	132	99	76	59	—	—	—	—	—	—	—	—	—	—
13-1/2	2338	1508	1044	765	511	356	257	190	144	111	87	69	55	—	—	—	—	—	—	—	—
15	2716	1864	1291	945	704	491	355	264	201	155	122	97	78	63	51	—	—	—	—	—	—
16-1/2	3130	2256	1563	1145	874	656	475	354	270	209	165	132	106	87	71	59	—	—	—	—	—
18	3586	2558	1861	1364	1041	820	619	462	353	274	217	174	141	115	95	79	65	55	—	—	—
19-1/2	4090	2874	2186	1602	1223	963	777	590	451	351	278	224	182	149	123	102	86	72	61	51	—
21	4651	3215	2455	1859	1420	1118	901	735	566	441	350	282	229	189	156	131	110	93	78	67	57
22-1/2	5277	3583	2710	2135	1631	1285	1029	839	696	545	433	349	285	234	195	163	137	116	99	84	72
24	5982	3982	2982	2382	1857	1457	1164	950	788	663	528	426	348	287	239	200	169	144	123	105	90
25-1/2	6781	4415	3271	2596	2097	1636	1307	1067	885	745	635	514	420	347	289	243	206	175	150	129	111
27	7694	4889	3579	2822	2327	1824	1458	1190	988	832	709	611	501	414	346	291	246	210	180	155	134

3-1/2 Inch Width

Depth (in)	Span (ft.)																				
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
6	405	205	116	71	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7-1/2	795	404	231	143	94	64	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9	1174	701	403	251	165	114	81	59	—	—	—	—	—	—	—	—	—	—	—	—	—
10-1/2	1599	1020	642	401	266	184	132	97	72	55	—	—	—	—	—	—	—	—	—	—	—
12	2090	1334	923	602	400	278	200	148	111	85	66	52	—	—	—	—	—	—	—	—	—
13-1/2	2618	1690	1170	856	573	399	288	213	162	125	97	77	62	—	—	—	—	—	—	—	—
15	3042	2087	1446	1059	788	550	397	295	225	174	137	109	87	71	58	—	—	—	—	—	—
16-1/2	3506	2527	1751	1282	979	735	532	396	302	234	185	148	119	97	80	66	54	—	—	—	—
18	4017	2865	2085	1528	1166	918	693	517	395	307	243	195	158	129	106	88	73	61	51	—	—
19-1/2	4581	3219	2448	1794	1370	1079	866	660	505	394	312	250	203	167	138	115	96	81	68	57	—
21	5209	3601	2749	2082	1590	1249	998	814	633	494	392	316	257	211	175	146	123	104	88	75	64
22-1/2	5910	4013	3035	2392	1827	1426	1139	929	771	611	485	391	319	263	218	183	154	130	111	95	81
24	6700	4460	3340	2668	2071	1613	1289	1051	872	734	592	477	390	322	268	225	190	161	137	118	101
25-1/2	7594	4945	3663	2908	2325	1811	1447	1181	980	825	703	575	470	388	324	272	230	196	168	144	124
27	8617	5475	4009	3160	2593	2020	1614	1317	1094	921	785	676	561	464	387	326	276	235	202	174	150

5-1/8 Inch Width

Depth (in)	Span (ft.)																				
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
12	3060	1953	1352	882	586	407	293	216	163	125	97	76	60	—	—	—	—	—	—	—	—
13-1/2	3834	2474	1713	1254	838	584	421	312	237	182	143	113	90	72	58	—	—	—	—	—	—
15	4454	3056	2117	1550	1154	805	582	433	329	255	200	159	128	104	84	69	56	—	—	—	—
16-1/2	5134	3700	2563	1878	1426	1076	779	580	442	343	271	216	175	142	117	96	79	66	55	—	—
18	5882	4195	3053	2237	1684	1310	1015	757	578	450	356	285	231	189	156	129	107	90	75	63	53
19-1/2	6708	4713	3585	2606	1963	1527	1219	967	739	576	457	367	298	244	202	168	141	118	100	84	71
21	7627	5272	4026	3002	2261	1760	1406	1146	928	724	574	462	376	309	256	214	180	152	129	109	93
22-1/2	8654	5876	4445	3424	2580	2008	1604	1308	1085	895	711	573	467	385	320	267	225	191	162	139	119
24	9810	6530	4890	3873	2918	2272	1815	1481	1228	1034	867	699	571	471	392	329	278	236	201	172	148
25-1/2	11120	7241	5364	4257	3276	2551	2039	1663	1380	1162	990	843	689	569	474	398	337	287	245	211	182
27	12618	8017	5870	4627	3654	2846	2274	1856	1540	1297	1105	951	821	679	567	477	404	345	295	254	220
28-1/2	14346	8867	6411	5017	4051	3156	2522	2058	1709	1439	1226	1056	918	803	671	565	479	409	351	303	262
30	16363	9803	6991	5429	4435	3480	2782	2271	1885	1588	1354	1166	1013	888	783	663	563	481	414	358	310
31-1/2	18746	10837	7614	5865	4766	3820	3054	2493	2070	1744	1487	1281	1114	976	861	764	656	561	483	418	363
33	21607	11986	8285	6326	5113	4175	3338	2725	2263	1907	1626	1401	1218	1068	942	837	747	649	559	484	421

Table 7.3 Allowable Loads in Pounds per Lineal Foot for Simple Span Western Species 24F-1.8E Glulam Floor Beams

Load Duration Factor = 1.00, $F_b = 2,400$ psi, $F_v = 240$ psi, $E_x = 1,800,000$ psi

5-1/2 Inch Width

Depth (in)	Span (ft.)																				
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
12	3284	2096	1451	946	628	437	314	232	175	134	104	82	65	51	—	—	—	—	—	—	—
13-1/2	4114	2655	1838	1346	900	626	452	335	254	196	153	121	97	78	63	50	—	—	—	—	—
15	4780	3280	2272	1664	1239	864	624	464	353	273	215	171	137	111	90	74	61	—	—	—	—
16-1/2	5509	3971	2751	2015	1520	1155	836	622	474	368	291	232	187	153	125	103	85	71	59	—	—
18	6312	4502	3276	2383	1795	1396	1090	813	620	483	382	306	248	203	167	138	115	96	81	67	57
19-1/2	7199	5058	3847	2777	2091	1627	1299	1038	793	618	490	393	320	262	217	180	151	127	107	90	76
21	8185	5658	4320	3199	2410	1875	1498	1221	995	777	616	496	404	332	275	230	193	163	138	117	100
22-1/2	9288	6306	4770	3649	2749	2140	1709	1394	1156	960	763	614	501	413	343	287	242	205	174	149	127
24	10528	7008	5248	4126	3110	2421	1934	1578	1309	1101	930	750	612	505	421	353	298	253	216	185	159
25-1/2	11934	7771	5757	4569	3491	2719	2172	1772	1470	1238	1054	904	739	610	509	428	362	308	263	226	195
27	13541	8604	6300	4966	3893	3032	2423	1977	1641	1381	1177	1014	881	729	608	512	434	370	317	273	236
28-1/2	15396	9516	6881	5385	4317	3362	2687	2193	1820	1533	1306	1125	978	856	720	606	515	439	377	325	282
30	17560	10520	7503	5827	4760	3708	2964	2419	2009	1692	1442	1242	1080	946	834	712	604	517	444	384	333
31-1/2	20118	11629	8171	6294	5155	4071	3254	2656	2206	1858	1584	1365	1186	1040	917	814	704	602	518	448	390
33	23188	12863	8891	6789	5487	4449	3557	2904	2411	2031	1732	1493	1298	1137	1004	891	796	697	600	520	452

6-3/4 Inch Width

Depth (in)	Span (ft.)																				
	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
18	5525	3972	2865	2157	1678	1337	997	761	593	469	375	304	249	205	170	141	118	99	83	69	58
19-1/2	6208	4626	3338	2514	1956	1562	1272	974	759	601	483	392	322	266	221	185	156	131	111	94	79
21	6944	5302	3845	2897	2254	1800	1467	1216	954	757	609	495	407	338	282	237	200	169	144	123	104
22-1/2	7739	5854	4386	3305	2572	2054	1675	1389	1169	936	754	615	506	421	352	297	251	214	183	156	134
24	8601	6441	4961	3738	2910	2325	1896	1573	1323	1127	921	752	620	516	433	366	310	265	227	195	168
25-1/2	9537	7065	5569	4197	3268	2611	2130	1767	1487	1267	1090	907	749	625	525	444	378	323	278	239	207
27	10559	7732	6095	4681	3645	2913	2376	1972	1660	1415	1218	1058	895	747	628	532	454	389	335	289	251
28-1/2	11679	8444	6608	5189	4042	3230	2636	2188	1842	1570	1352	1175	1029	884	744	631	539	463	399	346	300
30	12911	9208	7151	5723	4458	3563	2908	2414	2033	1733	1493	1297	1136	1002	873	742	634	545	471	409	356
31-1/2	14273	10028	7724	6278	4893	3912	3193	2651	2233	1904	1640	1425	1249	1102	978	864	739	636	550	478	417
33	15786	10912	8332	6734	5348	4276	3490	2898	2442	2082	1794	1560	1367	1206	1071	956	855	737	638	555	485
34-1/2	17478	11867	8976	7214	5821	4655	3800	3156	2659	2268	1954	1699	1489	1315	1167	1042	935	843	734	640	559
36	19381	12901	9661	7717	6314	5049	4123	3424	2885	2461	2121	1845	1617	1428	1268	1132	1016	916	829	732	641
37-1/2	21538	14025	10390	8246	6826	5459	4457	3703	3120	2662	2294	1996	1750	1545	1373	1226	1101	993	899	816	729
39	24005	15252	11168	8803	7261	5883	4804	3991	3364	2870	2474	2152	1888	1667	1481	1323	1188	1072	970	882	804

8-3/4 Inch Width

Depth (in)	Span (ft.)																				
	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
24	11149	8349	6265	4720	3675	2935	2394	1985	1670	1422	1193	974	804	669	561	474	402	343	294	253	218
25-1/2	12363	9159	7032	5300	4126	3297	2689	2231	1877	1599	1376	1176	971	810	680	575	490	419	360	310	268
27	13688	10023	7842	5911	4603	3678	3000	2490	2096	1785	1537	1335	1160	968	814	690	588	504	434	375	325
28-1/2	15139	10946	8566	6553	5104	4079	3328	2762	2325	1981	1706	1482	1298	1144	965	819	699	600	517	448	390
30	16736	11936	9270	7227	5629	4499	3672	3048	2566	2187	1884	1637	1434	1264	1122	962	822	707	610	530	461
31-1/2	18501	13000	10013	7932	6179	4939	4031	3347	2819	2403	2070	1799	1576	1390	1234	1101	958	825	713	620	541
33	20463	14145	10800	8668	6753	5399	4407	3659	3082	2628	2264	1968	1724	1521	1351	1205	1081	955	827	720	629
34-1/2	22656	15383	11636	9351	7351	5877	4798	3984	3357	2862	2466	2144	1879	1658	1473	1315	1180	1063	952	829	725
36	25123	16723	12523	10003	7973	6375	5205	4323	3642	3106	2677	2328	2041	1801	1600	1428	1282	1155	1046	949	831
37-1/2	27920	18181	13469	10689	8619	6893	5628	4675	3939	3360	2896	2519	2208	1949	1732	1547	1388	1252	1133	1029	938
39	31117	19772	14477	11412	9289	7429	6066	5039	4247	3623	3123	2717	2382	2103	1869	1669	1499	1351	1224	1112	1014
40-1/2	34512	21514	15555	12173	9983	7984	6520	5417	4566	3895	3358	2922	2562	2262	2010	1796	1613	1455	1318	1198	1092
42	36984	23431	16711	12977	10602	8558	6990	5807	4895	4177	3601	3134	2748	2427	2157	1928	1731	1562	1415	1286	1173
43-1/2	39537	25550	17952	13827	11238	9151	7475	6211	5236	4468	3853	3353	2941	2598	2309	2064	1854	1673	1515	1378	1257
45	42170	27904	19289	14728	11904	9763	7975	6627	5587	4768	4112	3579	3139	2773	2465	2204	1980	1787	1619	1472	1344

Notes:

- Span = simply supported beam.
- Maximum deflection = $L/360$ under live load, based on live/total load = 0.8. Where additional stiffness is desired or for other live/total load ratios, design for deflection must be modified per requirements.
- Service condition = dry.
- Tabulated values represent total loads based on live/total load = 0.8 and have taken the dead weight of the beam (assumed 35 pcf) into account.
- Sufficient bearing length shall be provided at supports.
- Maximum beam shear is located at a distance from the supports equal to the depth of the beam.

Table 7.4 Allowable Loads in Pounds per Lineal Foot for Simple Span Southern Pine 24F-1.8E Glulam Roof Beams – Non-Snow Loads

Load Duration Factor = 1.25, $F_b = 2,400$ psi, $F_v = 270$ psi, $E_x = 1,800,000$ psi

3 Inch Width

Depth (in)	Span (ft.)																				
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
6-7/8	733	428	246	153	101	69	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8-1/4	1057	674	427	267	177	122	87	64	—	—	—	—	—	—	—	—	—	—	—	—	—
9-5/8	1440	919	636	426	283	197	141	104	79	60	—	—	—	—	—	—	—	—	—	—	—
11	1882	1202	832	609	425	296	214	158	120	93	73	57	—	—	—	—	—	—	—	—	—
12-3/8	2384	1522	1054	772	589	424	307	228	174	134	106	84	68	55	—	—	—	—	—	—	—
13-3/4	2944	1880	1303	954	728	573	423	315	240	187	148	118	95	78	64	53	—	—	—	—	—
15-1/8	3563	2276	1577	1156	882	695	561	422	322	251	199	160	129	106	88	73	61	51	—	—	—
16-1/2	4230	2710	1878	1377	1051	828	668	550	421	328	260	209	170	140	116	97	81	68	58	—	—
17-7/8	4793	3182	2205	1617	1235	973	785	647	537	420	333	269	219	180	150	125	106	89	76	65	55
19-1/4	5409	3691	2559	1876	1433	1129	912	751	627	527	419	338	276	228	189	159	134	114	97	83	72
20-5/8	6087	4227	2939	2155	1646	1297	1048	861	718	607	517	418	342	282	235	198	167	142	122	105	90
22	6837	4673	3345	2453	1874	1477	1192	978	815	689	590	509	417	345	288	242	205	175	150	129	112
23-3/8	7671	5152	3777	2770	2117	1669	1343	1101	919	777	665	575	502	416	347	293	249	212	182	157	136
24-3/4	8604	5669	4224	3107	2374	1869	1502	1232	1028	870	744	644	562	494	415	350	297	254	219	189	164
26-1/8	9654	6227	4593	3463	2646	2078	1670	1370	1143	967	828	716	625	550	487	414	352	301	259	225	195

3-1/2 Inch Width

Depth (in)	Span (ft.)																				
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
6-7/8	856	499	287	178	117	81	57	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8-1/4	1234	787	498	311	206	143	102	75	56	—	—	—	—	—	—	—	—	—	—	—	—
9-5/8	1680	1072	742	497	330	229	165	122	92	70	55	—	—	—	—	—	—	—	—	—	—
11	2196	1402	971	711	496	345	249	185	140	108	85	67	54	—	—	—	—	—	—	—	—
12-3/8	2781	1776	1230	901	687	495	358	266	202	157	123	98	79	64	52	—	—	—	—	—	—
13-3/4	3434	2194	1520	1113	850	669	493	368	280	218	172	138	111	91	75	62	51	—	—	—	—
15-1/8	4157	2656	1840	1348	1029	811	654	492	376	293	232	186	151	124	102	85	71	59	—	—	—
16-1/2	4936	3162	2191	1606	1226	966	780	642	491	383	304	244	199	163	135	113	95	80	68	57	—
17-7/8	5592	3712	2573	1886	1440	1135	916	752	627	490	389	313	255	210	175	146	123	104	89	76	65
19-1/4	6311	4306	2985	2189	1672	1317	1062	870	725	613	489	394	322	265	221	185	157	133	113	97	83
20-5/8	7102	4932	3428	2514	1921	1513	1216	997	831	703	601	487	398	329	274	231	195	166	142	122	105
22	7977	5452	3902	2862	2186	1717	1380	1132	944	798	683	590	486	402	336	283	240	204	175	151	131
23-3/8	8950	6011	4406	3232	2468	1934	1554	1275	1063	899	770	665	580	485	405	342	290	248	213	184	159
24-3/4	10038	6613	4928	3625	2760	2163	1739	1426	1190	1007	862	745	650	572	484	408	347	297	255	221	192
26-1/8	11263	7265	5359	4040	3068	2405	1933	1586	1323	1120	959	829	724	636	563	483	411	352	303	262	228

5 Inch Width

Depth (in)	Span (ft.)																				
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
12-3/8	3973	2537	1757	1287	982	707	511	380	289	224	176	141	113	92	75	61	50	—	—	—	—
13-3/4	4906	3134	2171	1590	1214	955	705	525	401	311	246	197	159	130	107	88	73	61	51	—	—
15-1/8	5939	3794	2629	1926	1470	1155	927	703	537	419	331	266	216	177	146	121	101	85	71	60	51
16-1/2	7051	4517	3130	2294	1750	1370	1100	901	701	547	434	349	284	233	193	161	135	114	97	82	70
17-7/8	7988	5303	3676	2695	2047	1603	1288	1055	879	700	556	448	365	301	250	209	176	149	127	108	92
19-1/4	9015	6152	4265	3120	2367	1854	1489	1221	1017	860	698	563	460	379	316	265	224	190	162	139	119
20-5/8	10145	7046	4898	3571	2710	2123	1706	1398	1166	985	843	696	569	470	392	330	279	237	203	175	151
22	11396	7788	5568	4052	3075	2410	1936	1588	1324	1119	958	828	695	575	480	404	342	292	250	216	186
23-3/8	12786	8587	6269	4562	3463	2714	2181	1789	1492	1261	1080	933	814	693	579	488	414	354	304	262	227
24-3/4	14340	9448	7010	5102	3873	3035	2440	2001	1669	1412	1209	1045	912	802	691	583	495	424	365	315	274
26-1/8	16090	10379	7655	5671	4305	3375	2713	2225	1857	1571	1345	1163	1015	892	790	689	586	502	432	374	326
27-1/2	18075	11389	8308	6269	4760	3731	3000	2461	2054	1738	1488	1287	1123	988	875	780	688	589	508	440	384
28-7/8	20346	12488	9003	6897	5237	4105	3301	2709	2260	1913	1638	1417	1237	1088	964	859	770	686	592	514	448
30-1/4	22969	13689	9744	7553	5735	4497	3616	2968	2477	2096	1795	1554	1356	1193	1057	942	845	761	684	594	518
31-5/8	26006	15007	10535	8112	6257	4906	3945	3238	2703	2288	1960	1696	1481	1303	1155	1029	923	831	752	683	596

Table 7.4 Allowable Loads in Pounds per Lineal Foot for Simple Span Southern Pine 24F-1.8E Glulam Roof Beams – Non-Snow Loads

Load Duration Factor = 1.25, $F_b = 2,400$ psi, $F_v = 270$ psi, $E_x = 1,800,000$ psi

5-1/2 Inch Width

Depth (in)	Span (ft.)																				
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
12-3/8	4370	2791	1933	1415	1080	777	562	418	318	247	194	155	124	101	82	67	55	—	—	—	—
13-3/4	5397	3447	2388	1750	1335	1048	775	578	441	343	271	216	175	143	117	97	80	67	56	—	—
15-1/8	6532	4173	2892	2119	1615	1264	1015	774	591	460	364	292	237	194	160	133	111	93	78	66	56
16-1/2	7756	4969	3443	2524	1916	1500	1204	986	772	602	478	384	312	257	213	177	149	126	106	90	77
17-7/8	8787	5833	4043	2955	2241	1755	1409	1155	962	770	611	492	401	331	275	230	194	164	139	119	102
19-1/4	9917	6767	4691	3416	2592	2030	1630	1336	1114	941	768	619	506	417	347	291	246	209	178	153	131
20-5/8	11160	7750	5373	3910	2967	2324	1867	1531	1276	1079	923	766	626	517	431	362	307	261	223	192	166
22	12535	8567	6096	4436	3366	2638	2120	1738	1449	1225	1048	906	764	632	528	444	376	321	275	237	205
23-3/8	14064	9446	6863	4995	3791	2971	2387	1958	1633	1381	1182	1022	891	762	637	537	456	389	334	289	250
24-3/4	15774	10393	7674	5585	4240	3323	2671	2191	1827	1546	1323	1144	998	877	760	641	545	466	401	347	301
26-1/8	17699	11417	8421	6208	4713	3694	2970	2436	2032	1719	1472	1273	1111	977	865	758	645	552	476	412	358
27-1/2	19883	12528	9139	6863	5211	4085	3284	2694	2248	1902	1629	1409	1230	1081	958	853	757	648	559	484	422
28-7/8	22381	13737	9903	7550	5733	4494	3614	2965	2474	2094	1793	1551	1354	1191	1055	940	843	755	651	565	492
30-1/4	25266	15058	10718	8269	6279	4923	3959	3249	2711	2295	1965	1701	1485	1306	1157	1031	924	832	753	654	570
31-5/8	28500	16507	11588	8923	6849	5371	4319	3545	2958	2504	2145	1856	1621	1426	1264	1127	1010	910	823	748	656

6-3/4 Inch Width

Depth (in)	Span (ft.)																				
	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
17-7/8	7159	4934	3589	2722	2132	1712	1403	1169	945	750	604	493	406	337	282	238	201	171	146	125	107
19-1/4	8303	5703	4149	3148	2466	1980	1623	1353	1143	942	760	621	512	426	358	302	256	219	187	161	139
20-5/8	9501	6527	4749	3603	2823	2268	1859	1550	1310	1120	940	768	635	529	445	376	320	274	236	203	176
22	10514	7405	5388	4089	3204	2574	2111	1760	1488	1273	1100	938	776	648	545	462	394	338	291	252	218
23-3/8	11592	8336	6067	4605	3608	2900	2378	1983	1677	1435	1241	1082	935	782	659	559	478	410	354	307	267
24-3/4	12755	9321	6784	5150	4036	3244	2661	2219	1877	1607	1389	1212	1065	933	787	669	572	492	426	370	322
26-1/8	14011	10335	7541	5725	4487	3607	2959	2468	2088	1788	1546	1349	1186	1050	931	792	678	584	505	440	384
27-1/2	15375	11216	8337	6329	4962	3989	3273	2730	2310	1978	1711	1493	1313	1163	1036	928	796	686	595	518	453
28-7/8	16859	12154	9171	6963	5459	4389	3602	3005	2543	2178	1884	1645	1447	1281	1142	1023	921	799	693	604	529
30-1/4	18480	13154	10044	7627	5980	4808	3946	3293	2787	2387	2065	1803	1586	1405	1253	1122	1011	914	802	700	613
31-5/8	20259	14222	10951	8320	6524	5246	4305	3593	3041	2605	2255	1969	1732	1535	1368	1226	1105	999	908	805	706
33	22219	15365	11737	9042	7090	5702	4680	3907	3307	2833	2452	2141	1884	1670	1489	1335	1202	1088	988	901	807
34-3/8	24390	16593	12566	9793	7680	6177	5070	4233	3583	3070	2657	2321	2043	1811	1615	1448	1304	1180	1073	978	895
35-3/4	26807	17913	13443	10574	8293	6670	5476	4571	3870	3316	2871	2508	2208	1957	1745	1565	1410	1277	1160	1058	968
37-1/8	29516	19338	14372	11384	8928	7182	5896	4923	4168	3572	3093	2702	2378	2109	1881	1687	1520	1376	1251	1141	1045

8-1/2 Inch Width

Depth (in)	Span (ft.)																				
	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
24-3/4	16061	11603	8445	6410	5024	4038	3312	2762	2336	1999	1729	1508	1326	1173	991	842	720	620	536	465	406
26-1/8	17644	12896	9387	7126	5585	4489	3683	3072	2599	2225	1924	1679	1476	1307	1164	997	854	735	637	554	483
27-1/2	19361	14124	10377	7878	6176	4965	4073	3398	2875	2462	2129	1858	1634	1447	1289	1155	1002	864	749	652	570
28-7/8	21230	15305	11416	8667	6795	5463	4483	3740	3165	2710	2345	2047	1800	1594	1421	1273	1146	1006	873	761	666
30-1/4	23271	16564	12503	9493	7443	5985	4911	4098	3468	2970	2570	2244	1974	1749	1558	1396	1257	1137	1010	881	772
31-5/8	25511	17909	13638	10356	8120	6530	5359	4472	3785	3242	2806	2450	2156	1910	1702	1526	1374	1243	1129	1013	889
33	27980	19349	14780	11255	8825	7097	5825	4862	4116	3526	3052	2665	2345	2078	1853	1661	1496	1354	1230	1121	1016
34-3/8	30714	20895	15824	12190	9560	7688	6311	5268	4460	3821	3307	2888	2542	2253	2009	1801	1623	1469	1334	1217	1113
35-3/4	33758	22557	16928	13162	10322	8302	6815	5690	4817	4127	3573	3121	2747	2435	2172	1947	1755	1588	1443	1316	1205
37-1/8	37168	24352	18098	14170	11113	8939	7339	6127	5188	4445	3849	3362	2960	2624	2340	2099	1892	1712	1556	1420	1299
38-1/2	40008	26294	19337	15214	11933	9599	7881	6580	5572	4775	4134	3612	3180	2820	2515	2256	2033	1841	1674	1527	1398
39-7/8	42844	28402	20655	16220	12781	10282	8442	7049	5969	5116	4430	3871	3408	3022	2696	2419	2180	1974	1795	1638	1500
41-1/4	45775	30699	22057	17203	13657	10987	9022	7534	6380	5469	4736	4138	3644	3232	2883	2587	2332	2112	1921	1753	1605
42-5/8	48800	33211	23553	18237	14562	11716	9620	8034	6804	5833	5051	4414	3888	3448	3077	2760	2489	2254	2050	1871	1714
44	51920	35699	25152	19326	15495	12467	10238	8550	7242	6208	5377	4699	4139	3671	3276	2940	2651	2401	2184	1994	1826

Notes:

- Span = simply supported beam.
- Maximum deflection = L/180 under total load. Other deflection limits may apply.
- Service condition = dry.
- Tabulated values represent total loads and have taken the dead weight of the beam (assumed 36 pcf) into account.
- Sufficient bearing length shall be provided at supports.
- Maximum beam shear is located at a distance from the supports equal to the depth of the beam.

Table 7.5 Allowable Loads in Pounds per Lineal Foot for Simple Span Southern Pine 24F-1.8E Glulam Roof Beams – Snow LoadsLoad Duration Factor = 1.15, $F_b = 2,400$ psi, $F_v = 270$ psi, $E_x = 1,800,000$ psi**3 Inch Width**

Depth (in)	Span (ft.)																				
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
6-7/8	674	428	246	153	101	69	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8-1/4	972	620	427	267	177	122	87	64	—	—	—	—	—	—	—	—	—	—	—	—	—
9-5/8	1324	845	585	426	283	197	141	104	79	60	—	—	—	—	—	—	—	—	—	—	—
11	1731	1105	765	560	425	296	214	158	120	93	73	57	—	—	—	—	—	—	—	—	—
12-3/8	2192	1400	969	710	541	424	307	228	174	134	106	84	68	55	—	—	—	—	—	—	—
13-3/4	2707	1729	1198	877	669	527	423	315	240	187	148	118	95	78	64	53	—	—	—	—	—
15-1/8	3277	2093	1450	1062	811	638	515	422	322	251	199	160	129	106	88	73	61	51	—	—	—
16-1/2	3891	2492	1727	1266	966	761	614	505	421	328	260	209	170	140	116	97	81	68	58	—	—
17-7/8	4408	2926	2028	1486	1135	894	721	594	497	420	333	269	219	180	150	125	106	89	76	65	55
19-1/4	4975	3395	2353	1725	1317	1038	838	690	575	486	416	338	276	228	189	159	134	114	97	83	72
20-5/8	5599	3888	2702	1981	1513	1192	963	791	659	557	476	412	342	282	235	198	167	142	122	105	90
22	6289	4298	3076	2255	1723	1358	1095	898	749	633	541	468	408	345	288	242	205	175	150	129	112
23-3/8	7056	4739	3473	2547	1946	1534	1234	1012	844	713	610	528	460	404	347	293	249	212	182	157	136
24-3/4	7914	5214	3885	2857	2183	1718	1381	1132	944	799	683	591	515	453	401	350	297	254	219	189	164
26-1/8	8880	5728	4224	3184	2433	1910	1535	1259	1050	888	760	657	574	504	446	397	352	301	259	225	195

3-1/2 Inch Width

Depth (in)	Span (ft.)																				
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
6-7/8	787	499	287	178	117	81	57	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8-1/4	1134	723	498	311	206	143	102	75	56	—	—	—	—	—	—	—	—	—	—	—	—
9-5/8	1545	986	682	497	330	229	165	122	92	70	55	—	—	—	—	—	—	—	—	—	—
11	2020	1289	892	653	496	345	249	185	140	108	85	67	54	—	—	—	—	—	—	—	—
12-3/8	2557	1633	1131	828	631	495	358	266	202	157	123	98	79	64	52	—	—	—	—	—	—
13-3/4	3159	2017	1397	1023	781	614	493	368	280	218	172	138	111	91	75	62	51	—	—	—	—
15-1/8	3823	2442	1692	1240	946	745	601	492	376	293	232	186	151	124	102	85	71	59	—	—	—
16-1/2	4540	2908	2008	1476	1127	887	716	589	491	383	304	244	199	163	135	113	95	80	68	57	—
17-7/8	5143	3414	2366	1734	1324	1043	842	691	575	486	389	313	255	210	175	146	123	104	89	76	65
19-1/4	5804	3961	2745	2012	1537	1211	975	799	666	563	481	394	322	265	221	185	157	133	113	97	83
20-5/8	6532	4536	3153	2311	1765	1391	1117	916	763	645	551	476	398	329	274	231	195	166	142	122	105
22	7337	5014	3588	2631	2010	1578	1268	1040	867	733	627	541	472	402	336	283	240	204	175	151	131
23-3/8	8232	5528	4052	2972	2269	1778	1428	1171	977	826	706	611	532	468	405	342	290	248	213	184	159
24-3/4	9233	6083	4532	3333	2538	1989	1598	1311	1093	924	791	684	596	524	464	408	347	297	255	221	192
26-1/8	10360	6682	4928	3715	2821	2211	1777	1458	1216	1028	880	761	664	584	517	460	411	352	303	262	228

5 Inch Width

Depth (in)	Span (ft.)																				
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
12-3/8	3654	2333	1615	1183	902	707	511	380	289	224	176	141	113	92	75	61	50	—	—	—	—
13-3/4	4512	2882	1996	1462	1115	878	705	525	401	311	246	197	159	130	107	88	73	61	51	—	—
15-1/8	5462	3489	2417	1771	1351	1061	851	697	537	419	331	266	216	177	146	121	101	85	71	60	51
16-1/2	6485	4154	2878	2109	1608	1259	1010	827	689	547	434	349	284	233	193	161	135	114	97	82	70
17-7/8	7347	4877	3380	2477	1882	1473	1183	969	807	681	556	448	365	301	250	209	176	149	127	108	92
19-1/4	8292	5658	3922	2869	2176	1704	1368	1121	934	789	675	563	460	379	316	265	224	190	162	139	119
20-5/8	9332	6480	4504	3284	2491	1951	1567	1284	1070	905	773	668	569	470	392	330	279	237	203	175	151
22	10482	7163	5121	3726	2827	2215	1779	1458	1216	1028	879	759	662	575	480	404	342	292	250	216	186
23-3/8	11760	7898	5765	4195	3183	2494	2004	1643	1370	1158	991	856	747	656	579	488	414	354	304	262	227
24-3/4	13190	8689	6446	4691	3561	2790	2242	1839	1533	1297	1109	959	836	735	650	579	495	424	365	315	274
26-1/8	14800	9546	7040	5215	3958	3102	2493	2045	1705	1442	1234	1067	931	818	724	645	577	502	432	374	326
27-1/2	16627	10475	7641	5765	4376	3430	2757	2262	1887	1596	1366	1181	1031	906	802	714	640	576	508	440	384
28-7/8	18716	11486	8280	6342	4815	3774	3034	2489	2077	1757	1504	1301	1135	998	884	787	705	635	574	514	448
30-1/4	21129	12591	8961	6946	5274	4134	3324	2727	2275	1925	1649	1426	1245	1095	970	864	774	697	630	572	518
31-5/8	23922	13803	9689	7460	5753	4510	3626	2976	2483	2101	1800	1557	1359	1196	1059	944	846	761	689	625	570

Table 7.5 Allowable Loads in Pounds per Lineal Foot for Simple Span Southern Pine 24F-1.8E Glulam Roof Beams – Snow Loads

Load Duration Factor = 1.15, $F_b = 2,400$ psi, $F_v = 270$ psi, $E_x = 1,800,000$ psi

5-1/2 Inch Width

Depth (in)	Span (ft.)																				
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
12-3/8	4019	2566	1777	1301	992	777	562	418	318	247	194	155	124	101	82	67	55	—	—	—	—
13-3/4	4964	3170	2196	1608	1227	963	772	578	441	343	271	216	175	143	117	97	80	67	56	—	—
15-1/8	6008	3838	2659	1948	1484	1161	932	763	591	460	364	292	237	194	160	133	111	93	78	66	56
16-1/2	7134	4569	3166	2320	1761	1378	1106	906	754	602	478	384	312	257	213	177	149	126	106	90	77
17-7/8	8082	5365	3718	2716	2060	1613	1295	1061	883	746	611	492	401	331	275	230	194	164	139	119	102
19-1/4	9121	6224	4314	3140	2382	1865	1498	1227	1023	864	738	619	506	417	347	291	246	209	178	153	131
20-5/8	10265	7128	4941	3595	2727	2136	1716	1406	1172	990	847	731	626	517	431	362	307	261	223	192	166
22	11530	7879	5606	4079	3095	2424	1948	1597	1331	1125	962	831	724	632	528	444	376	321	275	237	205
23-3/8	12936	8687	6311	4592	3485	2730	2194	1799	1500	1268	1085	937	817	718	635	537	456	389	334	289	250
24-3/4	14509	9558	7057	5136	3898	3054	2454	2013	1678	1419	1214	1050	915	804	712	634	545	466	401	347	301
26-1/8	16280	10500	7744	5709	4333	3396	2729	2238	1867	1579	1351	1168	1019	896	793	706	632	552	476	412	358
27-1/2	18289	11522	8405	6311	4791	3755	3018	2476	2065	1747	1495	1293	1128	992	878	782	700	630	559	484	422
28-7/8	20587	12635	9108	6943	5271	4132	3321	2725	2273	1923	1646	1424	1243	1093	968	862	772	695	628	565	492
30-1/4	23242	13850	9857	7604	5773	4526	3639	2985	2491	2108	1805	1561	1363	1198	1061	946	847	763	689	626	570
31-5/8	26216	15183	10658	8206	6298	4938	3970	3258	2718	2300	1970	1704	1488	1309	1159	1033	926	833	754	684	623

6-3/4 Inch Width

Depth (in)	Span (ft.)																				
	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
17-7/8	6584	4537	3299	2502	1959	1572	1288	1073	906	750	604	493	406	337	282	238	201	171	146	125	107
19-1/4	7636	5244	3815	2893	2266	1819	1491	1242	1049	897	760	621	512	426	358	302	256	219	187	161	139
20-5/8	8738	6002	4366	3312	2594	2084	1708	1423	1202	1028	888	768	635	529	445	376	320	274	236	203	176
22	9670	6809	4954	3759	2945	2365	1939	1616	1366	1168	1009	880	772	648	545	462	394	338	291	252	218
23-3/8	10662	7666	5578	4233	3317	2665	2185	1821	1540	1317	1138	992	872	771	659	559	478	410	354	307	267
24-3/4	11731	8572	6238	4734	3710	2981	2445	2038	1724	1475	1275	1112	977	864	769	669	572	492	426	370	322
26-1/8	12887	9504	6934	5263	4125	3315	2719	2267	1918	1641	1419	1238	1088	963	857	767	678	584	505	440	384
27-1/2	14141	10315	7666	5819	4561	3666	3007	2508	2122	1816	1570	1370	1205	1066	949	850	765	686	595	518	453
28-7/8	15506	11178	8434	6402	5018	4034	3310	2761	2336	2000	1729	1509	1327	1175	1047	937	843	762	692	604	529
30-1/4	16998	12097	9237	7013	5497	4420	3626	3025	2560	2192	1896	1655	1455	1289	1148	1029	926	837	760	692	613
31-5/8	18634	13080	10071	7650	5997	4822	3957	3302	2794	2393	2070	1807	1589	1408	1254	1124	1012	915	831	757	692
33	20437	14132	10794	8314	6519	5242	4301	3590	3038	2602	2251	1965	1729	1532	1365	1224	1102	996	905	825	754
34-3/8	22434	15261	11556	9005	7061	5678	4660	3889	3292	2820	2440	2131	1875	1661	1481	1327	1195	1081	982	895	819
35-3/4	24658	16475	12363	9723	7625	6132	5033	4201	3556	3046	2636	2302	2026	1795	1601	1435	1293	1170	1062	969	886
37-1/8	27149	17786	13217	10468	8209	6602	5419	4524	3830	3281	2840	2480	2183	1935	1725	1547	1394	1261	1146	1045	956

8-1/2 Inch Width

Depth (in)	Span (ft.)																				
	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
24-3/4	14772	10670	7765	5893	4618	3710	3043	2537	2145	1835	1586	1383	1215	1075	957	842	720	620	536	465	406
26-1/8	16228	11860	8631	6551	5134	4126	3384	2822	2386	2042	1766	1540	1353	1198	1066	954	854	735	637	554	483
27-1/2	17807	12990	9542	7243	5677	4563	3743	3122	2640	2260	1954	1705	1499	1327	1181	1058	951	859	749	652	570
28-7/8	19526	14076	10498	7969	6246	5021	4119	3436	2907	2488	2152	1878	1651	1462	1302	1166	1049	948	860	761	666
30-1/4	21405	15234	11497	8729	6842	5501	4513	3765	3186	2728	2359	2059	1811	1604	1429	1280	1152	1041	945	861	772
31-5/8	23465	16471	12541	9522	7465	6002	4925	4109	3477	2978	2576	2248	1978	1752	1561	1398	1259	1138	1033	941	860
33	25736	17796	13592	10349	8114	6524	5354	4468	3781	3238	2802	2446	2152	1906	1699	1522	1371	1240	1126	1026	938
34-3/8	28251	19217	14553	11209	8789	7067	5800	4841	4097	3509	3037	2651	2333	2067	1842	1651	1487	1345	1222	1114	1018
35-3/4	31051	20747	15568	12103	9490	7632	6264	5228	4426	3791	3281	2865	2521	2234	1992	1785	1608	1455	1322	1205	1102
37-1/8	34188	22397	16643	13030	10218	8218	6745	5630	4766	4084	3535	3087	2717	2408	2147	1925	1734	1569	1426	1300	1189
38-1/2	36800	24184	17784	13991	10972	8825	7244	6047	5120	4387	3797	3316	2919	2587	2307	2069	1864	1687	1533	1398	1279
39-7/8	39410	26123	18996	14916	11752	9453	7760	6478	5485	4700	4069	3554	3129	2774	2474	2218	1999	1810	1645	1500	1373
41-1/4	42106	28236	20286	15820	12558	10101	8293	6924	5863	5024	4350	3800	3346	2966	2646	2373	2139	1936	1760	1606	1470
42-5/8	44889	30547	21661	16771	13390	10771	8843	7384	6253	5359	4640	4054	3569	3165	2823	2532	2283	2067	1879	1714	1569
44	47759	32836	23132	17772	14248	11462	9411	7858	6655	5704	4939	4316	3800	3370	3006	2697	2431	2202	2002	1827	1673

Notes:

- Span = simply supported beam.
- Maximum deflection = L/180 under total load. Other deflection limits may apply.
- Service condition = dry.
- Tabulated values represent total loads and have taken the dead weight of the beam (assumed 36 pcf) into account.
- Sufficient bearing length shall be provided at supports.
- Maximum beam shear is located at a distance from the supports equal to the depth of the beam.

Table 7.6 Allowable Loads in Pounds per Lineal Foot for Simple Span Southern Pine 24F-1.8E Glulam Floor Beams

Load Duration Factor = 1.00, $F_b = 2,400$ psi, $F_v = 270$ psi, $E_x = 1,800,000$ psi

3 Inch Width

Depth (in)	Span (ft.)																				
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
6-7/8	524	266	152	94	61	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8-1/4	845	462	265	164	108	74	52	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9-5/8	1151	734	423	264	174	120	86	63	—	—	—	—	—	—	—	—	—	—	—	—	—
11	1504	960	634	396	263	182	130	96	72	55	—	—	—	—	—	—	—	—	—	—	—
12-3/8	1905	1216	842	566	376	262	188	139	105	81	63	—	—	—	—	—	—	—	—	—	—
13-3/4	2353	1502	1040	761	519	361	260	193	146	113	88	70	56	—	—	—	—	—	—	—	—
15-1/8	2848	1819	1260	922	693	483	349	259	197	153	120	95	77	62	50	—	—	—	—	—	—
16-1/2	3382	2166	1500	1099	838	630	456	339	258	201	158	126	102	83	68	56	—	—	—	—	—
17-7/8	3832	2543	1762	1291	985	776	582	434	331	257	203	163	132	108	89	73	61	51	—	—	—
19-1/4	4324	2950	2044	1498	1144	901	727	544	416	324	256	206	167	137	113	94	78	66	55	—	—
20-5/8	4867	3379	2348	1721	1314	1035	835	671	513	401	318	255	208	171	141	118	99	83	70	60	51
22	5467	3735	2672	1959	1496	1179	950	779	625	488	388	312	254	209	174	145	122	103	88	75	64
23-3/8	6134	4118	3018	2213	1690	1332	1071	878	731	588	467	377	307	253	211	176	149	126	107	92	79
24-3/4	6880	4531	3376	2482	1896	1491	1198	982	819	692	557	449	367	303	252	212	179	152	130	111	96
26-1/8	7719	4978	3671	2766	2113	1658	1332	1092	911	770	657	531	434	358	299	251	213	181	155	133	115

3-1/2 Inch Width

Depth (in)	Span (ft.)																				
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
6-7/8	611	310	177	109	71	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8-1/4	985	539	309	192	126	86	61	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9-5/8	1343	856	493	308	203	140	100	73	54	—	—	—	—	—	—	—	—	—	—	—	—
11	1755	1120	739	462	306	212	152	112	84	64	—	—	—	—	—	—	—	—	—	—	—
12-3/8	2222	1418	982	661	439	305	219	162	122	94	73	57	—	—	—	—	—	—	—	—	—
13-3/4	2745	1753	1213	888	605	421	304	225	171	132	103	82	65	52	—	—	—	—	—	—	—
15-1/8	3323	2122	1470	1076	808	564	407	303	230	178	140	111	89	72	59	—	—	—	—	—	—
16-1/2	3946	2527	1750	1282	978	734	531	396	301	234	185	147	119	97	79	65	54	—	—	—	—
17-7/8	4470	2967	2055	1506	1149	905	678	506	386	300	237	190	154	126	103	86	71	59	—	—	—
19-1/4	5045	3442	2385	1748	1334	1051	846	634	485	378	299	240	195	160	132	110	92	77	65	54	—
20-5/8	5678	3942	2739	2008	1533	1207	969	783	599	467	371	298	242	199	165	137	115	97	82	70	59
22	6378	4358	3118	2286	1745	1370	1100	902	730	570	452	364	297	244	203	169	143	120	102	87	74
23-3/8	7156	4805	3521	2581	1970	1543	1239	1016	847	686	545	439	358	295	246	206	174	147	125	107	92
24-3/4	8026	5286	3938	2895	2204	1726	1387	1137	948	801	650	524	428	353	294	247	209	177	151	130	112
26-1/8	9006	5808	4282	3227	2450	1920	1542	1264	1054	891	762	619	506	418	349	293	248	211	181	155	134

5 Inch Width

Depth (in)	Span (ft.)																				
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
12-3/8	3175	2026	1403	944	627	436	314	232	175	134	104	82	65	51	—	—	—	—	—	—	—
13-3/4	3922	2504	1733	1269	864	602	434	322	244	188	147	117	93	75	60	—	—	—	—	—	—
15-1/8	4747	3031	2099	1537	1154	805	582	432	329	255	200	159	128	103	84	69	56	—	—	—	—
16-1/2	5637	3609	2500	1831	1396	1049	759	565	431	334	264	210	170	138	113	93	77	64	53	—	—
17-7/8	6386	4238	2936	2151	1633	1278	969	723	551	429	339	271	220	179	148	122	102	85	71	59	—
19-1/4	7207	4917	3407	2491	1889	1479	1187	906	693	540	427	343	278	228	188	156	131	110	92	78	66
20-5/8	8111	5631	3913	2852	2163	1693	1359	1114	856	668	529	426	346	284	235	196	165	139	117	99	84
22	9111	6225	4449	3236	2455	1922	1543	1265	1042	814	646	520	424	349	289	242	204	172	146	124	106
23-3/8	10223	6864	5009	3644	2764	2165	1739	1425	1187	980	779	628	512	422	351	294	248	210	179	153	131
24-3/4	11466	7552	5601	4075	3092	2422	1946	1595	1329	1123	928	749	612	505	420	353	298	253	216	185	159
26-1/8	12866	8296	6118	4530	3438	2693	2164	1774	1479	1250	1069	885	723	597	498	419	354	302	258	222	191
27-1/2	14453	9104	6640	5009	3801	2978	2393	1962	1636	1383	1183	1023	847	701	585	492	417	355	305	262	227
28-7/8	16270	9983	7195	5510	4182	3277	2634	2160	1801	1523	1303	1127	983	815	681	573	486	415	356	307	266
30-1/4	18368	10944	7787	6035	4581	3590	2885	2367	1974	1669	1429	1235	1078	940	786	663	563	481	414	357	310
31-5/8	20797	11997	8420	6482	4997	3917	3148	2583	2154	1822	1560	1349	1177	1035	902	761	647	553	476	412	358

Table 7.6 Allowable Loads in Pounds per Lineal Foot for Simple Span Southern Pine 24F-1.8E Glulam Floor Beams

Load Duration Factor = 1.00, $F_b = 2,400$ psi, $F_v = 270$ psi, $E_x = 1,800,000$ psi

5-1/2 Inch Width

Depth (in)	Span (ft.)																				
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
12-3/8	3492	2229	1543	1038	690	479	345	255	192	148	115	90	71	57	—	—	—	—	—	—	—
13-3/4	4314	2754	1907	1396	951	662	478	354	268	207	162	128	102	82	66	53	—	—	—	—	—
15-1/8	5222	3334	2309	1691	1270	886	640	476	362	280	220	175	141	114	93	76	62	51	—	—	—
16-1/2	6200	3970	2750	2015	1528	1154	835	622	474	368	290	231	187	152	124	102	85	70	58	—	—
17-7/8	7025	4662	3230	2359	1788	1399	1066	795	607	472	373	299	242	197	162	134	112	93	78	65	54
19-1/4	7928	5408	3748	2727	2068	1619	1299	997	762	594	470	377	306	251	207	172	144	121	101	85	72
20-5/8	8922	6194	4293	3122	2368	1854	1488	1219	941	734	582	468	381	313	259	216	181	153	129	109	93
22	10022	6848	4871	3543	2687	2104	1690	1384	1147	895	711	572	466	384	318	266	224	189	161	137	117
23-3/8	11245	7550	5484	3989	3026	2370	1903	1560	1300	1078	857	691	563	464	386	323	273	231	197	168	144
24-3/4	12612	8307	6132	4461	3385	2652	2130	1746	1455	1230	1021	824	673	555	462	388	328	279	238	204	175
26-1/8	14152	9126	6730	4959	3763	2948	2369	1942	1619	1368	1170	973	795	657	548	461	390	332	284	244	210
27-1/2	15899	10014	7304	5483	4161	3260	2620	2148	1791	1514	1295	1120	932	771	643	541	459	391	335	289	249
28-7/8	17897	10982	7915	6032	4578	3588	2883	2364	1971	1667	1427	1233	1075	896	749	631	535	457	392	338	293
30-1/4	20205	12038	8566	6607	5015	3930	3159	2591	2161	1827	1564	1352	1179	1034	865	729	619	529	455	393	341
31-5/8	22791	13197	9262	7130	5471	4288	3446	2827	2358	1995	1707	1476	1288	1132	992	837	712	609	524	453	393

6-3/4 Inch Width

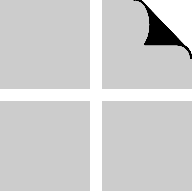
Depth (in)	Span (ft.)																				
	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
17-7/8	5721	3941	2865	2172	1699	1308	976	744	579	458	366	297	242	199	165	137	114	96	80	67	56
19-1/4	6636	4556	3313	2512	1966	1578	1224	935	728	577	463	376	308	254	211	176	148	125	105	88	75
20-5/8	7594	5215	3792	2876	2251	1807	1480	1155	901	715	574	467	384	318	265	222	187	158	134	114	97
22	8404	5916	4303	3264	2556	2052	1681	1401	1099	872	702	572	471	391	327	275	232	197	168	143	123
23-3/8	9266	6661	4846	3676	2879	2312	1895	1579	1323	1051	847	691	570	474	397	335	284	242	207	177	152
24-3/4	10195	7449	5419	4111	3221	2587	2120	1767	1493	1253	1011	826	681	568	476	402	342	292	250	215	186
26-1/8	11200	8259	6024	4571	3581	2877	2358	1966	1662	1421	1194	976	807	672	565	478	407	348	299	258	223
27-1/2	12291	8964	6660	5054	3960	3182	2609	2175	1839	1573	1360	1144	946	789	664	563	480	411	354	306	266
28-7/8	13477	9714	7327	5561	4358	3502	2871	2394	2025	1732	1498	1306	1100	919	774	657	561	481	415	359	312
30-1/4	14774	10513	8025	6091	4774	3836	3146	2624	2219	1899	1642	1432	1259	1061	895	760	649	558	482	418	364
31-5/8	16197	11367	8750	6645	5208	4186	3434	2864	2422	2074	1793	1564	1375	1217	1027	873	747	643	556	483	421
33	17764	12281	9378	7222	5661	4551	3733	3114	2634	2255	1950	1702	1496	1325	1172	997	854	735	637	554	483
34-3/8	19501	13263	10041	7823	6133	4930	4045	3374	2855	2444	2114	1845	1623	1437	1280	1132	970	836	724	631	551
35-3/4	21434	14319	10742	8447	6622	5324	4368	3645	3084	2641	2285	1994	1754	1553	1384	1240	1096	945	820	714	625
37-1/8	23600	15458	11485	9095	7130	5733	4704	3926	3322	2845	2461	2149	1890	1674	1492	1337	1204	1064	923	805	705

8-1/2 Inch Width

Depth (in)	Span (ft.)																				
	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
24-3/4	12838	9272	6745	5117	4008	3220	2639	2199	1858	1578	1273	1040	858	715	600	507	431	368	315	271	234
26-1/8	14104	10306	7498	5689	4457	3580	2935	2447	2068	1769	1504	1229	1016	847	712	602	513	439	377	325	281
27-1/2	15477	11288	8290	6291	4929	3960	3247	2707	2288	1958	1692	1440	1191	994	836	709	604	518	446	386	334
28-7/8	16971	12232	9120	6922	5424	4358	3574	2980	2520	2156	1863	1625	1385	1157	975	827	706	606	523	453	393
30-1/4	18604	13238	9989	7582	5942	4775	3916	3266	2762	2364	2043	1782	1566	1337	1127	957	818	703	607	527	459
31-5/8	20396	14314	10897	8271	6483	5210	4274	3564	3015	2580	2231	1946	1711	1514	1294	1100	941	809	700	608	530
33	22370	15465	11810	8990	7046	5664	4646	3876	3279	2807	2427	2118	1862	1648	1468	1256	1075	926	802	697	609
34-3/8	24556	16701	12645	9738	7633	6136	5034	4200	3553	3042	2631	2296	2019	1788	1593	1425	1221	1053	912	794	694
35-3/4	26991	18031	13528	10514	8243	6627	5437	4536	3838	3287	2843	2481	2183	1933	1722	1543	1380	1190	1032	900	787
37-1/8	29718	19466	14462	11320	8875	7136	5855	4886	4134	3541	3063	2674	2352	2083	1856	1663	1497	1339	1162	1014	888
38-1/2	31990	21018	15454	12155	9530	7663	6288	5248	4441	3804	3291	2873	2528	2239	1996	1788	1610	1456	1302	1137	996
39-7/8	34258	22705	16507	12959	10208	8209	6737	5622	4759	4076	3527	3080	2710	2401	2140	1918	1727	1563	1419	1269	1113
41-1/4	36602	24542	17628	13745	10908	8772	7200	6009	5087	4357	3771	3293	2898	2568	2289	2052	1848	1672	1519	1385	1238
42-5/8	39022	26551	18824	14572	11632	9354	7678	6409	5425	4648	4023	3513	3092	2740	2443	2190	1973	1785	1622	1479	1353
44	41517	28541	20103	15442	12377	9955	8171	6821	5775	4948	4283	3740	3292	2918	2602	2333	2102	1902	1729	1576	1442

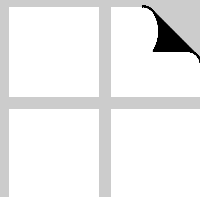
Notes:

- Span = simply supported beam.
- Maximum deflection = $L/360$ under live load, based on live/total load = 0.8. Where additional stiffness is desired or for other live/total load ratios, design for deflection must be modified per requirements.
- Service condition = dry.
- Tabulated values represent total loads based on live/total load = 0.8 and have taken the dead weight of the beam (assumed 36 pcf) into account.
- Sufficient bearing length shall be provided at supports.
- Maximum beam shear is located at a distance from the supports equal to the depth of the beam.



DESIGN EXAMPLES

8.1	General	GL-78
8.2	Examples	GL-78



8.1 General

General design examples for tension members, compression members, and bending members are available in various wood engineering handbooks, such as the McGraw-Hill APA Engineered Wood Handbook, *Wood*

Engineering and Construction Handbook, and *AITC Timber Construction Manual*. See Section 2.4 for the associations that are available for technical assistance.

8.2 Examples

Design Example 1: Low Slope Roof Design Using Section Capacities

Given:

- 24-ft. x 24-ft. column grid layout
- Live load = 30 psf (snow); $C_D = 1.15$
- Dead load = 10 psf (actual)
- Allowable total load deflection = $L / 180$
- Allowable live load deflection = $L / 240$
- Use 24F-1.8E/DF
- The compression edge of the beam is supported by sheathing throughout its length

Then:

- Glulam span = 24 ft.
- Load $w = (30 + 10)(24) = 960$ plf
- Moment $_{max} = wL^2 / 8 = (960)(24)^2 / 8 = 69,120$ lbf-ft.
- Shear $_{max} = wL / 2 = (960)(24) / 2 = 11,520$ lbf

Note: For preliminary design, all loads within a distance from supports equal to the beam depth are not neglected.

Design:

- From Table 5.1, try 5-1/8 x 21
- Beam wt = $(35 \text{ pcf})(5.125/12 \text{ ft.})(21/12 \text{ ft.}) = 26$ plf

Note: Beam weight has been assumed to be 35 pcf, which is typical for glulam beams made of Douglas fir-Larch. See Section 6.2 for more information.

- Total load = $960 + 26 = 986$ plf
- From Table 4.5, volume factor = 0.9330
- From Table 5.1, Design Moment Capacity = $(75,338)(0.933)(1.15) = 80,834$ lbf-ft.

Note: Beam stability factor is equal to 1 as the compression edge of the beam is supported by sheathing throughout its length.

- Moment $_{max} = (69,120)(986) / (960) = 70,992$ lbf-ft. < 80,834 lbf-ft. — OK
- From Table 5.1, Design Shear Capacity = $(17,220)(1.15) = 19,803$ lbf
- Neglect all loads within a distance from supports equal to the beam depth. Shear $_{max} = (11,520)(986)/(960) - (21/12)(986) = 10,107$ lbf < 19,803 lbf — OK
- From Table 5.3, $EI = 7,119 \times 10^6$ lbf-in.²
- Deflection, total load = $5wL^4 / 384EI = (5)(986)(24)^4(1,728) / [(384)(7,119 \times 10^6)] = 1.03$ in. = $L / 279$ < $L / 180$ — OK
- Deflection, live load = $(1.03)(30)(24) / 986 = 0.75$ in. = $L / 383$ < $L / 240$ — OK

Design Example 2: Low Slope Roof Design Using Load-Span Tables

Given:

- The same conditions as Design Example 1 except that 24F-1.8E/SP is specified.

Then:

- Load $w = (30 + 10)(24) = 960$ plf, excluding beam weight

Design:

- From Table 7.5, select 3 x 26-1/8, 3-1/2 x 23-3/8, 5 x 20-5/8, or 5-1/2 x 19-1/4

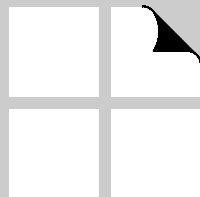
Note: Beam weight has been included in the table.

SECTION PROPERTIES

9.1 Cross Sectional Properties GL-80

Table 9.1 Section Properties for *Western Species* Glued
Laminated Timber GL-81

Table 9.2 Section Properties for *Southern Pine* Glued
Laminated Timber GL-87



9.1 Cross Sectional Properties

Cross sectional properties are provided for glued laminated timber manufactured from Western species in Table 9.1 and from Southern Pine in Table 9.2. These tables list the beam depths; the reference and actual beam widths, the cross-sectional areas, moments of inertia, section moduli and radii of gyration. Note that the plane of the glue line is in the X-X direction. Further, the width of glued laminated timber is in the X-X direction and its depth is

in the Y-Y direction. The thickness of each lamination provided here for Western species and Southern Pine glued laminated timber members is based on 1-1/2 and 1-3/8 inches, respectively. However, other lamination thicknesses may be used in glued laminated timber manufacturing and the availability shall be verified prior to design.

Table 9.1 Section Properties for Western Species Glued Laminated Timber

Depth d (in.)	Area A (in. ²)	X-X Axis			Y-Y Axis	
		I _x (in. ⁴)	S _x (in. ³)	r _x (in.)	I _y (in. ⁴)	S _y (in. ³)
2-1/2 in. Width (r_y = 0.722 in.)						
6	15.00	45.00	15.00	1.732	7.813	6.250
7-1/2	18.75	87.89	23.44	2.165	9.766	7.813
9	22.50	151.9	33.75	2.598	11.72	9.375
10-1/2	26.25	241.2	45.94	3.031	13.67	10.94
12	30.00	360.0	60.00	3.464	15.63	12.50
13-1/2	33.75	512.6	75.94	3.897	17.58	14.06
15	37.50	703.1	93.75	4.330	19.53	15.63
16-1/2	41.25	935.9	113.4	4.763	21.48	17.19
18	45.00	1215	135.0	5.196	23.44	18.75
19-1/2	48.75	1545	158.4	5.629	25.39	20.31
21	52.50	1929	183.8	6.062	27.34	21.88
3-1/8 in. Width (r_y = 0.902 in.)						
6	18.75	56.25	18.75	1.732	15.26	9.766
7-1/2	23.44	109.9	29.30	2.165	19.07	12.21
9	28.13	189.8	42.19	2.598	22.89	14.65
10-1/2	32.81	301.5	57.42	3.031	26.70	17.09
12	37.50	450.0	75.00	3.464	30.52	19.53
13-1/2	42.19	640.7	94.92	3.897	34.33	21.97
15	46.88	878.9	117.2	4.330	38.15	24.41
16-1/2	51.56	1170	141.8	4.763	41.96	26.86
18	56.25	1519	168.8	5.196	45.78	29.30
19-1/2	60.94	1931	198.0	5.629	49.59	31.74
21	65.63	2412	229.7	6.062	53.41	34.18
22-1/2	70.31	2966	263.7	6.495	57.22	36.62
24	75.00	3600	300.0	6.928	61.04	39.06
3-1/2 in. Width (r_y = 1.010 in.)						
6	21.00	63.00	21.00	1.732	21.44	12.25
7-1/2	26.25	123.0	32.81	2.165	26.80	15.31
9	31.50	212.6	47.25	2.598	32.16	18.38
10-1/2	36.75	337.6	64.31	3.031	37.52	21.44
12	42.00	504.0	84.00	3.464	42.88	24.50
13-1/2	47.25	717.6	106.3	3.897	48.23	27.56
15	52.50	984.4	131.3	4.330	53.59	30.63
16-1/2	57.75	1310	158.8	4.763	58.95	33.69
18	63.00	1701	189.0	5.196	64.31	36.75
19-1/2	68.25	2163	221.8	5.629	69.67	39.81
21	73.50	2701	257.3	6.062	75.03	42.88
22-1/2	78.75	3322	295.3	6.495	80.39	45.94
24	84.00	4032	336.0	6.928	85.75	49.00

Table 9.1 Section Properties for Western Species Glued Laminated Timber (Cont.)

Depth d (in.)	Area A (in. ²)	X-X Axis			Y-Y Axis	
		I _x (in. ⁴)	S _x (in. ³)	r _x (in.)	I _y (in. ⁴)	S _y (in. ³)
5-1/8 in. Width (r_y = 1.479 in.)						
6	30.75	92.25	30.75	1.732	67.31	26.27
7-1/2	38.44	180.2	48.05	2.165	84.13	32.83
9	46.13	311.3	69.19	2.598	101.0	39.40
10-1/2	53.81	494.4	94.17	3.031	117.8	45.96
12	61.50	738.0	123.0	3.464	134.6	52.53
13-1/2	69.19	1051	155.7	3.897	151.4	59.10
15	76.88	1441	192.2	4.330	168.3	65.66
16-1/2	84.56	1919	232.5	4.763	185.1	72.23
18	92.25	2491	276.8	5.196	201.9	78.80
19-1/2	99.94	3167	324.8	5.629	218.7	85.36
21	107.6	3955	376.7	6.062	235.6	91.93
22-1/2	115.3	4865	432.4	6.495	252.4	98.50
24	123.0	5904	492.0	6.928	269.2	105.1
25-1/2	130.7	7082	555.4	7.361	286.0	111.6
27	138.4	8406	622.7	7.794	302.9	118.2
28-1/2	146.1	9887	693.8	8.227	319.7	124.8
30	153.8	11530	768.8	8.660	336.5	131.3
31-1/2	161.4	13350	847.5	9.093	353.4	137.9
33	169.1	15350	930.2	9.526	370.2	144.5
34-1/2	176.8	17540	1017	9.959	387.0	151.0
36	184.5	19930	1107	10.39	403.8	157.6
5-1/2 in. Width (r_y = 1.588 in.)						
6	33.00	99.00	33.00	1.732	83.19	30.25
7-1/2	41.25	193.4	51.56	2.165	104.0	37.81
9	49.50	334.1	74.25	2.598	124.8	45.38
10-1/2	57.75	530.6	101.1	3.031	145.6	52.94
12	66.00	792.0	132.0	3.464	166.4	60.50
13-1/2	74.25	1128	167.1	3.897	187.2	68.06
15	82.50	1547	206.3	4.330	208.0	75.63
16-1/2	90.75	2059	249.6	4.763	228.8	83.19
18	99.00	2673	297.0	5.196	249.6	90.75
19-1/2	107.3	3398	348.6	5.629	270.4	98.31
21	115.5	4245	404.3	6.062	291.2	105.9
22-1/2	123.8	5221	464.1	6.495	312.0	113.4
24	132.0	6336	528.0	6.928	332.8	121.0
25-1/2	140.3	7600	596.1	7.361	353.5	128.6
27	148.5	9021	668.3	7.794	374.3	136.1
28-1/2	156.8	10610	744.6	8.227	395.1	143.7
30	165.0	12380	825.0	8.660	415.9	151.3
31-1/2	173.3	14330	909.6	9.093	436.7	158.8
33	181.5	16470	998.3	9.526	457.5	166.4
34-1/2	189.8	18820	1091	9.959	478.3	173.9
36	198.0	21380	1188	10.39	499.1	181.5

Table 9.1 Section Properties for Western Species Glued Laminated Timber (Cont.)

Depth d (in.)	Area A (in. ²)	X-X Axis			Y-Y Axis	
		I _x (in. ⁴)	S _x (in. ³)	r _x (in.)	I _y (in. ⁴)	S _y (in. ³)
6-3/4 in. Width (r_y = 1.949 in.)						
7-1/2	50.63	237.3	63.28	2.165	192.2	56.95
9	60.75	410.1	91.13	2.598	230.7	68.34
10-1/2	70.88	651.2	124.0	3.031	269.1	79.73
12	81.00	972.0	162.0	3.464	307.5	91.13
13-1/2	91.13	1384	205.0	3.897	346.0	102.5
15	101.3	1898	253.1	4.330	384.4	113.9
16-1/2	111.4	2527	306.3	4.763	422.9	125.3
18	121.5	3281	364.5	5.196	461.3	136.7
19-1/2	131.6	4171	427.8	5.629	499.8	148.1
21	141.8	5209	496.1	6.062	538.2	159.5
22-1/2	151.9	6407	569.5	6.495	576.7	170.9
24	162.0	7776	648.0	6.928	615.1	182.3
25-1/2	172.1	9327	731.5	7.361	653.5	193.6
27	182.3	11070	820.1	7.794	692.0	205.0
28-1/2	192.4	13020	913.8	8.227	730.4	216.4
30	202.5	15190	1013	8.660	768.9	227.8
31-1/2	212.6	17580	1116	9.093	807.3	239.2
33	222.8	20210	1225	9.526	845.8	250.6
34-1/2	232.9	23100	1339	9.959	884.2	262.0
36	243.0	26240	1458	10.39	922.6	273.4
37-1/2	253.1	29660	1582	10.83	961.1	284.8
39	263.3	33370	1711	11.26	999.5	296.2
40-1/2	273.4	37370	1845	11.69	1038	307.5
42	283.5	41670	1985	12.12	1076	318.9
43-1/2	293.6	46300	2129	12.56	1115	330.3
45	303.8	51260	2278	12.99	1153	341.7
46-1/2	313.9	56560	2433	13.42	1192	353.1
48	324.0	62210	2592	13.86	1230	364.5
49-1/2	334.1	68220	2757	14.29	1269	375.9
51	344.3	74620	2926	14.72	1307	387.3
52-1/2	354.4	81400	3101	15.16	1346	398.7
54	364.5	88570	3281	15.59	1384	410.1
55-1/2	374.6	96160	3465	16.02	1422	421.5
57	384.8	104200	3655	16.45	1461	432.8
58-1/2	394.9	112600	3850	16.89	1499	444.2
60	405.0	121500	4050	17.32	1538	455.6

Table 9.1 Section Properties for Western Species Glued Laminated Timber (Cont.)

Depth d (in.)	Area A (in. ²)	X-X Axis			Y-Y Axis	
		I _x (in. ⁴)	S _x (in. ³)	r _x (in.)	I _y (in. ⁴)	S _y (in. ³)
8-3/4 in. Width (r_y = 2.526 in.)						
9	78.75	531.6	118.1	2.598	502.4	114.8
10-1/2	91.88	844.1	160.8	3.031	586.2	134.0
12	105.0	1260	210.0	3.464	669.9	153.1
13-1/2	118.1	1794	265.8	3.897	753.7	172.3
15	131.3	2461	328.1	4.330	837.4	191.4
16-1/2	144.4	3276	397.0	4.763	921.1	210.5
18	157.5	4253	472.5	5.196	1005	229.7
19-1/2	170.6	5407	554.5	5.629	1089	248.8
21	183.8	6753	643.1	6.062	1172	268.0
22-1/2	196.9	8306	738.3	6.495	1256	287.1
24	210.0	10080	840.0	6.928	1340	306.3
25-1/2	223.1	12090	948.3	7.361	1424	325.4
27	236.3	14350	1063	7.794	1507	344.5
28-1/2	249.4	16880	1185	8.227	1591	363.7
30	262.5	19690	1313	8.660	1675	382.8
31-1/2	275.6	22790	1447	9.093	1759	402.0
33	288.8	26200	1588	9.526	1842	421.1
34-1/2	301.9	29940	1736	9.959	1926	440.2
36	315.0	34020	1890	10.39	2010	459.4
37-1/2	328.1	38450	2051	10.83	2094	478.5
39	341.3	43250	2218	11.26	2177	497.7
40-1/2	354.4	48440	2392	11.69	2261	516.8
42	367.5	54020	2573	12.12	2345	535.9
43-1/2	380.6	60020	2760	12.56	2428	555.1
45	393.8	66450	2953	12.99	2512	574.2
46-1/2	406.9	73310	3153	13.42	2596	593.4
48	420.0	80640	3360	13.86	2680	612.5
49-1/2	433.1	88440	3573	14.29	2763	631.6
51	446.3	96720	3793	14.72	2847	650.8
52-1/2	459.4	105500	4020	15.16	2931	669.9
54	472.5	114800	4253	15.59	3015	689.1
55-1/2	485.6	124700	4492	16.02	3098	708.2
57	498.8	135000	4738	16.45	3182	727.3
58-1/2	511.9	146000	4991	16.89	3266	746.5
60	525.0	157500	5250	17.32	3350	765.6

Table 9.1 Section Properties for Western Species Glued Laminated Timber (Cont.)

Depth d (in.)	Area A (in. ²)	X-X Axis			Y-Y Axis	
		I _x (in. ⁴)	S _x (in. ³)	r _x (in.)	I _y (in. ⁴)	S _y (in. ³)
10-3/4 in. Width (r_y = 3.103 in.)						
12	129.0	1548	258.0	3.464	1242	231.1
13-1/2	145.1	2204	326.5	3.897	1398	260.0
15	161.3	3023	403.1	4.330	1553	288.9
16-1/2	177.4	4024	487.8	4.763	1708	317.8
18	193.5	5225	580.5	5.196	1863	346.7
19-1/2	209.6	6642	681.3	5.629	2019	375.6
21	225.8	8296	790.1	6.062	2174	404.5
22-1/2	241.9	10200	907.0	6.495	2329	433.4
24	258.0	12380	1032	6.928	2485	462.3
25-1/2	274.1	14850	1165	7.361	2640	491.1
27	290.3	17630	1306	7.794	2795	520.0
28-1/2	306.4	20740	1455	8.227	2950	548.9
30	322.5	24190	1613	8.660	3106	577.8
31-1/2	338.6	28000	1778	9.093	3261	606.7
33	354.8	32190	1951	9.526	3416	635.6
34-1/2	370.9	36790	2133	9.959	3572	664.5
36	387.0	41800	2322	10.39	3727	693.4
37-1/2	403.1	47240	2520	10.83	3882	722.3
39	419.3	53140	2725	11.26	4037	751.2
40-1/2	435.4	59510	2939	11.69	4193	780.0
42	451.5	66370	3161	12.12	4348	808.9
43-1/2	467.6	73740	3390	12.56	4503	837.8
45	483.8	81630	3628	12.99	4659	866.7
46-1/2	499.9	90070	3874	13.42	4814	895.6
48	516.0	99070	4128	13.86	4969	924.5
49-1/2	532.1	108700	4390	14.29	5124	953.4
51	548.3	118800	4660	14.72	5280	982.3
52-1/2	564.4	129600	4938	15.16	5435	1011
54	580.5	141100	5225	15.59	5590	1040
55-1/2	596.6	153100	5519	16.02	5746	1069
57	612.8	165900	5821	16.45	5901	1098
58-1/2	628.9	179300	6132	16.89	6056	1127
60	645.0	193500	6450	17.32	6211	1156

Table 9.1 Section Properties for Western Species Glued Laminated Timber (Cont.)

Depth d (in.)	Area A (in. ²)	X-X Axis			Y-Y Axis	
		I _x (in. ⁴)	S _x (in. ³)	r _x (in.)	I _y (in. ⁴)	S _y (in. ³)
12-1/4 in. Width (r_y = 3.536 in.)						
13-1/2	165.4	2512	372.1	3.897	2068	337.6
15	183.8	3445	459.4	4.330	2298	375.2
16-1/2	202.1	4586	555.8	4.763	2528	412.7
18	220.5	5954	661.5	5.196	2757	450.2
19-1/2	238.9	7569	776.3	5.629	2987	487.7
21	257.3	9454	900.4	6.062	3217	525.2
22-1/2	275.6	11630	1034	6.495	3447	562.7
24	294.0	14110	1176	6.928	3677	600.3
25-1/2	312.4	16930	1328	7.361	3906	637.8
27	330.8	20090	1488	7.794	4136	675.3
28-1/2	349.1	23630	1658	8.227	4366	712.8
30	367.5	27560	1838	8.660	4596	750.3
31-1/2	385.9	31910	2026	9.093	4825	787.8
33	404.3	36690	2223	9.526	5055	825.3
34-1/2	422.6	41920	2430	9.959	5285	862.9
36	441.0	47630	2646	10.39	5515	900.4
37-1/2	459.4	53830	2871	10.83	5745	937.9
39	477.8	60550	3105	11.26	5974	975.4
40-1/2	496.1	67810	3349	11.69	6204	1013
42	514.5	75630	3602	12.12	6434	1050
43-1/2	532.9	84030	3863	12.56	6664	1088
45	551.3	93020	4134	12.99	6893	1125
46-1/2	569.6	102600	4415	13.42	7123	1163
48	588.0	112900	4704	13.86	7353	1201
49-1/2	606.4	123800	5003	14.29	7583	1238
51	624.8	135400	5310	14.72	7813	1276
52-1/2	643.1	147700	5627	15.16	8042	1313
54	661.5	160700	5954	15.59	8272	1351
55-1/2	679.9	174500	6289	16.02	8502	1388
57	698.3	189100	6633	16.45	8732	1426
58-1/2	716.6	204400	6987	16.89	8962	1463
60	735.0	220500	7350	17.32	9191	1501

Table 9.2 Section Properties for Southern Pine Glued Laminated Timber

Depth d (in.)	Area A (in. ²)	X-X Axis			Y-Y Axis	
		I _x (in. ⁴)	S _x (in. ³)	r _x (in.)	I _y (in. ⁴)	S _y (in. ³)
2-1/2 in. Width (r_y = 0.722 in.)						
5-1/2	13.75	34.66	12.60	1.588	7.161	5.729
6-7/8	17.19	67.70	19.69	1.985	8.952	7.161
8-1/4	20.63	117.0	28.36	2.382	10.74	8.594
9-5/8	24.06	185.8	38.60	2.778	12.53	10.03
11	27.50	277.3	50.42	3.175	14.32	11.46
12-3/8	30.94	394.8	63.81	3.572	16.11	12.89
13-3/4	34.38	541.6	78.78	3.969	17.90	14.32
15-1/8	37.81	720.9	95.32	4.366	19.69	15.76
16-1/2	41.25	935.9	113.4	4.763	21.48	17.19
17-7/8	44.69	1190	133.1	5.160	23.27	18.62
19-1/4	48.13	1486	154.4	5.557	25.07	20.05
20-5/8	51.56	1828	177.2	5.954	26.86	21.48
22	55.00	2218	201.7	6.351	28.65	22.92
23-3/8	58.44	2661	227.7	6.748	30.44	24.35
3 in. Width (r_y = 0.866 in.)						
5-1/2	16.50	41.59	15.13	1.588	12.38	8.250
6-7/8	20.63	81.24	23.63	1.985	15.47	10.31
8-1/4	24.75	140.4	34.03	2.382	18.56	12.38
9-5/8	28.88	222.9	46.32	2.778	21.66	14.44
11	33.00	332.8	60.50	3.175	24.75	16.50
12-3/8	37.13	473.8	76.57	3.572	27.84	18.56
13-3/4	41.25	649.9	94.53	3.969	30.94	20.63
15-1/8	45.38	865.0	114.4	4.366	34.03	22.69
16-1/2	49.50	1123	136.1	4.763	37.13	24.75
17-7/8	53.63	1428	159.8	5.160	40.22	26.81
19-1/4	57.75	1783	185.3	5.557	43.31	28.88
20-5/8	61.88	2193	212.7	5.954	46.41	30.94
22	66.00	2662	242.0	6.351	49.50	33.00
23-3/8	70.13	3193	273.2	6.748	52.59	35.06
3-1/8 in. Width (r_y = 0.902 in.)						
5-1/2	17.19	17.19	43.33	15.76	13.99	8.952
6 7/8	21.48	21.48	84.62	24.62	17.48	11.19
8-1/4	25.78	25.78	146.2	35.45	20.98	13.43
9-5/8	30.08	30.08	232.2	48.25	24.48	15.67
11	34.38	34.38	346.6	63.02	27.97	17.90
12-3/8	38.67	38.67	493.5	79.76	31.47	20.14
13-3/4	42.97	42.97	677.0	98.47	34.97	22.38
15-1/8	47.27	47.27	901.1	119.1	38.46	24.62
16-1/2	51.56	51.56	1170	141.8	41.96	26.86
17-7/8	55.86	55.86	1487	166.4	45.46	29.09
19-1/4	60.16	60.16	1858	193.0	48.96	31.33
20-5/8	64.45	64.45	2285	221.6	52.45	33.57
22	68.75	68.75	2773	252.1	55.95	35.81
23-3/8	73.05	73.05	3326	284.6	59.45	38.05

Table 9.2 Section Properties for Southern Pine Glued Laminated Timber (Cont.)

Depth d (in.)	Area A (in. ²)	X-X Axis			Y-Y Axis	
		I _x (in. ⁴)	S _x (in. ³)	r _x (in.)	I _y (in. ⁴)	S _y (in. ³)
3-1/2 in. Width (r_y = 1.010 in.)						
5-1/2	19.25	48.53	17.65	1.588	19.65	11.23
6-7/8	24.06	94.78	27.57	1.985	24.56	14.04
8-1/4	28.88	163.8	39.70	2.382	29.48	16.84
9-5/8	33.69	260.1	54.04	2.778	34.39	19.65
11	38.50	388.2	70.58	3.175	39.30	22.46
12-3/8	43.31	552.7	89.33	3.572	44.21	25.27
13-3/4	48.13	758.2	110.3	3.969	49.13	28.07
15-1/8	52.94	1009	133.4	4.366	54.04	30.88
16-1/2	57.75	1310	158.8	4.763	58.95	33.69
17-7/8	62.56	1666	186.4	5.160	63.87	36.49
19-1/4	67.38	2081	216.2	5.557	68.78	39.30
20-5/8	72.19	2559	248.1	5.954	73.69	42.11
22	77.00	3106	282.3	6.351	78.60	44.92
23-3/8	81.81	3725	318.7	6.748	83.52	47.72
5 in. Width (r_y = 1.443 in.)						
6-7/8	34.38	135.4	39.39	1.985	71.61	28.65
8-1/4	41.25	234.0	56.72	2.382	85.94	34.38
9-5/8	48.13	371.5	77.20	2.778	100.3	40.10
11	55.00	554.6	100.8	3.175	114.6	45.83
12-3/8	61.88	789.6	127.6	3.572	128.9	51.56
13-3/4	68.75	1083	157.6	3.969	143.2	57.29
15-1/8	75.63	1442	190.6	4.366	157.6	63.02
16-1/2	82.50	1872	226.9	4.763	171.9	68.75
17-7/8	89.38	2380	266.3	5.160	186.2	74.48
19-1/4	96.25	2972	308.8	5.557	200.5	80.21
20-5/8	103.1	3656	354.5	5.954	214.8	85.94
22	110.0	4437	403.3	6.351	229.2	91.67
23-3/8	116.9	5322	455.3	6.748	243.5	97.40
24-3/4	123.8	6317	510.5	7.145	257.8	103.1
26-1/8	130.6	7429	568.8	7.542	272.1	108.9
27-1/2	137.5	8665	630.2	7.939	286.5	114.6
28-7/8	144.4	10030	694.8	8.335	300.8	120.3
30-1/4	151.3	11530	762.6	8.732	315.1	126.0
31-5/8	158.1	13180	833.5	9.129	329.4	131.8
33	165.0	14970	907.5	9.526	343.8	137.5
34-3/8	171.9	16920	984.7	9.923	358.1	143.2
35-3/4	178.8	19040	1065	10.32	372.4	149.0

Table 9.2 Section Properties for Southern Pine Glued Laminated Timber (Cont.)

Depth d (in.)	Area A (in. ²)	X-X Axis			Y-Y Axis	
		I _x (in. ⁴)	S _x (in. ³)	r _x (in.)	I _y (in. ⁴)	S _y (in. ³)
5-1/8 in. Width (r_y = 1.479 in.)						
6-7/8	35.23	138.8	40.37	1.985	77.12	30.10
8-1/4	42.28	239.8	58.14	2.382	92.55	36.12
9-5/8	49.33	380.8	79.13	2.778	108.0	42.13
11	56.38	568.4	103.4	3.175	123.4	48.15
12-3/8	63.42	809.4	130.8	3.572	138.8	54.17
13-3/4	70.47	1110	161.5	3.969	154.2	60.19
15-1/8	77.52	1478	195.4	4.366	169.7	66.21
16-1/2	84.56	1919	232.5	4.763	185.1	72.23
17-7/8	91.61	2439	272.9	5.160	200.5	78.25
19-1/4	98.66	3047	316.5	5.557	215.9	84.27
20-5/8	105.7	3747	363.4	5.954	231.4	90.29
22	112.8	4548	413.4	6.351	246.8	96.31
23-3/8	119.8	5455	466.7	6.748	262.2	102.3
24-3/4	126.8	6475	523.2	7.145	277.6	108.3
26-1/8	133.9	7615	583.0	7.542	293.1	114.4
27-1/2	140.9	8882	646	7.939	308.5	120.4
28-7/8	148.0	10280	712.2	8.335	323.9	126.4
30-1/4	155.0	11820	781.6	8.732	339.3	132.4
31-5/8	162.1	13510	854.3	9.129	354.8	138.4
33	169.1	15350	930.2	9.526	370.2	144.5
34-3/8	176.2	17350	1009	9.923	385.6	150.5
35-3/4	183.2	19510	1092	10.32	401.0	156.5
5-1/2 in. Width (r_y = 1.588 in.)						
6-7/8	37.81	148.9	43.33	1.985	95.32	34.66
8-1/4	45.38	257.4	62.39	2.382	114.4	41.59
9-5/8	52.94	408.7	84.92	2.778	133.4	48.53
11	60.50	610.0	110.9	3.175	152.5	55.46
12-3/8	68.06	868.6	140.4	3.572	171.6	62.39
13-3/4	75.63	1191	173.3	3.969	190.6	69.32
15-1/8	83.19	1586	209.7	4.366	209.7	76.26
16-1/2	90.75	2059	249.6	4.763	228.8	83.19
17-7/8	98.31	2618	292.9	5.160	247.8	90.12
19-1/4	105.9	3269	339.7	5.557	266.9	97.05
20-5/8	113.4	4021	389.9	5.954	286.0	104.0
22	121.0	4880	443.7	6.351	305.0	110.9
23-3/8	128.6	5854	500.9	6.748	324.1	117.8
24-3/4	136.1	6949	561.5	7.145	343.1	124.8
26-1/8	143.7	8172	625.6	7.542	362.2	131.7
27-1/2	151.3	9532	693.2	7.939	381.3	138.6
28-7/8	158.8	11030	764.3	8.335	400.3	145.6
30-1/4	166.4	12690	838.8	8.732	419.4	152.5
31-5/8	173.9	14500	916.8	9.129	438.5	159.4
33	181.5	16470	998.3	9.526	457.5	166.4
34-3/8	189.1	18620	1083	9.923	476.6	173.3
35-3/4	196.6	20940	1172	10.32	495.7	180.2

Table 9.2 Section Properties for Southern Pine Glued Laminated Timber (Cont.)

Depth d (in.)	Area A (in. ²)	X-X Axis			Y-Y Axis	
		I _x (in. ⁴)	S _x (in. ³)	r _x (in.)	I _y (in. ⁴)	S _y (in. ³)
6-3/4 in. Width (r_y = 1.949 in.)						
6-7/8	46.41	182.8	53.17	1.985	176.2	52.21
8-1/4	55.69	315.9	76.57	2.382	211.4	62.65
9-5/8	64.97	501.6	104.2	2.778	246.7	73.09
11	74.25	748.7	136.1	3.175	281.9	83.53
12-3/8	83.53	1066	172.3	3.572	317.2	93.97
13-3/4	92.81	1462	212.7	3.969	352.4	104.4
15-1/8	102.1	1946	257.4	4.366	387.6	114.9
16-1/2	111.4	2527	306.3	4.763	422.9	125.3
17-7/8	120.7	3213	359.5	5.160	458.1	135.7
19-1/4	129.9	4012	416.9	5.557	493.4	146.2
20-5/8	139.2	4935	478.6	5.954	528.6	156.6
22	148.5	5990	544.5	6.351	563.8	167.1
23-3/8	157.8	7184	614.7	6.748	599.1	177.5
24-3/4	167.1	8528	689.1	7.145	634.3	187.9
26-1/8	176.3	10030	767.8	7.542	669.6	198.4
27-1/2	185.6	11700	850.8	7.939	704.8	208.8
28-7/8	194.9	13540	938.0	8.335	740.0	219.3
30-1/4	204.2	15570	1029	8.732	775.3	229.7
31-5/8	213.5	17790	1125	9.129	810.5	240.2
33	222.8	20210	1225	9.526	845.8	250.6
34-3/8	232.0	22850	1329	9.923	881.0	261.0
35-3/4	241.3	25700	1438	10.32	916.2	271.5
37-1/8	250.6	28780	1551	10.72	951.5	281.9
38-1/2	259.9	32100	1668	11.11	986.7	292.4
39-7/8	269.2	35660	1789	11.51	1022	302.8
41-1/4	278.4	39480	1914	11.91	1057	313.2
42-5/8	287.7	43560	2044	12.30	1092	323.7
44	297.0	47920	2178	12.70	1128	334.1
45-3/8	306.3	52550	2316	13.10	1163	344.6
46-3/4	315.6	57470	2459	13.50	1198	355.0
48-1/8	324.8	62700	2606	13.89	1233	365.4
49-1/2	334.1	68220	2757	14.29	1269	375.9
50-7/8	343.4	74070	2912	14.69	1304	386.3
52-1/4	352.7	80240	3071	15.08	1339	396.8
53-5/8	362.0	86740	3235	15.48	1374	407.2
55	371.3	93590	3403	15.88	1410	417.7
56-3/8	380.5	100800	3575	16.27	1445	428.1
57-3/4	389.8	108300	3752	16.67	1480	438.5
59-1/8	399.1	116300	3933	17.07	1515	449.0
60-1/2	408.4	124600	4118	17.46	1551	459.4

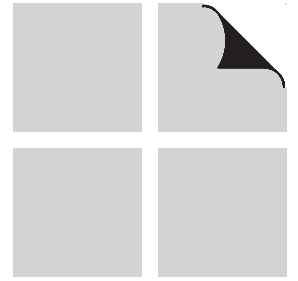
Table 9.2 Section Properties for Southern Pine Glued Laminated Timber (Cont.)

Depth d (in.)	Area A (in. ²)	X-X Axis			Y-Y Axis	
		I _x (in. ⁴)	S _x (in. ³)	r _x (in.)	I _y (in. ⁴)	S _y (in. ³)
8 1/2 in. Width (r_y = 2.454 in.)						
9-5/8	81.81	631.6	131.2	2.778	492.6	115.9
11	93.50	942.8	171.4	3.175	562.9	132.5
12-3/8	105.2	1342	216.9	3.572	633.3	149.0
13-3/4	116.9	1841	267.8	3.969	703.7	165.6
15-1/8	128.6	2451	324.1	4.366	774.1	182.1
16-1/2	140.3	3182	385.7	4.763	844.4	198.7
17-7/8	151.9	4046	452.6	5.160	914.8	215.2
19-1/4	163.6	5053	525.0	5.557	985.2	231.8
20-5/8	175.3	6215	602.6	5.954	1056	248.4
22	187.0	7542	685.7	6.351	1126	264.9
23-3/8	198.7	9047	774.1	6.748	1196	281.5
24-3/4	210.4	10740	867.8	7.145	1267	298.0
26-1/8	222.1	12630	966.9	7.542	1337	314.6
27-1/2	233.8	14730	1071	7.939	1407	331.1
28-7/8	245.4	17050	1181	8.335	1478	347.7
30-1/4	257.1	19610	1296	8.732	1548	364.3
31-5/8	268.8	22400	1417	9.129	1618	380.8
33	280.5	25460	1543	9.526	1689	397.4
34-3/8	292.2	28770	1674	9.923	1759	413.9
35-3/4	303.9	32360	1811	10.32	1830	430.5
37-1/8	315.6	36240	1953	10.72	1900	447.0
38-1/2	327.3	40420	2100	11.11	1970	463.6
39-7/8	338.9	44910	2253	11.51	2041	480.2
41-1/4	350.6	49720	2411	11.91	2111	496.7
42-5/8	362.3	54860	2574	12.30	2181	513.3
44	374.0	60340	2743	12.70	2252	529.8
45-3/8	385.7	66170	2917	13.10	2322	546.4
46-3/4	397.4	72370	3096	13.50	2393	562.9
48-1/8	409.1	78950	3281	13.89	2463	579.5
49-1/2	420.8	85910	3471	14.29	2533	596.1
50-7/8	432.4	93270	3667	14.69	2604	612.6
52-1/4	444.1	101000	3868	15.08	2674	629.2
53-5/8	455.8	109200	4074	15.48	2744	645.7
55	467.5	117800	4285	15.88	2815	662.3
56-3/8	479.2	126900	4502	16.27	2885	678.8
57-3/4	490.9	136400	4725	16.67	2955	695.4
59-1/8	502.6	146400	4952	17.07	3026	712.0
60-1/2	514.3	156900	5185	17.46	3096	728.5

Table 9.2 Section Properties for Southern Pine Glued Laminated Timber (Cont.)

Depth d (in.)	Area A (in. ²)	X-X Axis			Y-Y Axis	
		I _x (in. ⁴)	S _x (in. ³)	r _x (in.)	I _y (in. ⁴)	S _y (in. ³)
10-1/2 in. Width (r_y = 3.031 in.)						
11	115.5	1165	211.8	3.175	1061	202.1
12-3/8	129.9	1658	268.0	3.572	1194	227.4
13-3/4	144.4	2275	330.9	3.969	1326	252.7
15-1/8	158.8	3028	400.3	4.366	1459	277.9
16-1/2	173.3	3931	476.4	4.763	1592	303.2
17-7/8	187.7	4997	559.2	5.160	1724	328.5
19-1/4	202.1	6242	648.5	5.557	1857	353.7
20-5/8	216.6	7677	744.4	5.954	1990	379.0
22	231.0	9317	847.0	6.351	2122	404.3
23-3/8	245.4	11180	956.2	6.748	2255	429.5
24-3/4	259.9	13270	1072	7.145	2388	454.8
26-1/8	274.3	15600	1194	7.542	2520	480.0
27-1/2	288.8	18200	1323	7.939	2653	505.3
28-7/8	303.2	21070	1459	8.335	2786	530.6
30-1/4	317.6	24220	1601	8.732	2918	555.8
31-5/8	332.1	27680	1750	9.129	3051	581.1
33	346.5	31440	1906	9.526	3183	606.4
34-3/8	360.9	35540	2068	9.923	3316	631.6
35-3/4	375.4	39980	2237	10.32	3449	656.9
37-1/8	389.8	44770	2412	10.72	3581	682.2
38-1/2	404.3	49930	2594	11.11	3714	707.4
39-7/8	418.7	55480	2783	11.51	3847	732.7
41-1/4	433.1	61420	2978	11.91	3979	758.0
42-5/8	447.6	67760	3180	12.30	4112	783.2
44	462.0	74540	3388	12.70	4245	808.5
45-3/8	476.4	81740	3603	13.10	4377	833.8
46-3/4	490.9	89400	3825	13.50	4510	859.0
48-1/8	505.3	97530	4053	13.89	4643	884.3
49-1/2	519.8	106100	4288	14.29	4775	909.6
50-7/8	534.2	115200	4529	14.69	4908	934.8
52-1/4	548.6	124800	4778	15.08	5040	960.1
53-5/8	563.1	134900	5032	15.48	5173	985.4
55	577.5	145600	5294	15.88	5306	1011
56-3/8	591.9	156800	5562	16.27	5438	1036
57-3/4	606.4	168500	5836	16.67	5571	1061
59-1/8	620.8	180900	6118	17.07	5704	1086
60-1/2	635.3	193800	6405	17.46	5836	1112

SUPPLEMENT
**Timber Poles
and Piles**



A S D

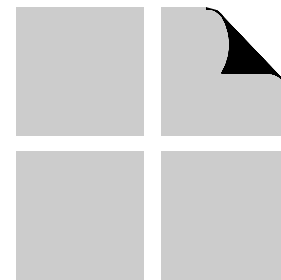
ALLOWABLE | STRESS | DESIGN

**MANUAL FOR ENGINEERED
WOOD CONSTRUCTION**

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Forest &
Paper
Association**

American Wood Council

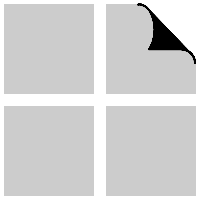
SUPPLEMENT
Timber Poles
and Piles



A S D

ALLOWABLE STRESS DESIGN

**MANUAL FOR ENGINEERED
WOOD CONSTRUCTION**



Preface

This Supplement contains adjustment factors, dimensions, allowable design capacities, tabulated design values, and other properties required to design timber poles and piles in ASD format.

Allowable design capacities tabulated in this supplement are to be used in conjunction with design methodologies provided in ANSI/AF&PA NDS-2001 *National Design Specification*[®] (*NDS*[®]) for Wood Construction.

Tabulated design values were derived according to the principles of ASTM D2899-95 *Establishing Design Stresses for Round Timber Piles*.

Tabulated design values are to be used within the reference end-use conditions defined therein. When end-use conditions fall outside the range of reference conditions, the tabulated design values shall be adjusted by the product of applicable adjustment factors as defined in *NDS* and also provided in this Supplement. For unusual end-use conditions, the designer should consult additional literature for possible further adjustments.

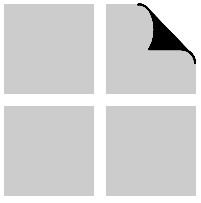


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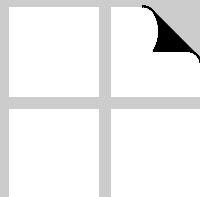
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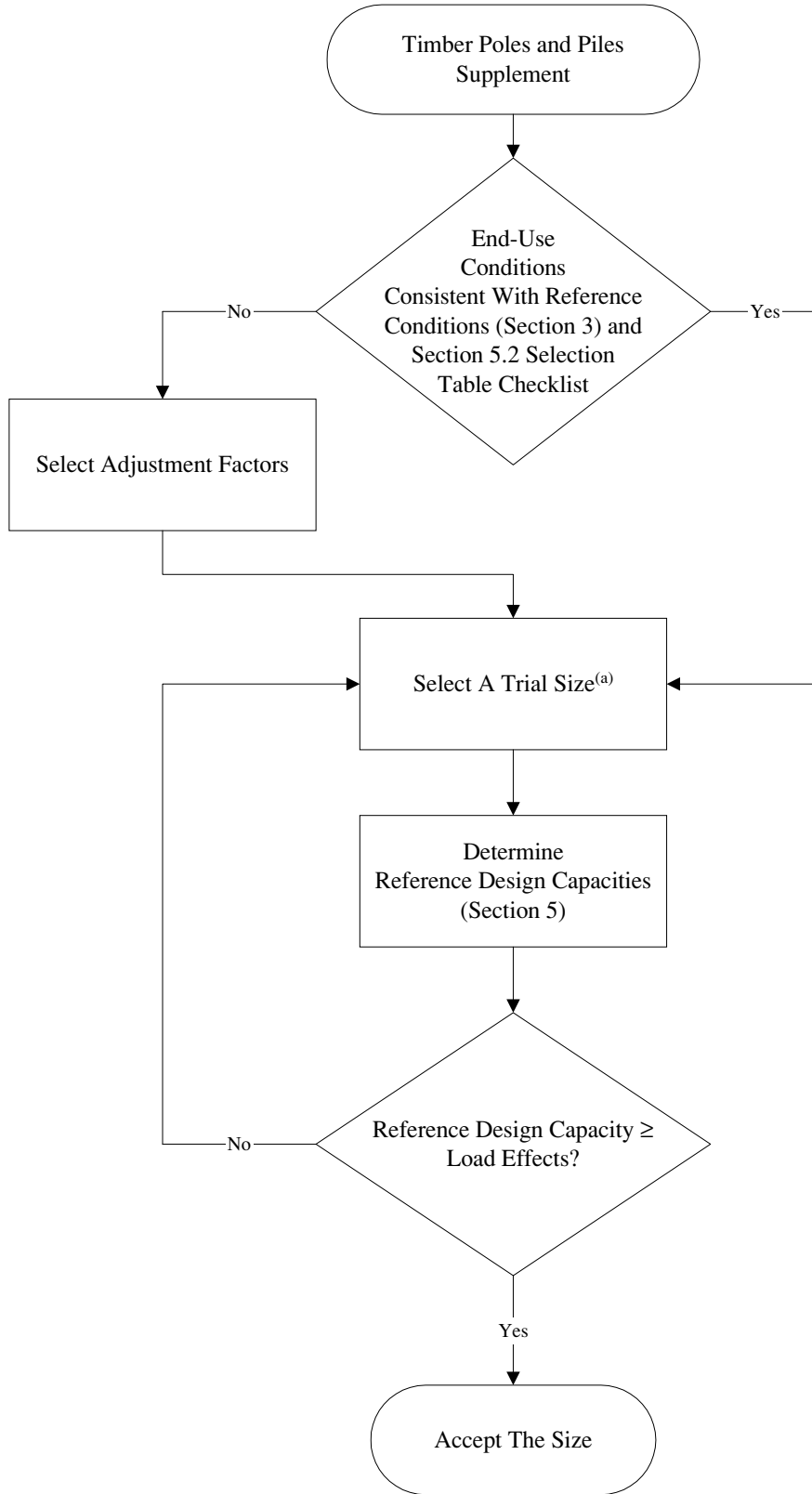
DESIGNER FLOWCHART

1.1 Flowchart

PP-2



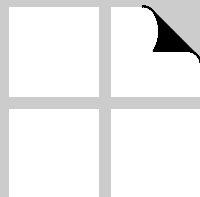
1.1 Flowchart



^(a) Tables 4.1 and 4.2 provide tabulated design values for various poles and piles. This information could be used in conjunction with Tables 5.1 through 5.11 to determine the trial size.

INTRODUCTION TO TIMBER POLES AND PILES

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2.1 Product Information

A **pole** is a round, tapered timber with its larger (butt) end embedded in the ground. A **pile** is a round, tapered timber with its small (tip) end embedded in the ground. The tabulated values and adjustment factors shall be used according to these definitions.

This Supplement provides tabulated design values, F , tabulated modulus of elasticity, E , and tabulated design capacities for poles graded according to ASTM D3200 and for piles graded according to ASTM D25 specifications.

2.2 Common Uses

Timber poles are used extensively in Post-Frame construction and are also used architecturally. This Supplement is not for use with poles used in the support of utility lines. Timber piles are generally used as part of foundation systems.

Timber poles and piles offer many advantages relative to competing materials. As with other wood products, timber poles and piles offer the unique advantage of

being the only major construction material that is a renewable resource. Additional information regarding the environmental advantages of wood is provided on the inside cover of this Supplement.

2.3 Availability

Timber piles are typically available in four species: Pacific Coast Douglas-Fir, Southern Pine, Red Oak, and Red Pine. However, local pile suppliers should be contacted because availability is dependent upon geographic locations.

Timber poles are supplied to the utility industry in a variety of grades and species. Because these poles are graded according to ANSI 05.1, Specifications and Dimensions for Wood Poles, they must be regraded accord-

ing to ASTM D3200 if they are to be used with this Supplement.

The organizations listed below can provide additional information regarding pole and pile availability:

Western Wood Preservers Institute
(360) 693-9958
American Wood Products Institute
1-800-356-AWPI

DESIGN ADJUSTMENT FACTORS

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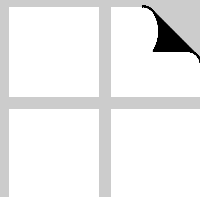
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3.1 General

Two alternative approaches may be used to generate member design capacity — the calculation method, in which tabulated design values are multiplied by adjustment factors and section properties to obtain member capacity, and the tabulation method, in which tabulated values are fully adjusted for a given set of conditions.

The selection tables in Chapter 5 include pre-calculated ASD capacities for members under “standard” (reference) conditions of use. For conditions that fall outside the reference conditions, an alternative approach permits the use of tabulated design values (from Chapter 4), modified appropriately by the adjustment factors included in this Chapter.

The adjustment factors provided in this Chapter are for applications outside the reference end-use conditions and for member configuration effects (i.e., size, lateral support conditions, etc.). When one or more of the specific end-use or member configuration conditions fall outside the range of the reference conditions defined in Section 2.2 and 6.3 of *NDS*, these adjustment factors shall be used to modify the appropriate properties. Adjustment factors for the effects of moisture, temperature, preservative treatment, member configuration and size are provided in this Supplement. Table 3.1 specifies adjustment factors which apply to each tabulated design value.

3.2 Use of Adjustment Factors

3.2.1 Bending (Moment and Shear)

Allowable moment and shear design capacity is based upon the following equations:

For moment:

$$M' = F'_b S$$

For shear:

$$V' = \frac{F'_v I b}{Q} \text{ for round sections } V' = \frac{3F'_v A}{4}$$

where:

$$F'_b = F_b (C_D C_F C_t C_u C_{sp})$$

$$F'_v = F_v (C_D C_t C_u)$$

and where:

- C_D is 1.0 for poles and piles under normal load duration (10 years) and as shown in Table 3.2 otherwise.
- C_t is 1.0 up to 100°F and otherwise as shown in Table 3.2. See 3.2.5.
- C_F is 1.0 for piles with circumferences less than or equal to 43" and as given in *NDS* section 6.3.7 otherwise.

C_u is 1.0 for poles and piles treated in conjunction with a steam conditioning or Boultonizing and as shown in Table 3.4 otherwise. See 3.2.6.

C_{sp} is 1.0 for piles used in a load sharing system such as a pile cluster and as shown in Table 3.5 for a pile supporting its own load individually. See 3.2.7.

3.2.2 Compression

The allowable compression design capacity is computed as follows:

$$P' = F'_c A$$

where:

$$F'_c = F_c (C_D C_t C_u C_{sp} C_P C_{cs})$$

and where:

- C_P is 1.0 for fully supported or “zero length” columns and as given in *NDS* section 3.7.1 otherwise.
- C_{cs} is 1.0 for compression parallel to grain strength at the tip of a pole or pile and increased as shown in Table 3.6 to account for strength increases as the critical section becomes further from the tip. See 3.2.8.

3.2.3 Bearing

For parallel to grain (end bearing):

Allowable bearing design capacity parallel to grain for timber poles are computed based upon the following equations:

$$P'_g = F'_g A$$

where:

$$F'_g = F_g (C_D C_t C_u)$$

For perpendicular to grain:

Allowable bearing design capacity perpendicular to grain for timber poles and piles:

$$P'_\perp = F_{c\perp} A$$

where:

$$F_{c\perp} = F_{c\perp} (C_t C_u C_b)$$

C_b is 1.0 for bearings of any length at the ends of a member, and to all bearings 6" or more in length at any other location, and as stated in 3.2.9 otherwise.

3.2.4 Load Duration Factor, C_D

All tabulated design values except modulus of elasticity, E , shall be multiplied by load duration factors, C_D , as specified in 2.3.2 of *NDS* (see Table 3.2). Load duration factors greater than 1.6 shall not apply to structural members pressure-treated with water-borne preservatives

or fire retardant chemicals. The impact load duration factor shall not apply to connections.

3.2.5 Temperature Effect Factor, C_t

End-use temperature conditions, other than those defined in Section 2.3.4 of *NDS*, require use of the temperature effect factor, C_t . Temperature effect factors for poles and piles exposed to sustained temperatures between the range of 100°F to 150°F are provided in Table 3.3.

3.2.6 Untreated Factor, C_u

If preservative treatment is necessary, poles and piles shall be treated in accordance with American Wood Preservers Association standards. The Untreated Factors provided in Table 3.4 apply for poles and piles that are either air-dried prior to treatment or are not treated.

3.2.7 Single Pile Factor, C_{sp}

Tabulated compression parallel to grain and bending design values for timber piles assume use of piles in clusters. The corresponding single pile (load sharing) factor is 1.0. For design of single piles, reduction factors provided in Table 3.5 shall be applied.

3.2.8 Critical Section Factor, C_{cs}

Tabulated compression parallel to grain design values at the tip of a pole or pile shall be permitted to be increased as shown in Table 3.6 to account for strength

Table 3.1 Applicability of Adjustment Factors for Poles and Piles

	Load Duration Factor	Temperature Factor	Untreated Factor	Size Factor	Single Pile Factor	Column Stability Factor	Critical Section Factor	Bearing Area Factor
$F'_c = F_c$	C_D	C_t	C_u	—	C_{sp}	C_P	C_{cs}	—
$F'_b = F_b$	C_D	C_t	C_u	C_F	C_{sp}	—	—	—
$F'_v = F_v$	C_D	C_t	C_u	—	—	—	—	—
$F'_{c\perp} = F_{c\perp}$	—	C_t	C_u	—	—	—	—	C_b
$E' = E$	—	C_t	—	—	—	—	—	—
$F'_g = F_g$	C_D	C_t	C_u	—	—	—	—	—

increases as the critical section becomes further from the tip. Critical section factors, C_{cs} , are independent of tapered column provisions in Section 3.7.2 of *NDS* and both shall be permitted to be used in design calculations.

3.2.9 Bearing Area Factor, C_b

Tabulated compression design values perpendicular to grain, $F_{c\perp}$, for timber poles and piles shall be permitted to be multiplied by the bearing area factor, C_b , specified in *NDS* section 2.3.10. Table 3.7 provides bearing

area factors for the indicated bearing length on such small areas as plates and washers.

3.2.10 Wet Service Factor, C_M

Tabulated design values apply to wet or dry service conditions.

Table 3.2 Frequently Used Load Duration Factors, C_D ¹

Load Duration	C_D	Typical Design Loads
Permanent	0.9	Dead Load
Ten years	1.0	Occupancy Live Load
Two months	1.15	Snow Load
Seven days	1.25	Construction Load
Ten minutes	1.6	Wind/Earthquake Load
Impact ²	2.0	Impact Load

- ¹ Load duration factors shall not apply to modulus of elasticity, E , nor to compression perpendicular to grain design values, $F_{c\perp}$, based on a deformation limit.
² Load duration factors greater than 1.6 shall not apply to structural members pressure-treated with water-borne preservatives or fire retardant chemicals. The impact load duration factor shall not apply to connections.

Table 3.3 Temperature Effect Factor, C_t , for Poles and Piles Exposed to Sustained Elevated Temperatures

Design Values	In Service Moisture Condition	C_t	
		100<F°≤125	125<F°≤150
E	Dry	0.9	0.9
	Wet	0.9	0.9
Other Properties and Connections	Dry	0.8	0.7
	Wet	0.7	0.5

Table 3.4 Untreated Factor, C_u , for Poles and Piles that are Either Air-Dried Before Treating or are not Treated at All

Species	C_u	
	Strength	Stiffness
Southern Pine	1.18	1.0
Others	1.11	1.0

Table 3.5 Single Pile Factors, C_{sp} , for Round Timber Piles

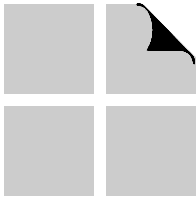
Reference Resistance	C_{sp}	
	Pile Cluster	Single Pile
F_b	1.0	0.77
F_c	1.0	0.80

Table 3.6 Compression Parallel to Grain Critical Section Modification Factor, C_{cs} , for Poles and Piles

Species	C_{cs}
	Pile Cluster
Pacific Coast Douglas-Fir, Southern Pine	$1 + 0.002L$, where L = length (ft.) from tip to critical section. Note C_{cs} shall not exceed 1.10.
Other Species	1.0

Table 3.7 Bearing Area Factors, C_b , for Poles and Piles

l_b	0.5"	1"	1.5"	2"	3"	4"	6" or more
C_b	1.75	1.38	1.25	1.19	1.13	1.10	1.00

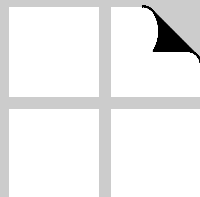


DESIGN VALUES

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Table 4.1 Design Values for Poles Graded in Accordance with ASTM D3200 PP-13

Table 4.2 Design Values for Treated Round Timber Piles Graded in Accordance with ASTM D25 PP-13



4.1 General

The tables in this Chapter provide design values for timber pole and pile members. These design values are used when manual calculation of member strength is required and shall be used in conjunction with adjustment factors specified in Chapter 3.

4.2 Tables of Design Values

4.2.1 Pole Design Values

Design values for poles are provided in Table 4.1. These values, with the exception of F_c , are applicable for all locations in the pole. The F_c values are for the tip of the pole and can be increased for Pacific Coast Douglas-Fir and Southern Pine poles in accordance with Table 3.6.

Design values are applicable for wet exposure and for poles treated with a steam conditioning or Boultonizing process. For poles that are not treated, or are air-dried or kiln-dried prior to treating, the factors in Table 3.4 shall be applied.

4.2.2 Pile Design Values

Design values for piles are provided in Table 4.2. These values, with the exception of F_c , are applicable at any location along the length of the pile. The tabulated F_c values for Pacific Coast Douglas-Fir and Southern Pine may be increased for locations other than the tip as provided by Table 3.6.

Design values in Table 4.2 are applicable for wet exposures. These tabulated values are given for air-dried piles treated with a preservative using a steam conditioning or Boultonizing processes. For piles that are not treated, or are air-dried or kiln-dried prior to treating, the factors in Table 3.4 shall be applied.

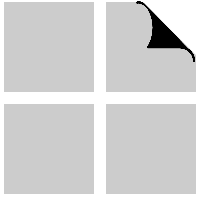
Table 4.1 Design Values for Poles Graded in Accordance with ASTM D3200

Species	Design values in pounds per square inch (psi)					
	Bending	Shear	Compression perpendicular to grain	Compression parallel to grain	Bearing	Modulus of Elasticity
	F _b	F _v	F _{c⊥}	F _c	F _g	E
Pacific Coast Douglas-Fir	1850	115	375	1000	1200	1,500,000
Jack Pine	1500	95	280	800	875	1,070,000
Lodgepole Pine	1350	85	240	700	875	1,080,000
Northern White Cedar	1050	80	225	525	675	640,000
Ponderosa Pine	1300	90	320	650	825	1,000,000
Red Pine	1450	85	265	725	800	1,280,000
Southern Pine	1700	105	320	900	1125	1,400,000
Western Hemlock	1650	115	245	900	950	1,310,000
Western Larch	2050	120	375	1075	1125	1,460,000
Western Red Cedar	1350	95	255	750	1200	940,000

Table 4.2 Design Values for Treated Round Timber Piles Graded in Accordance with ASTM D25

Species	Design values in pounds per square inch (psi)				
	F _c	F _b	F _v	F _{c⊥}	E
Pacific Coast Douglas Fir ¹	1250	2450	115	230	1,500,000
Red Oak ²	1100	2450	135	350	1,250,000
Red Pine ³	900	1900	85	155	1,280,000
Southern Pine ⁴	1200	2400	110	250	1,500,000

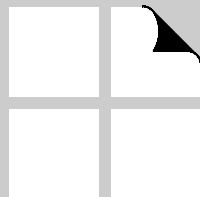
1. Pacific Coast Douglas Fir design values apply to this species as defined in ASTM Standard D1760-86. For connection design use Douglas Fir-Larch design values.
2. Red Oak design values apply to Northern and Southern Red Oak.
3. Red Pine design values apply to Red Pine grown in the United States. For connection design use Northern Pine design values.
4. Southern Pine design values apply to Loblolly, Longleaf, Shortleaf, and Slash Pines.



TIMBER POLE AND PILE SELECTION TABLES

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5.1 General

Pole and pile selection tables provide allowable design capacities that include all factors needed for many common designs. Before using the selection tables, please refer to the checklists to be certain that tabulated values are appropriate for your application.

Refer to the selection table checklist to see whether your design condition meets the assumptions built into the tabulated values. Note that tabulated values include adjustment factors for the assumed design conditions. Thus, the force or moment on the member can be used directly to select a member that meets the design requirement.

5.1.1 Selection Tables for Poles

Tables 5.1 through 5.10 provide allowable moment capacity, M' , for poles at the groundline location preservatively treated according to AWPAs standards. These values apply for wet exposures. However, for poles that are not treated or are air-dried or kiln-dried prior to treatment, the appropriate adjustment factors given in Table 3.4 shall be used. Allowable M' values are applicable only for poles graded in accordance with ASTM D3200. Additionally, M' values apply 3-ft. from the butt of the pole. When the location of maximum stress is not 3-ft. from the butt, M' values shall be adjusted by assuming a linear taper along the pole.

5.1.2 Selection Tables for Piles

Table 5.11 provides allowable compression parallel-to-grain capacity, P' , as a function of ASTM D25 specified pile tip circumference and species. The allowable P' values are applicable only when the pile tip circumference is specified according to Tables 7.2 through 7.6, and the piles are graded according to ASTM D25 specifications. These values do not consider buckling capacity of piles.

As the tip represents the smallest circumference and the lowest strength section of a pile, the P' values are applicable at any other location in the pile. Additional capacity may be computed at other locations by considering the increased cross-sectional area away from the tip using linear taper and specified butt circumference. Further, for Pacific Coast Douglas-Fir and Southern Pine piles, an additional increase in P' may be obtained by the application of the critical section modification factor provided in Table 3.6.

5.2 Selection Table Checklists

Checklist for Poles and Piles:

The selection tables provide values for allowable design capacities for common species, grades, and sizes. Tabulated values apply to members that satisfy the following conditions:

- ✓ “normal” temperature range ($C_t = 1.0$)
- ✓ material treated in an approved process ($C_u = 1.0$)
- ✓ load duration factor based on “wind” (W) load ($C_D = 1.6$) for Poles and “snow” (S) load ($C_D = 1.15$) for Piles
- ✓ compression members fully laterally supported ($C_p = 1.0$)
- ✓ wet or dry service conditions
- ✓ piles in a cluster ($C_{sp} = 1.0$)
- ✓ critical location for compression parallel to grain is the tip for Pacific Coast Douglas-Fir and Southern Pine piles and poles

If the answer to any of these questions is NO, the selection tables should NOT be used directly. For these cases the designer should refer to the flowchart (Chapter 1) and follow the procedures for manual calculation of timber pole or pile capacity.

For manual calculation, two approaches are possible — review the governing design equations and modify the tabulated values as necessary or compute allowable design capacity directly from the tabulated design values and adjustment factors.

To compute allowable design capacity for a specific condition, apply the design equations directly. Design adjustment factors and tabulated design values are provided in Chapters 3 and 4 of this Supplement, respectively.

Table 5.1 Pole Selection Table - Pacific Coast Douglas-FirGraded to ASTM D3200, $C_D=1.6$

Pole Length (ft)	Allowable Moment Capacity ¹ , M' (inch-kips)							
	Minimum Tip Circumference (in.)							
	16	19	22	25	28	31	35	38
10	59.34	93.14	137.83	194.91	265.91	352.35	494.24	618.00
15	72.75	111.08	160.95	223.88	301.39	394.98	547.44	684.50
20	99.80	129.56	184.47	253.05	336.81	437.27	599.82	745.16
25	102.54	149.98	210.18	284.65	374.90	482.47	655.44	809.30
30	121.63	174.41	240.61	321.73	419.30	534.84	719.46	882.83
35	142.95	201.36	273.84	361.90	467.07	590.87	787.52	960.68
40	164.73	228.58	307.11	401.83	514.27	645.94	854.04	1036.49

¹ Allowable moment capacity is three feet from butt with minimum circumferences as specified in Table 7.1.**Table 5.2 Pole Selection Table - Jack Pine**Graded to ASTM D3200, $C_D=1.6$

Pole Length (ft)	Allowable Moment Capacity ¹ , M' (inch-kips)							
	Minimum Tip Circumference (in.)							
	16	19	22	25	28	31	35	38
10	48.11	75.52	111.75	158.04	215.61	285.69	400.73	501.08
15	58.99	90.07	130.50	181.53	244.37	320.26	443.87	555.00
20	80.92	105.05	149.57	205.18	273.09	354.54	486.34	604.18
25	83.14	121.61	170.42	230.79	303.98	391.19	531.44	656.19
30	98.62	141.42	195.09	260.86	339.97	433.65	583.35	715.81
35	115.91	163.27	222.03	293.43	378.71	479.08	638.53	778.93
40	133.56	185.33	249.01	325.81	416.98	523.74	692.47	840.40

¹ Allowable moment capacity is three feet from butt with minimum circumferences as specified in Table 7.1.**Table 5.3 Pole Selection Table - Lodgepole Pine**Graded to ASTM D3200, $C_D=1.6$

Pole Length (ft)	Allowable Moment Capacity ¹ , M' (inch-kips)							
	Minimum Tip Circumference (in.)							
	16	19	22	25	28	31	35	38
10	43.30	67.97	100.58	142.23	194.05	257.12	360.66	450.97
15	53.09	81.06	117.45	163.37	219.93	288.23	399.48	499.50
20	72.82	94.54	134.62	184.66	245.78	319.09	437.71	543.76
25	74.83	109.45	153.37	207.71	273.58	352.07	478.29	590.57
30	88.76	127.27	175.58	234.78	305.98	390.29	525.01	644.23
35	104.32	146.94	199.83	264.09	340.84	431.17	574.68	701.04
40	120.21	166.80	224.11	293.23	375.28	471.36	623.22	756.36

¹ Allowable moment capacity is three feet from butt with minimum circumferences as specified in Table 7.1.

Table 5.4 Pole Selection Table - Northern White Cedar

Graded to ASTM D3200, $C_D=1.6$

Pole Length (ft)	Allowable Moment Capacity ¹ , M' (inch-kips)							
	Minimum Tip Circumference (in.)							
	16	19	22	25	28	31	35	38
10	33.68	52.87	78.23	110.63	150.92	199.98	280.51	350.75
15	41.29	63.05	91.35	127.07	171.06	224.18	310.71	388.50
20	56.64	73.53	104.70	143.62	191.16	248.18	340.44	422.93
25	58.20	85.13	119.29	161.56	212.78	273.83	372.01	459.33
30	69.03	98.99	136.56	182.60	237.98	303.56	408.34	501.06
35	81.14	114.29	155.42	205.40	265.10	335.36	446.97	545.25
40	93.49	129.73	174.30	228.07	291.88	366.62	484.73	588.28

¹ Allowable moment capacity is three feet from butt with minimum circumferences as specified in Table 7.1.

Table 5.5 Pole Selection Table - Ponderosa Pine

Graded to ASTM D3200, $C_D=1.6$

Pole Length (ft)	Allowable Moment Capacity ¹ , M' (inch-kips)							
	Minimum Tip Circumference (in.)							
	16	19	22	25	28	31	35	38
10	41.70	65.45	96.85	136.97	186.86	247.60	347.30	434.27
15	51.12	78.06	113.10	157.32	211.78	277.56	384.69	481.00
20	70.13	91.04	129.63	177.82	236.68	307.27	421.50	523.62
25	72.06	105.39	147.69	200.02	263.45	339.03	460.58	568.70
30	85.47	122.56	169.08	226.08	294.64	375.83	505.57	620.37
35	100.45	141.50	192.43	254.31	328.21	415.21	553.40	675.07
40	115.75	160.62	215.81	282.37	361.38	453.91	600.14	728.35

¹ Allowable moment capacity is three feet from butt with minimum circumferences as specified in Table 7.1.

Table 5.6 Pole Selection Table - Red Pine

Graded to ASTM D3200, $C_D=1.6$

Pole Length (ft)	Allowable Moment Capacity ¹ , M' (inch-kips)							
	Minimum Tip Circumference (in.)							
	16	19	22	25	28	31	35	38
10	46.51	73.01	108.03	152.77	208.42	276.17	387.38	484.38
15	57.02	87.06	126.15	175.48	236.22	309.58	429.08	536.50
20	78.22	101.55	144.59	198.34	263.99	342.72	470.13	584.04
25	80.37	117.55	164.73	223.10	293.84	378.15	513.72	634.32
30	95.33	136.70	188.58	252.17	328.64	419.20	563.90	691.95
35	112.05	157.82	214.63	283.65	366.08	463.11	617.25	752.97
40	129.11	179.16	240.71	314.95	403.08	506.28	669.38	812.39

¹ Allowable moment capacity is three feet from butt with minimum circumferences as specified in Table 7.1.

Table 5.7 Pole Selection Table - Southern PineGraded to ASTM D3200, $C_D=1.6$

Pole Length (ft)	Allowable Moment Capacity ¹ , M' (inch-kips)							
	Minimum Tip Circumference (in.)							
	16	19	22	25	28	31	35	38
10	54.53	85.59	126.65	179.11	244.35	323.78	454.16	567.89
15	66.85	102.08	147.90	205.73	276.95	362.96	503.05	629.00
20	91.70	119.06	169.52	232.53	309.50	401.82	551.19	684.74
25	94.23	137.82	193.14	261.57	344.51	443.35	602.30	743.68
30	111.77	160.27	221.10	295.64	385.30	491.47	661.13	811.25
35	131.36	185.03	251.64	332.56	429.20	542.96	723.67	882.79
40	151.37	210.05	282.21	369.25	472.57	593.57	784.80	952.45

¹ Allowable moment capacity is three feet from butt with minimum circumferences as specified in Table 7.1.**Table 5.8 Pole Selection Table - Western Hemlock**Graded to ASTM D3200, $C_D=1.6$

Pole Length (ft)	Allowable Moment Capacity ¹ , M' (inch-kips)							
	Minimum Tip Circumference (in.)							
	16	19	22	25	28	31	35	38
10	52.93	83.07	122.93	173.84	237.17	314.26	440.81	551.19
15	64.89	99.07	143.55	199.68	268.80	352.28	488.26	610.50
20	89.01	115.55	164.53	225.69	300.40	390.00	534.98	664.60
25	91.46	133.77	187.46	253.87	334.37	430.31	584.58	721.81
30	108.48	155.56	214.60	286.95	373.97	477.02	641.68	787.39
35	127.50	179.59	244.23	322.78	416.58	526.99	702.39	856.82
40	146.92	203.87	273.91	358.39	458.67	576.11	761.71	924.44

¹ Allowable moment capacity is three feet from butt with minimum circumferences as specified in Table 7.1.**Table 5.9 Pole Selection Table - Western Larch**Graded to ASTM D3200, $C_D=1.6$

Pole Length (ft)	Allowable Moment Capacity ¹ , M' (inch-kips)							
	Minimum Tip Circumference (in.)							
	16	19	22	25	28	31	35	38
10	65.76	103.21	152.73	215.98	294.66	390.44	547.67	684.81
15	80.62	123.09	178.35	248.09	333.97	437.69	606.62	758.50
20	110.58	143.57	204.42	280.41	373.22	484.54	664.67	825.71
25	113.63	166.20	232.90	315.42	415.43	534.63	726.30	896.79
30	134.78	193.27	266.62	356.51	464.63	592.66	797.24	978.27
35	158.41	223.13	303.44	401.03	517.57	654.75	872.66	1064.54
40	182.53	253.29	340.31	445.27	569.87	715.77	946.37	1148.54

¹ Allowable moment capacity is three feet from butt with minimum circumferences as specified in Table 7.1.

Table 5.10 Pole Selection Table - Western Red Cedar

Graded to ASTM D3200, $C_D=1.6$

Pole Length (ft)	Allowable Moment Capacity ¹ , M' (inch-kips)							
	Minimum Tip Circumference (in.)							
	16	19	22	25	28	31	35	38
10	43.30	67.97	100.58	142.23	194.05	257.12	360.66	450.97
15	53.09	81.06	117.45	163.37	219.93	288.23	399.48	499.50
20	72.82	94.54	134.62	184.66	245.78	319.09	437.71	543.76
25	74.83	109.45	153.37	207.71	273.58	352.07	478.29	590.57
30	88.76	127.27	175.58	234.78	305.98	390.29	525.01	644.23
35	104.32	146.94	199.83	264.09	340.84	431.17	574.68	701.04
40	120.21	166.80	224.11	293.23	375.28	471.36	623.22	756.36

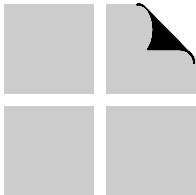
¹ Allowable moment capacity is three feet from butt with minimum circumferences as specified in Table 7.1.

Table 5.11 Pile Selection Table - Compression Parallel to Grain Design Capacity

Graded to ASTM D25, $C_D=1.15$

Species	Allowable Compression Parallel to Grain Capacity ¹ , P' (inch-kips)							
	Minimum Tip Circumference (in.)							
	16	19	22	25	28	31	35	38
Pacific Coast Douglas fir	29.28	41.30	55.37	71.50	89.68	109.93	140.13	165.18
Red Oak	25.77	36.34	48.72	62.92	78.92	96.74	123.32	145.36
Red Pine	21.08	29.73	39.86	51.48	64.57	79.15	100.89	118.93
Southern Pine	28.11	39.64	53.15	68.64	86.10	105.53	134.53	158.58

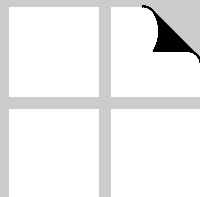
¹ Allowable capacities do not consider buckling capacities of piles.



OTHER CONSIDERATIONS

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6.1 General

With proper detailing and protection, timber poles and piles can perform well in a variety of environments. One key to proper detailing is planning for the natural shrinkage and swelling of wood products as they are subjected to various drying and wetting cycles (Table 6.1). While moisture changes have the largest impact on product dimensions, some designs must also check the effects of temperature as well.

In addition to designing to accommodate dimensional changes and detailing for durability, another significant issue in the planning of wood structures is that of fire performance. Several facets of this issue are discussed in this Chapter.

6.2 Dimensional Changes

6.2.1 Approximate Moisture and Thermal Dimensional Changes

Description	Radial or Tangential Direction
Dimensional change due to moisture content change ¹	1% change in dimension per 4% change in MC
Dimension change due to temperature change ²	≈ 20 x 10 ⁻⁶ in/in per degree F

¹ Corresponding longitudinal direction shrinkage/expansion is about 0.1 to 0.2 percent.

² Corresponding longitudinal direction coefficient is about one-tenth as large as radial and tangential.

6.2.2 Equations for Computing Moisture and Thermal Shrinkage/Expansion

Due to Moisture Changes

For more precise computation of dimensional changes due to changes in moisture, the change in radial (R), tangential (T), and volumetric (V) dimensions due to changes in moisture content can be computed as:

$$X = X_o(\Delta MC)e_{ME}$$

where:

X_o = initial dimension or volume

X = new dimension or volume

ΔMC = moisture content change (%)

e_{ME} = coefficient of moisture expansion linear
(in./in./%MC), or volumetric (in.³/in.³/%MC)

and:

$$\Delta MC = M - M_o$$

where:

M_o = initial moisture content % ($M_o \leq FSP$)

M = new moisture content % ($M \leq FSP$)

FSP = fiber saturation point

Values for e_{ME} are tabulated in Table 6.1.

Due to Temperature Changes

For more precise computation of dimensional changes due to changes in temperature, the shrinkage/expansion of solid wood including lumber and timber can be computed as:

$$X = X_o(\Delta T)e_{TE}$$

where:

X_o = reference dimension at T_o

X = computed dimension at T

T_o = reference temperature (°F)

T = temperature at which the new dimension is computed (°F)

e_{TE} = coefficient of thermal expansion (in./in./°F)

and:

$$\Delta T = T - T_0$$

where:

$$-60^\circ\text{F} \leq T_0 \leq 130^\circ\text{F}$$

The coefficient of thermal expansion of oven-dry wood parallel to grain ranges from about 1.7×10^{-6} to 2.5×10^{-6} per °F.

The linear expansion coefficients across the grain (radial and tangential) are proportional to wood density. These coefficients are about five to ten times greater than the parallel-to-the-grain coefficients and are given as:

Radial:

$$e_{TE} = [18(G) + 5.5] (10^{-6} \text{ in./in.}^\circ\text{F})$$

Tangential:

$$e_{TE} = [18(G) + 10.2] (10^{-6} \text{ in./in.}^\circ\text{F})$$

where:

G = tabulated specific gravity for the species

Table 6.1 Coefficient of Moisture Expansion (e_{ME}) and Fiber Saturation Point (FSP) for Solid Woods

Species	e_{ME}			FSP (%)
	Radial (in./in./%)	Tangential (in./in./%)	Volumetric (in. ³ /in. ³ /%)	
Alaska Cedar	0.0010	0.0021	0.0033	28
Douglas Fir-Larch	0.0018	0.0033	0.0050	28
Englemann Spruce	0.0013	0.0024	0.0037	30
Redwood	0.0012	0.0022	0.0032	22
Red Oak	0.0017	0.0038	0.0063	30
Southern Pine	0.0020	0.0030	0.0047	26
Western Hemlock	0.0015	0.0028	0.0044	28
Yellow Poplar	0.0015	0.0026	0.0041	31

6.3 Durability

Designing for durability is a key part of the architectural and engineering design of the building. This issue is particularly important in the design of buildings that use poles and piles. Many design conditions can be detailed to minimize the potential for decay; for other problem conditions, preservatively treated wood or naturally durable species should be specified.

This Supplement does not cover the topic of designing for durability in detail. There are many excellent texts on the topic, including AF&PA’s *Design of Wood Structures for Permanence*, WCD No. 6, and designers are advised to use this type of information to assist in designing “difficult” design areas, such as:

- in moist or humid structures
- where wood comes in contact with concrete or masonry
- where wood members are supported in steel hangers or connectors in which condensation could collect

- anywhere that wood is directly or indirectly exposed to the elements
- where wood, if it should ever become wet, could not naturally dry out.

This list is not intended to be all-inclusive — it is merely an attempt to alert designers to special conditions that have been found to cause problems when not designed with durability in mind.

Durability issues related to piles are generally both more critical and more easily accommodated. Since piles are in constant ground contact, they cannot be “insulated” from contact with moisture — thus, the standard reference condition for piles is to be preservatively treated. The importance of proper treatment processing of piles cannot be overemphasized.

6.3 Fire Performance

Very few elements of modern structures can be called “fire-proof.” Even in buildings where the major structural members are noncombustible, most of the furnishings are flammable. It is for this reason that much of the attention in modern building codes addresses issues related to containing and limiting fires, rather than simply calling materials combustible and noncombustible.

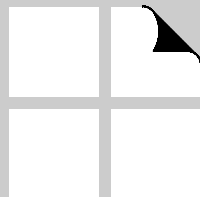
While this topic is fairly complex for other types of products, fire performance is relatively straightforward for poles and piles. Poles are generally used in cross-sectional sizes that qualify as heavy timber construction in

the model codes. On this basis, timber poles compare favorably with other construction materials in their performance under fire conditions. Piles are generally not exposed to fire conditions unless they extend substantially above the groundline.

This Supplement does not address fire performance in an all-inclusive manner — it is merely an attempt to alert designers to the need to address fire performance issues in the design of their structures.

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7.1 Section Properties

7.1.1 Pole Dimensions

Pole sizes are standardized by ASTM D3200. Standardized sizes are independent of species. For a given pole, minimum circumference at the tip is specified along with minimum circumference 3 ft. from the butt, the latter being a function of pole length. These specified dimensions (Table 7.1) with assumed linear taper shall be used in design computations associated with *NDS*.

7.1.2 Pile Dimensions

Pile dimensions are specified either by minimum tip circumference or by minimum butt circumference. These dimensions are specified by ASTM D25 as a function of pile length, species, and class. These dimensions (Tables 7.2 through 7.6) with assumed linear taper or the actual measured dimensions shall be used in computations associated with *NDS*.

Table 7.2 provides the specified tip circumferences with corresponding minimum butt circumferences, and Table 7.3 gives the specified butt circumferences with corresponding minimum tip circumferences for Southern Pine piles. Tables 7.4 and 7.5 provide similar minimum circumferences for piles of Pacific Coast Douglas-Fir and other species, except Southern Pine. Note that the butt circumference is specified at 3 ft. from the butt.

Pacific Coast Douglas-Fir piles may be specified into Class A and Class B. This classification depends on the minimum pile circumferences given in Table 7.6. The designer should inquire as to the availability of Class A and B sizes, which generally represent larger circumferences than the minimums specified in Table 7.6.

Table 7.1 Specified Tip Circumferences with Corresponding Minimum Butt Circumferences for Poles Graded to (ASTM D3200)

Length (ft.)	Minimum Tip Circumference (in.)							
	16	19	22	25	28	31	35	38
	Minimum Circumference 3 feet from butt (in.)							
10	18.5	21.5	24.5	27.5	30.5	33.5	37.5	40.5
15	19.8	22.8	25.8	28.8	31.8	34.8	38.8	41.8
20	22.0	24.0	27.0	30.0	33.0	36.0	40.0	43.0
25	22.2	25.2	28.2	31.2	34.2	37.2	41.2	44.2
30	23.5	26.5	29.5	32.5	35.5	38.5	42.5	45.5
35	24.8	27.8	30.8	33.8	36.8	39.8	43.8	46.8
40	26.0	29.0	32.0	35.0	38.0	41.0	45.0	48.0

Table 7.2 Specified Tip Circumferences with Corresponding Minimum Butt Circumferences for Southern Pine Piles¹ (ASTM D25)

Length (ft.)	Minimum Tip Circumference (in.)							
	16	19	22	25	28	31	35	38
	Minimum Circumference 3 feet from butt (in.)							
20	19	22	25	28	31	34	38	41
25	20	23	26	29	32	35	39	42
30	21	24	27	30	33	36	40	43
35	22	25	28	31	34	37	41	44
40		26	29	32	35	38	42	45
45		27	30	33	36	39	43	46
50			31	34	37	40	44	47
55			32	35	38	41	45	48
60			33	36	39	42	46	49
65			34	37	40	43	47	50
70			35	38	41	44	48	51
75			36	39	42	45	49	52
80			37	40	43	46	50	53
85			38	41	44	47	51	54
90			39	42	45	48	52	55

1. Piles purchased as "8 in. and natural taper" have a required minimum tip circumference of 25 in. and are available in lengths of 20 to 45 ft.

Table 7.3 Specified Butt Circumferences with Corresponding Minimum Tip Circumferences for Southern Pine Piles^{1,2,3} (ASTM D25)

Length (ft.)	Minimum Circumference 3 feet from butt (in.)										
	22	25	28	31	35	38	41	44	47	50	57
	Minimum Tip Circumference (in.)										
20	16	16	18	21	25	28	31	34	37	40	47
25	16	16	17	20	24	27	30	33	36	39	46
30	16	16	16	19	23	26	29	32	35	38	45
35				18	22	25	28	31	34	37	44
40				17	21	24	27	30	33	36	43
45					20	23	26	29	32	35	42
50					19	22	25	28	31	34	41
55						21	24	27	30	33	40
60						20	23	26	29	32	39
65						19	22	25	28	31	38
70						18	21	24	27	30	37
75							20	23	26	29	36
80							19	22	25	28	35
85							18	21	24	27	34

1. Where the taper applied to the butt circumference calculates to a tip circumference of less than 16 in., corresponding values have been increased to 16 in. to assure a minimum 5 in. diameter tip for purposes of driving.

2. Class A piles are all those listed with a specified required minimum circumference of 44 in. at 3 ft. from butt.

3. Class B piles are those listed with a specified required minimum circumference at 3 ft. from butt of 35 in. and lengths of 20 to 25 ft. minimum circumference at 3 ft. from butt of 38 in. and lengths of 20 to 50 ft. and minimum circumference at 3 ft. from butt of 41 in. and lengths of 55 to 80 ft.

Table 7.4 Specified Tip Circumferences with Corresponding Minimum Butt Circumferences for Piles of Pacific Coast Douglas-Fir and Other Species Except Southern Pine¹ (ASTM D25)

Length (ft.)	Minimum Tip Circumference (in.)							
	16	19	22	25	28	31	35	38
Minimum Circumference 3 feet from butt (in.)								
20	21.0	24.0	27.0	30.0	33.0	36.0	40.0	43.0
25	22.8	25.3	28.3	31.3	34.3	37.3	41.3	44.3
30	23.5	26.5	29.5	32.5	35.5	38.5	42.5	45.5
35	24.8	27.8	30.8	33.8	36.8	39.8	43.8	46.8
40	26.0	29.0	32.0	35.0	38.0	41.0	45.0	48.0
45	27.3	30.3	33.3	36.3	39.3	42.3	46.3	49.3
50	28.5	31.5	34.5	37.5	40.5	43.5	47.5	50.5
55	29.8	32.8	35.8	38.8	41.8	44.8	48.8	51.8
60	31.0	34.0	37.0	40.0	43.0	46.0	50.0	53.0
65	32.3	35.3	38.3	41.3	44.3	47.3	51.3	54.3
70	33.5	36.5	39.5	42.5	45.5	48.5	52.5	55.5
75	34.8	37.8	40.8	43.8	46.8	49.8	53.8	56.8
80	36.0	39.0	42.0	45.0	48.0	51.0	55.0	58.0
85	37.3	40.3	43.3	46.3	49.3	52.3	56.3	59.3
90	38.5	41.5	44.5	47.5	50.5	53.5	57.5	60.5
95	39.8	42.8	45.8	48.8	51.8	54.8	58.8	61.8
100	41.0	44.0	47.0	50.0	53.0	56.0	60.0	
105	42.3	45.3	48.3	51.3	54.3	57.3		
110	43.5	46.5	49.5	52.5	55.5	58.5		
115	44.8	47.8	50.8	53.8	56.8			
120	46.0	49.0	52.0	55.0	58.0			

1. Piles purchased as "8 in. and natural taper" have a required minimum tip circumference of 25 in. and are available in lengths of 20 to 45 ft.

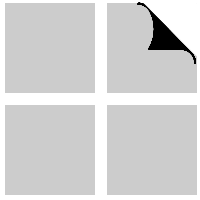
Table 7.5 Specified Butt Circumferences with Corresponding Minimum Tip Circumferences for Piles of Pacific Coast Douglas-Fir and Other Species Except Southern Pine¹ (ASTM D25)

Length (ft.)	Minimum Circumference 3 feet from butt (in.)										
	22	25	28	31	35	38	41	44	47	50	57
Minimum Tip Circumference (in.)											
20	16	16	16	18	22	25	28				
25	16	16	16	17	20.5	23.5	26.5	29.5			
30	16	16	16	16	19	22	25	28			
35				16	18	21	24	27	30		
40				16	17	20	23	26	29		
45					16.5	18.5	21	24	27	30	
50					16	17	19	22	25	28	
55						16.5	17.5	20.3	23.3	26.3	31.3
60						16	16	18.6	21.6	24.6	31.6
65						16	16	17.3	18.9	21.9	28.9
70						16	16	16	16.2	19.2	26.2
75							16	16	16.1	17.6	24
80							16	16	16	16	21.8
85							16	16	16	16	20.6
90							16	16	16	16	19.5
95							16	16	16	16	18.8
100							16	16	16	16	18
105										16	17
110										16	16
115											16
120											16

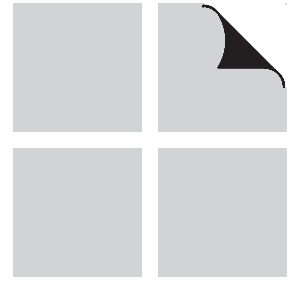
1. Where the taper applied to the butt circumference calculates to a tip circumference of less than 16 in., corresponding values have been increased to 16 in. to assure a minimum 5 in. diameter tip for purposes of driving.

Table 7.6 Minimum Circumferences (in.) of Class A and Class B Pacific Coast Douglas-Fir and Southern Pine Piles (ASTM D25)

Length (ft.)	3 feet from butt minimum		Tip minimum	
	Class A	Class B	Class A	Class B
20 to 25	--	34 (optional)	--	25
20 to 39	44	38	28	25
40 to 54	44	38	28	22
55 to 74	44	41	25	22
75 to 90	44	41	22	19
91 to 120	44	41	19	16



SUPPLEMENT
Wood Structural
Panels

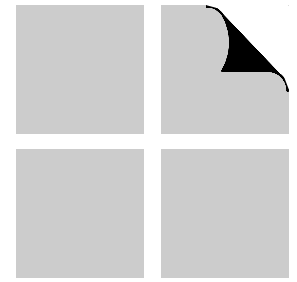


A S D

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MANUAL FOR ENGINEERED
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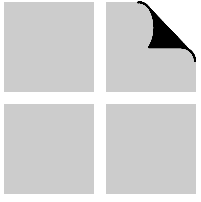
SUPPLEMENT
Wood Structural
Panels



A S D

ALLOWABLE STRESS DESIGN

MANUAL FOR ENGINEERED
WOOD CONSTRUCTION



Preface

This Supplement contains adjustment factors, section properties, design capacities, load-span tables, and other properties required to design wood structural panels in the ASD format. Design capacities are based on data from testing conducted by APA—The Engineered Wood Association and other organizations. Application recommendations given herein have been developed by APA through field experience and laboratory testing over more than 60 years. Wood structural sheathing and floor panels are classified by span rating. Panel span ratings identify the maximum recommended support spacings for these specific end uses. Design capacities are provided on the basis of the span ratings. For sanded plywood panels, design capacities are provided on the basis of nominal thickness of panels identified as having species Group 1 faces.

The design capacities tabulated in this Supplement are used in conjunction with the design methodologies provided in ANSI/AF&PA NDS-2001, *National Design Specification® (NDS®) for Wood Construction*.

The tabulated design capacities are to be used within the reference end-use conditions defined therein. When the end-use conditions fall outside the range of the reference conditions in the tables, the design capacities shall be adjusted by the product of the applicable factors defined in this Supplement, or contact one of the inspection and testing agencies listed in Section 6.4 of this Supplement.

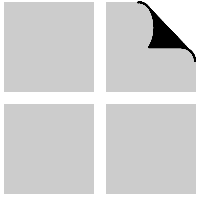
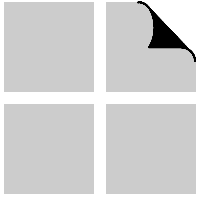


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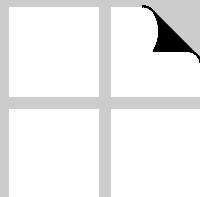
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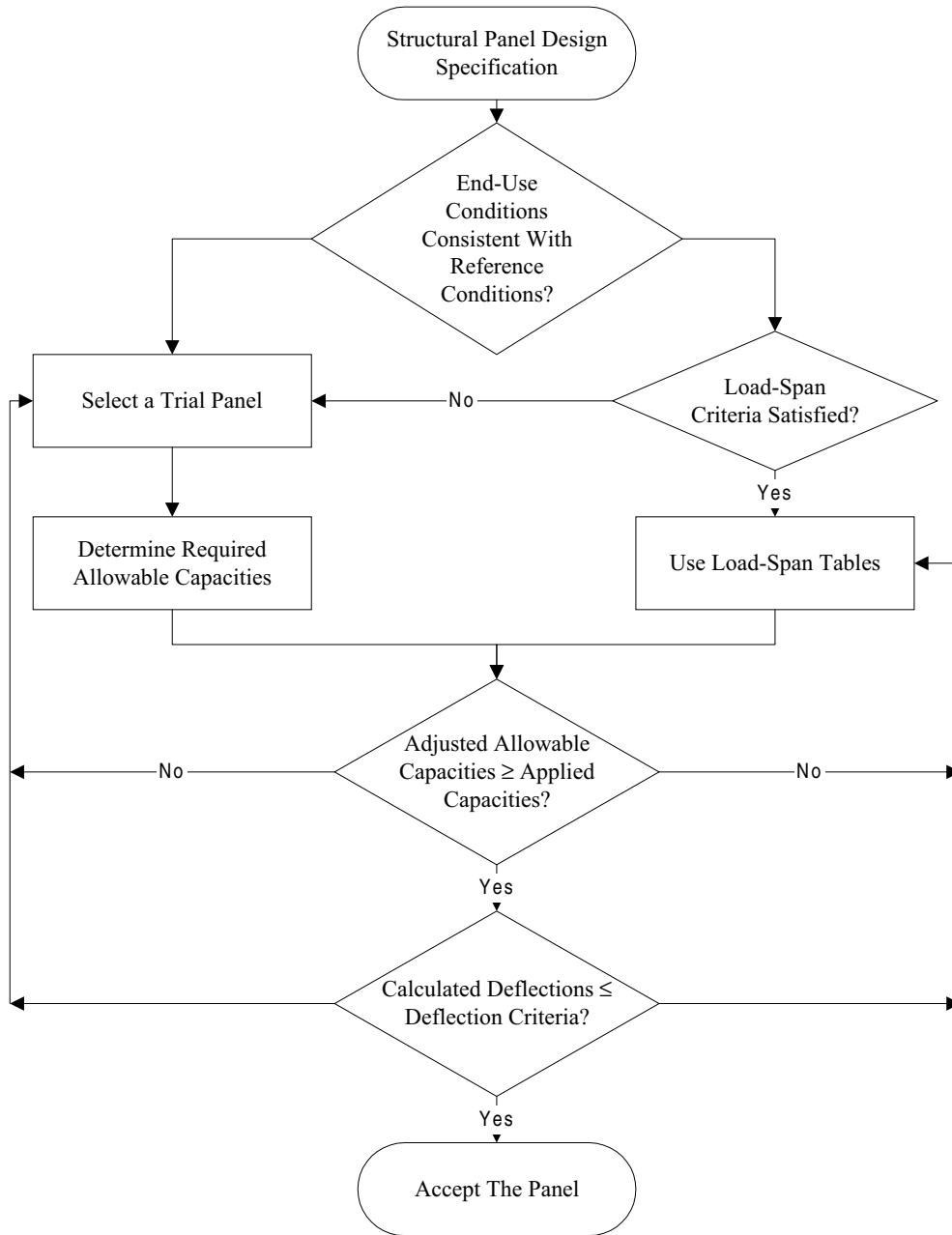
DESIGNER FLOWCHART

1.1 Flowchart

SP-2

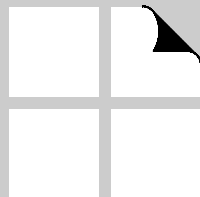


1.1 Flowchart



INTRODUCTION TO WOOD STRUCTURAL PANELS

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2.1 Product Description

Wood Structural Panels

Wood structural panels are wood-based panel products that have been rated for use in structural applications. Common applications for wood structural panels include roof sheathing, wall sheathing, subflooring, and single-layer flooring (combination subfloor-underlayment). Plywood is also manufactured in various sanded grades.

Wood structural panels are classified by span ratings. Panel span ratings identify the maximum recommended support spacings for specific end uses. Design capacities are provided on the basis of span ratings.

Sanded grades are classed according to nominal thickness and design capacities are provided on that basis.

Standards

- **PRP-108 and PRP-133:** APA and TECO Performance Standards PRP-108 and PRP-133, respectively, are oriented toward the end use of the product and do not prescribe by what means the product will be manufactured. The overall objective is to assure, for a particular end use, that the product will satisfy the requirements of the application for which it is intended.
- **PS 1:** Voluntary Product Standard PS 1 provides requirements for producing, marketing, and specifying plywood for construction and industrial uses. It covers manufacture of such plywood from some 70 wood species.
- **PS 2:** Voluntary Product Standard PS 2 provides requirements for producing, marketing, and specifying wood-based wood structural panels. It covers performance requirements, qualification procedures and test methods for such panels, which may be manufactured as plywood, composites, or as mat-formed panels.

Panel Grades

Based on PS 2 (see Section 6.4), wood structural panel grade names include Sheathing, Single Floor, and Structural I Sheathing. Corresponding grade names in PS 1 are C-D, Underlayment, and Structural I C-D.

- Sheathing grade panels are rated for use in subfloor, roof, and wall applications.

- Single Floor panels are rated for use as single floor (combination subfloor-underlayment) and are usually manufactured with tongue-and-groove (T&G) edge profiles. Single Floor panels are typically sanded or touch-sanded while Sheathing panels are usually unsanded.
- Structural I Sheathing panels meet the requirements of the sheathing grade as well as additional requirements associated with use in panelized roof systems, diaphragms, and shear walls.
- Sanded plywood panels are provided for in PS 1 (see Section 6.4) and are sanded on the faces which are A or B grade. High Density Overlay (HDO) and Medium Density Overlay (MDO) are also assumed to have sanded faces.

Span Ratings

Span ratings indicate the maximum recommended support spacing, in inches, for specific applications. The span rating system applies when the panel is applied with the strength axis across two or more supports. The strength axis is usually the primary axis (which is usually the long dimension) of the panel.

- **Sheathing:** Sheathing panels rated for use in roof or subfloor applications are identified with a dual span index – two numbers separated by a slash. The number preceding the slash is the maximum recommended support spacing for roof applications. The number following the slash is the maximum recommended support spacing for subfloor applications. For example, a panel rated as 24/16 may be applied as roof sheathing over supports spaced 24 inches oc (on center) or as subfloor over supports spaced 16 inches oc. Recommendations for use of sheathing panels also include wall applications.

Certain roof sheathing spans are dependent upon panel edge support (see Section 6.3).

Sheathing panels rated for use only as wall sheathing are usually identified as either Wall-24 or Wall-16. The numerical index (24 or 16) corresponds to the maximum wall stud spacing. Wall sheathing panels are performance tested with the secondary axis (usually the short dimension of panel) spanning across supports. For

this reason, wall sheathing panels may be applied with either the strength (primary) or secondary axis across supports.

- **Single Floor:** The Single Floor span rating is an index number that provides the maximum recommended support spacing with the strength axis across two or more supports. Typical Single Floor span ratings are 20 oc and 24 oc, although 16 oc, 32 oc, and 48 oc Single Floor panels are also available.

Panel Constructions

- **Plywood:** Plywood is comprised of alternating layers of veneer (plies). Each layer consists of one or more plies. Wood structural plywood panels are assembled with waterproof adhesive applied between plies. The adhesive cures upon application of heat and pressure.

Plywood has been manufactured since the early 1930s and was the original wood structural panel. Plywood panels were originally manufactured from Douglas-fir logs. Presently a variety of domestic species are used in plywood manufacture. Due to continued strong demand for forest products, along with artificial constraints on wood supply, imported species are becoming a factor in domestic plywood production.

- **Veneer Classifications:** Veneer is divided into five levels as follows:

N, A: Highest grade level. No knots, restricted patches. *N is intended for natural finish while A is intended for a paintable surface. Check local suppliers for availability of N grade before specifying.*

B: Solid surface - Small round knots. Patches and round plugs are allowed.

C Plugged: Special improved C grade. Used in Single Floor, Underlayment, C-C Plugged, and C-D Plugged.

C: Small knots, knotholes, patches. Lowest grade allowed in Exterior plywood. *For sheathing faces and inner plies in Exterior panels.*

D: Larger knots, knotholes, some limited white pocket in sheathing grades. This grade not permitted in Exterior panels.

- **Oriented Strand Board:** Oriented strand board (OSB) is comprised of thin rectangular wood strands arranged

in a minimum of three cross-aligned layers and bonded under heat and pressure with a waterproof and boil-proof adhesive. OSB's predecessor product was waferboard, a wood panel product that was first commercially produced in the mid-1960s. Waferboard manufacture involved a mat-formed panel product with random distribution of rectangular wafers. Oriented strand board, a significantly improved structural panel compared to waferboard, was first produced in the early 1980s.

Oriented strand board is manufactured from hardwood species, softwood species, and mixed species. The hardwood species used are selectively harvested from forests that naturally regenerate. The softwood resource is derived from fast-maturing species from managed forests. Much of the softwood resource represents selective harvesting from these managed forests.

- **COM-PLY®:** COM-PLY panels are composite panels of wood veneer and other wood-based material. COM-PLY panels are typically manufactured with five layers. The outer layers and the center layer are wood veneer, and the two remaining core layers are comprised of reconstituted wood fiber sandwiched between the veneer layers. COM-PLY panels are manufactured with waterproof adhesives.

COM-PLY was developed as a cooperative effort of the U.S. Forest Service and APA to more efficiently utilize the wood resource.

Bond Classification

The following bond classifications are based on product composition and adhesive bond durability.

- **Exterior:** Exterior panels may be used in applications that are subject to long-term exposure to the weather or to moisture or other conditions of similar severity.
- **Exposure 1:** Exposure 1 panels may be used in applications that are not subject to long-term exposure to weather or moisture, but where resistance to moisture effects due to exposure during construction or other conditions of similar severity is required.
- **Interior:** Interior panels may be used for permanently protected interior applications.

Design capacities in this specification are based on panels bonded with exterior glue (Exterior and Exposure 1 grades). For adjustments for interior glue (Interior and Exposure 2 grades), see applicable capacity tables.

Panel Applications

In addition to roof, subfloor, wall, and single-layer floor applications, wood structural panels are used in other applications. Such applications include structural insulated panels, I-joist webs, materials handling systems (pallets, bins, crating), transportation equipment, and concrete forming.

Shear Walls and Diaphragms

Wood structural panels are used as components of wall, floor, and roof systems to resist and transfer in-plane forces as may be imposed by wind or seismic loading. Shear walls and diaphragms represent an important application for wood structural panels. See Wood Structural Panel Shear Wall and Diaphragm Supplement.

2.2 Typical Applications

Table 2.1 Guide to Panel Use

Panel Grade	Description & Use	Common Nominal Thickness	Panel Construction		
			OSB	COM-PLY	Plywood & Veneer Grade
Sheathing EXP 1	Unsanded sheathing grade for wall, roof, subflooring, and industrial applications such as pallets and for engineering design with proper capacities. Manufactured with intermediate and exterior glue. For long-term exposure to weather or moisture, only Exterior type plywood is suitable.	5/16, 3/8, 15/32, 1/2, 19/32, 5/8, 23/32, 3/4	Yes	Yes	Yes, face C, back D, Inner D
Structural I Sheathing EXP 1	Panel grades to use where shear and cross-panel strength properties are of maximum importance. Made with exterior glue only. Plywood Structural I is made from all Group 1 woods.	19/32, 5/8, 23/32, 3/4	Yes	Yes	Yes, face C, back D, Inner D
Single Floor EXP 1	Combination subfloor-underlayment. Provides smooth surface for application of carpet and pad. Possesses high concentrated and impact load resistance during construction and occupancy. Manufactured with intermediate (plywood) and exterior glue. Touch-sanded. Available with tongue-and-groove edges.	19/32, 5/8, 23/32, 3/4, 7/8, 1, 1-3/32, 1-1/8	Yes	Yes	Yes, face C-Plugged, back D, Inner D
Underlayment EXP 1or INT	For underlayment under carpet and pad. Available with exterior glue. Touch-sanded. Available with tongue-and-groove edges.	1/4, 11/32, 3/8, 15/32, 1/2, 19/32, 5/8, 23/32, 3/4	No	No	Yes, face C-Plugged, back D, Inner D
C-D-Plugged EXP 1	For built-ins, wall and ceiling tile backing. Not for underlayment. Available with exterior glue. Touch-sanded.	1/2, 19/32, 5/8, 23/32, 3/4	No	No	Yes, face C-Plugged, back D, Inner D
Sanded Grades EXP 1or INT	Generally applied where a high quality surface is required. Includes APA N-N, N-A, N-B, N-D, A-A, A-D, B-B, and B-D INT grades	1/4, 11/32, 3/8, 15/32, 1/2, 19/32, 5/8, 23/32, 3/4	No	No	Yes, face B or better, back D or better, Inner C & D
Marine EXT	Superior Exterior-type plywood made only with Douglas-fir or Western Larch. Special solid-core construction. Available with MDO or HDO face. Ideal for boat hull construction.	1/4, 11/32, 3/8, 15/32, 1/2, 19/32, 5/8, 23/32, 3/4	No	No	Yes, face A or face B, back A or Inner B

2.3 Availability

Although other panel constructions may be available, Table 2.1 shows constructions most typically manufactured. Check with suppliers concerning availability.

Table 2.2 Typical Panel Constructions^a

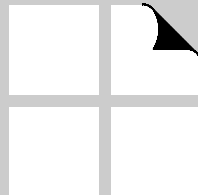
	Plywood			COM-PLY	OSB
	3-ply	4-ply	5-ply ^b		
Span Rating	Sheathing				
24/0	✓				✓
24/16					✓
32/16	✓	✓	✓		✓
40/20	✓	✓	✓		✓
48/24		✓	✓		✓
Span Rating	Single Floor				
16 oc					✓
20 oc		✓	✓	✓	✓
24 oc		✓	✓	✓	✓
32 oc			✓	✓	✓
48 oc			✓	✓	✓
Nominal Thickness	Sanded Plywood				
1/4	✓				
11/32	✓				
3/8	✓				
15/32		✓	✓		
1/2		✓	✓		
19/32			✓		
5/8			✓		
23/32			✓		
3/4			✓		
7/8			✓		
1			✓		
1-1/8			✓		

^a Constructions listed may not be available in every area. Check with suppliers concerning availability.

^b Applies to plywood with 5 or more layers.

DESIGN CAPACITIES

3.1	General	SP-10
3.2	Flexural Bending Capacities	SP-10
3.3	Axial Capacities	SP-10
3.4	Shear Capacities	SP-11
Table 3.1	Panel Dry Design Bending Stiffness and Strength Capacities	SP-12
Table 3.1.1	Adjustments to Flexural Design Capacities Based on Panel Grade and Construction, C_G	SP-13
Table 3.2	Panel Dry Design Axial Stiffness, Tension, and Compression Capacities	SP-14
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Table 3.4	Panel Dry Rigidity and Shear Capacities Through the Thickness	SP-17
Table 3.4.1	Adjustments to Design Capacities Based on Panel Grade and Construction, C_G ..	SP-18



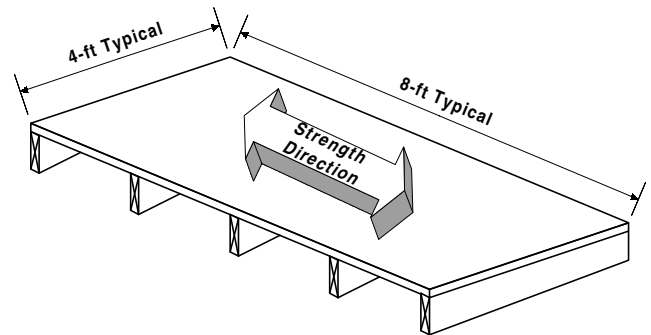
3.1 General

Panel design capacities listed in Tables 3.1 through 3.4 are minimum for grade and span rating. Tables 3.1.1 through 3.4.1 list allowable increases in capacity for specific panel constructions and grades. To take advantage of these, the specifier must insure that the correct panel is used in construction.

The tabulated capacities and adjustment factors are based on data from tests of panels manufactured in accordance with one or more of the standards listed in Section 2.1 and which bear the trademark of a qualified inspection and testing agency.

Structural panels have a strength direction and a cross panel direction. In general, the strength direction is along the standard 8-ft. length and the weaker direction is in the 4-ft. direction. This is illustrated in Figure 3.1.

Figure 3.1 Structural panel with strength direction across supports.



3.2 Flexural Bending Capacities

Panel design capacities listed in Table 3.1 are based on flat panel bending as measured by testing according to principles of ASTM D3043 Method C (large panel testing).

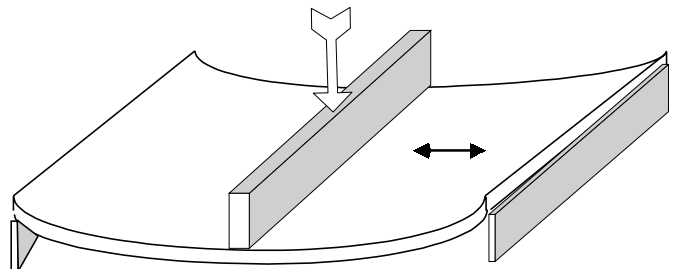
Stiffness (EI)

Panel bending stiffness is the capacity to resist deflection and is represented as EI. The E is the modulus of elasticity of the material and the I is the moment of inertia of the cross section. The units of EI are lb.-in.² per foot of panel width.

Strength (F_bS)

Allowable bending strength capacity is the design maximum moment, represented as F_bS . The F_b is the allowable extreme fiber stress of the material and the S is the section modulus of the cross section. The units of F_bS are lb.-in. per foot of panel width.

Figure 3.2 Example of structural panel in bending.



3.3 Axial Capacities

Axial Stiffness (EA)

Panel axial stiffnesses listed in Table 3.2 are based on testing according to the principles of ASTM D3501 Method B. Axial stiffness is the capacity to resist axial strain and is represented as EA. The E is the axial modu-

lus of elasticity of the material and A is the area of the cross section. The units of EA are lb. per foot of panel width.

Tension ($F_t A$)

Allowable tension capacities listed in Table 3.2 are based on testing according to the principles of ASTM D3500 Method B. Tension capacity is given as $F_t A$. The F_t is the allowable tensile stress of the material and A is the area of the cross section. The units of $F_t A$ are lb. per foot of panel width.

Compression ($F_c A$)

Allowable compression capacities listed in Table 3.2 are based on testing according to the principles of ASTM D3501 Method B. Compressive properties are generally influenced by buckling; however, this effect was eliminated by restraining edges of specimens during testing. Compression capacity is given as $F_c A$. The F_c is the allowable compression stress of the material and A is the area of the cross section. The units of $F_c A$ are lb. per foot of panel width.

3.4 Shear Capacities

Shear in the Plane (Rolling Shear) ($F_s [Ib/Q]$)

Allowable shear in the plane of the panel (rolling shear) listed in Table 3.3 are based on testing according to the principles of ASTM D2718. Shear strength in the plane of the panel is the capacity to resist horizontal shear breaking loads when loads are applied or developed on opposite faces of the panel, as in flat panel bending. Planar shear capacity is given as $F_s [Ib/Q]$. The F_s is the allowable material stress and Ib/Q is the panel cross sectional shear constant. The units of $F_s [Ib/Q]$ are lb. per foot of panel width.

Rigidity Through the Thickness ($G_v t_v$)

Panel rigidity listed in Table 3.4 are based on testing according to the principles of ASTM D2719 Method C. Panel rigidity is the capacity to resist deformation under shear-through-the-thickness stress. Rigidity is represented as $G_v t_v$, where G_v is the modulus of rigidity and t_v is the effective panel thickness for shear. The units of $G_v t_v$ are lb. per inch of panel depth (for vertical applications). Multiplication of $G_v t_v$ by panel depth gives GA , used by designers for some applications.

Figure 3.3 Structural panel with axial compression load in the plane of the panel.

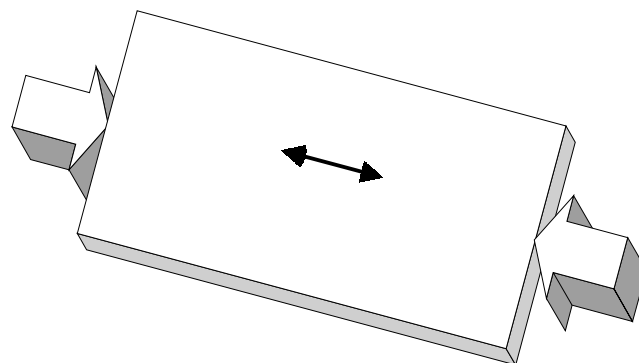
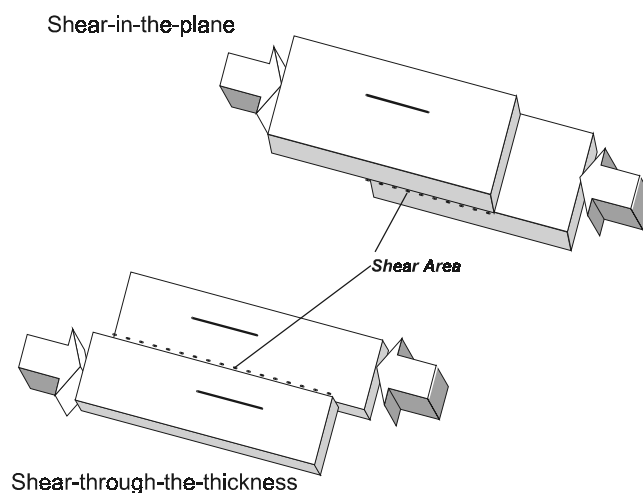


Figure 3.4 Two types of panel shear: shear-through-the-thickness and shear-in-the-plane of the panel called rolling shear in plywood.



Shear Through the Thickness ($F_v t_v$)

Allowable shear through the thickness values listed in Table 3.4 are based on testing according to the principles of ASTM D2719 Method C. Allowable shear through the thickness is the capacity to resist horizontal shear breaking loads when loads are applied or developed on opposite edges of the panel, such as in an I-beam. Where

additional support is not provided to prevent buckling, design capacities in Table 3.4 are limited to sections 2 ft. or less in depth. Deeper sections may require additional reductions. The term F_v is the allowable stress of the material and the t_v is the effective panel thickness for shear. The units of $F_v t_v$ are lb. per inch of shear resisting panel length.

Table 3.1 Panel Dry Design Bending Stiffness and Strength Capacities

	Bending Stiffness, EI (lb.-in. ² /ft. width)		Bending Strength, $F_b S$ (lb.-in./ft. width)	
	Stress Applied Parallel to Strength Axis ^a	Stress Applied Perpendicular to Strength Axis ^a	Stress Applied Parallel to Strength Axis ^a	Stress Applied Perpendicular to Strength Axis ^a
Span Rating	Sheathing			
24/0	60,000	3,600	250	54
24/16	78,000	5,200	320	64
32/16	115,000	8,100	370	92
40/20	225,000	18,000	625	150
48/24	400,000	29,500	845	225
Span Rating	Single Floor			
16 oc	150,000	11,000	415	100
20 oc	210,000	13,000	480	140
24 oc	300,000	26,000	640	215
32 oc	650,000	75,000	870	380
48 oc	1,150,000	160,000	1,600	680
Nominal Thickness	Sanded Plywood			
1/4	15,000	700	97	14
11/32	34,000	1,750	155	26
3/8	49,000	2,750	205	37
15/32	120,000	11,000	355	110
1/2	140,000	15,500	390	145
19/32	205,000	37,500	520	225
5/8	230,000	48,500	560	270
23/32	320,000	90,500	645	380
3/4	355,000	115,000	680	470
7/8	500,000	185,000	850	650
1	760,000	330,000	1,100	975
1-1/8	985,000	490,000	1,350	1,250

^a The strength axis is the long panel dimension unless otherwise identified.

Table 3.1.1 Adjustments to Flexural Design Capacities Based on Panel Grade and Construction, C_g

	Stress Applied			
	Parallel to Strength Axis ^a		Perpendicular to Strength Axis ^a	
	Other	Structural I	Other	Structural I
Panel Bending Stiffness, EI				
Rated Panels				
3-Ply Plywood	1.1	1.1	1.0	1.5
4-Ply Plywood, COM-PLY	1.1	1.1	2.2	3.3
5-Ply Plywood ^b	1.1	1.1	3.1	5.2
OSB	1.0	1.0	3.1	5.2
Sanded Plywood				
A-A, A-C	1.0	1.0	1.0	1.4
Marine	1.0	1.0	1.4	1.4
Other	1.0	1.0	1.0	1.4
Panel Bending Strength, $F_b S$				
Rated Panels				
3-Ply Plywood	1.0	1.0	1.0	1.3
4-Ply Plywood	1.1	1.1	1.2	1.7
COM-PLY	1.2	1.2	1.2	1.7
5-Ply Plywood ^b , OSB	1.2	1.2	1.8	2.8
Sanded Plywood				
A-A, A-C	1.2	1.3	1.2	1.7
Marine	1.1	1.1	1.4	1.4
Other	1.0	1.1	1.0	1.4

^a The strength axis is the long panel dimension unless otherwise identified.

^b Adjustments apply to plywood with 5 or more layers; for 5-ply/3-layer plywood, use adjustments for 4-ply.

Table 3.2 Panel Dry Design Axial Stiffness, Tension, and Compression Capacities

	Axial Stiffness, EA (lb./ft. width)		Tension, F _t A (lb./ft. width)		Compression, F _c A (lb./ft. width)	
	Stress Applied Parallel Strength Axis ^a	Stress Applied Perpendicular Strength Axis ^a	Stress Applied Parallel Strength Axis ^a	Stress Applied Perpendicular Strength Axis ^a	Stress Applied Parallel Strength Axis ^a	Stress Applied Perpendicular Strength Axis ^a
Span Rating	Sheathing					
24/0	3,350,000	2,900,000	2,300	600	2,850	2,500
24/16	3,800,000	2,900,000	2,600	990	3,250	2,500
32/16	4,150,000	3,600,000	2,800	1,250	3,550	3,100
40/20	5,000,000	4,500,000	2,900	1,600	4,200	4,000 ^b
48/24	5,850,000	5,000,000 ^b	4,000	1,950	5,000	4,800 ^b
Span Rating	Single Floor					
16 oc	4,500,000	4,200,000	2,600	1,450	4,000	3,600
20 oc	5,000,000	4,500,000	2,900	1,600	4,200	4,000 ^b
24 oc	5,850,000	5,000,000 ^b	3,350	1,950	5,000	4,800 ^b
32 oc	7,500,000	7,300,000 ^c	4,000	2,500	6,300	6,200
48 oc	8,200,000	7,300,000	5,600	3,650	8,100	6,750
Nominal Thickness	Sanded Plywood					
1/4	1,800,000	625,000	1,650	550	1,550	550
11/32	1,800,000	750,000	1,650	700	1,550	650
3/8	2,350,000	1,150,000	2,150	1,050	2,000	950
15/32	3,500,000	2,150,000	3,200	2,000	3,000	1,850
1/2	3,500,000	2,250,000	3,200	2,050	3,000	1,900
19/32	4,350,000	2,500,000	4,000	2,300	3,750	2,150
5/8	4,450,000	2,750,000	4,100	2,500	3,800	2,350
23/32	5,100,000	3,150,000	4,650	2,850	4,350	2,650
3/4	5,200,000	3,750,000	4,750	3,450	4,450	3,200
7/8	5,300,000	4,750,000	4,850	4,350	4,550	4,100
1	6,700,000	5,700,000	6,150	5,200	5,750	4,850
1-1/8	6,950,000	5,700,000	6,350	5,250	5,950	4,900

^a The strength axis is the long panel dimension unless otherwise identified.

^b Capacity shall be adjusted for OSB by multiplying by 0.9.

^c Capacity shall be adjusted for OSB by multiplying by 0.8.

Table 3.2.1 Adjustments to Axial Design Capacities Based on Panel Grade and Construction, C_g

	Stress Applied			
	Parallel to Strength Axis ^a		Perpendicular to Strength Axis ^a	
	Other	Structural I	Other	Structural I
Panel Axial Stiffness, EA				
Rated Panels				
3-Ply Plywood, COM-PLY	1.0	1.0	1.0	1.0
4-Ply Plywood	1.0	1.0	1.0	1.0
5-Ply Plywood ^b , OSB	1.0	1.0	1.0	1.0
Sanded Plywood				
A-A, A-C	1.0	1.0	1.0	1.8
Marine	1.0	1.0	1.8	1.8
Other	1.0	1.0	1.0	1.8
Panel Tension, F_tA				
Rated Panels				
3-Ply Plywood, COM-PLY	1.0	1.0	1.0	1.0
4-Ply Plywood	1.0	1.0	1.0	1.0
5-Ply Plywood ^b	1.3	1.3	1.3	1.3
OSB	1.0	1.0	1.3	1.3
Sanded Plywood				
A-A, A-C	1.2	1.2	1.2	2.1
Marine	1.0	1.0	1.8	1.8
Other	1.0	1.0	1.0	1.8
Panel Compression, F_cA				
Rated Panels				
3-Ply Plywood, COM-PLY	1.0	1.0	1.0	1.0
4-Ply Plywood	1.5	1.5	1.5 ^c	1.5 ^c
5-Ply Plywood ^b	1.5	1.5	1.5 ^c	1.5 ^c
OSB	1.0	1.0	1.0	1.0
Sanded Plywood				
A-A, A-C	1.1	1.1	1.1	2.0
Marine	1.0	1.0	1.8	1.8
Other	1.0	1.0	1.0	1.8

^a The strength axis is the long panel dimension unless otherwise identified.

^b Adjustments apply to plywood with 5 or more layers; for 5-ply/3-layer plywood, use adjustments for 4-ply.

^c Panel grade and construction factor for 48 oc shall be 1.6.



Table 3.3 Panel Dry Shear Capacities in the Plane

	Shear in the Plane (F_s [Ib/Q]) (Ib./ft. width)	
	Stress Applied Parallel to Strength Axis ^b	Stress Applied Perpendicular to Strength Axis ^b
Span Rating	Sheathing	
24/0	130	130
24/16	150	150
32/16	165	165
40/20	205	205
48/24	250	250
Span Rating	Single Floor	
16 oc	205	205
20 oc	205	205
24 oc	250	250
32 oc	300	300
48 oc	385	385
Nominal Thickness	Sanded Plywood ^a	
1/4	105	105
11/32	145	135
3/8	165	185
15/32	220	130
1/2	235	145
19/32	290	150
5/8	310	165
23/32	350	200
3/4	360	215
7/8	425	270
1	470	375
1-1/8	525	445

^a Exterior glue assumed (Exterior or Exposure 1 grades). For interior glue (Interior or Exposure 2 grades), multiply F_s [Ib/Q] by 0.90.

^b The strength axis is the long panel dimension unless otherwise identified.

Table 3.3.1 Adjustments to Shear Capacities in the Plane Based on Panel Grade and Construction, C_g

Panel Shear in the Plane, F_s [Ib/Q]	Stress Applied			
	Parallel to Strength Axis ^a		Perpendicular to Strength Axis ^a	
	Other	Structural I	Other	Structural I
Rated Panels				
3-Ply Plywood	1.2	1.7	2.1	3.0
4-Ply Plywood	1.2	1.7	2.9	4.1
5-Ply Plywood ^b	1.3	1.9	1.0	1.0
OSB, COM-PLY	1.0	1.0	1.0	1.0
Sanded Plywood				
A-A, A-C	1.0	1.3	1.0	1.4
Marine	1.3	1.3	1.4	1.4
Other	1.0	1.3	1.0	1.4

^a The strength axis is the long panel dimension unless otherwise identified.

^b Adjustments apply to plywood with 5 or more layers; for 5-ply/3-layer plywood, use adjustments for 4-ply.

Table 3.4 Panel Dry Rigidity and Shear Capacities Through the Thickness

	Rigidity Through the Thickness, $G_v t_v$		Shear Through the Thickness, $F_v t_v$	
	(lb./in. of panel depth)		(lb./in. of shear-resisting panel length)	
	Stress Applied Parallel to Strength Axis ^b	Stress Applied Perpendicular to Strength Axis ^b	Stress Applied Parallel to Strength Axis ^b	Stress Applied Perpendicular to Strength Axis ^b
Span Rating	Sheathing			
24/0	25,000	25,000	53	53
24/16	27,000	27,000	57	57
32/16	27,000	27,000	62	62
40/20	28,500	28,500	68	68
48/24	31,000	31,000	75	75
Span Rating	Single Floor			
16 oc	27,000	27,000	58	58
20 oc	28,000	28,000	67	67
24 oc	30,000	30,000	74	74
32 oc	36,000	36,000	80	80
48 oc	50,500	50,500	105	105
Nominal Thickness	Sanded Plywood^a			
1/4	24,000	24,000	51	51
11/32	25,500	25,500	54	54
3/8	26,000	26,000	55	55
15/32	38,000	38,000	80	80
1/2	38,500	38,500	81	81
19/32	49,000	49,000	105	105
5/8	49,500	49,500	105	105
23/32	50,500	50,500	105	105
3/4	51,000	51,000	110	110
7/8	52,500	52,500	110	110
1	73,500	73,500	155	155
1-1/8	75,000	75,000	160	160

^a Exterior glue assumed (Exterior or Exposure 1 grades). For interior glue (Interior or Exposure 2 grades), multiply $G_v t_v$ by 0.90 and multiply $F_v t_v$ by 0.84.

^b The strength axis is the long panel dimension unless otherwise identified.



Table 3.4.1 Adjustments to Design Capacities Based on Panel Grade and Construction, C_g

	Stress Applied			
	Parallel to Strength Axis ^a		Perpendicular to Strength Axis ^a	
	Other	Structural I	Other	Structural I
Panel Rigidity Through the Thickness, $G_v t_v$				
Rated Panels				
3-Ply Plywood	1.0	1.3	1.0	1.3
4-Ply Plywood, COM-PLY	1.3	1.7	1.3	1.7
5-Ply Plywood ^b	1.5	1.7	1.5	1.7
OSB	3.1	3.1	3.1	3.1
Sanded Plywood				
A-A, A-C	1.0	1.3	1.0	1.3
Marine	1.3	1.3	1.3	1.3
Other	1.0	1.3	1.0	1.3
Panel Shear Through the Thickness, $F_v t_v$				
Rated Panels				
3-Ply Plywood	1.0	1.3	1.0	1.3
4-Ply Plywood, COM-PLY	1.3	1.7	1.3	1.7
5-Ply Plywood ^b	1.5	2.0	1.5	2.0
OSB	2.9	2.9	2.9	2.9
Sanded Plywood				
A-A, A-C	1.0	1.3	1.0	1.3
Marine	1.3	1.3	1.3	1.3
Other	1.0	1.3	1.0	1.3

^a The strength axis is the long panel dimension unless otherwise identified.

^b Adjustments apply to plywood with 5 or more layers; for 5-ply/3-layer plywood, use adjustments for 4-ply.

DESIGN ADJUSTMENT FACTORS

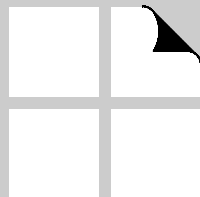
4.1	General	SP-20
4.2	Grade and Construction Factor, C_G	SP-20
4.3	Load Duration Factor, C_D	SP-20
4.4	Creep Adjustment Factor, C_C	SP-20
4.5	Moisture Effect Factor, C_M	SP-21
4.6	Preservative Treatment	SP-21
4.7	Fire Retardant Treatment	SP-21
4.8	Panel Size Factor, C_S	SP-22
4.9	Temperature Factor, C_t	SP-22

Table 4.2 Frequently Used Load Duration Factors, C_D .. SP-20

Table 4.3 Creep Adjustment Factor, C_C SP-20

Table 4.4 Moisture Effect Factor, C_M SP-21

Table 4.5 Panel Size Factor, C_S SP-21



4.1 General

Panel design capacities are determined by multiplying baseline capacities, as given in Tables 3.1 through 3.4, by the adjustment factors in *NDS* Section 9.3.

Tabulated capacities provided in this Supplement are suitable for reference end-use conditions. Reference end-use conditions are consistent with conditions typically associated with light-frame construction. For wood structural panels, these typical conditions involve the use of full-sized untreated panels in moderate temperature and moisture exposures.

Appropriate adjustment factors are provided for applications in which the conditions of use are inconsistent with reference conditions. In addition to temperature and moisture, this includes consideration of panel treatment and size effects. Reference conditions and adjustment factors are provided in Sections 4.2 through 4.9.

The tabulated adjustment factors are applicable for use with capacities of wood structural panels.

4.2 Grade and Construction Factor, C_G

Adjustments to wood structural panel design values for grade and construction and panel size, shall be in accordance with *NDS* Section 9.3.4. Reference capacities presented in Tables 3.1 through 3.4 of this Supplement represent minimum values for each listed grade and construction. Tables 3.1.1, 3.2.1, 3.3.1, and 3.4.1 provide

adjustments to the minimum capacities as appropriate for specific constructions and grades. These Tables are located close to the capacity tables for convenience. To take advantage of these, the specifier must insure that the correct panel is used in the final construction.

4.3 Load Duration Factor, C_D

Design capacities listed are based on normal load duration. Adjustment factors for strength capacities shall be based on *NDS* Section 9.3.2 (see Table 4.2).

Table 4.2 Frequently Used Load Duration Factors, C_D ¹

Load Duration	C_D	Typical Design Loads
Permanent	0.9	Dead Load
Ten years	1.0	Occupancy Live Load
Two months	1.15	Snow Load
Seven days	1.25	Construction Load
Ten minutes	1.6	Wind/Earthquake Load
Impact ²	2.0	Impact Load

1. Load duration factors shall not apply to modulus of elasticity, E , nor to compression perpendicular to grain design values, $F_{c\perp}$, based on a deformation limit.
2. Load duration factors greater than 1.6 shall not apply to structural members pressure-treated with water-borne preservatives, or fire retardant chemicals and are not recommended for wood structural panels. The impact load duration factor shall not apply to connections.

4.4 Creep Adjustment Factor, C_c

Wood-based panels under constant load will creep (deflection will increase) over time. For typical construction applications, panels are not normally under constant load and, accordingly, creep need not be considered in design. When panels will sustain permanent loads which will stress the product to one-half or more of its design capacity, allowance should be made for creep. Limited data indicates that under such conditions, creep may be taken into account in deflection calculations by applying the applicable following adjustment factor (C_c) to panel stiffness EI. See Section 4.5 for additional adjustments related to service moisture conditions, for which EI is cumulative with the adjustment for creep.

Table 4.3 Creep Adjustment Factor, C_c

Moisture Condition	Plywood	OSB
Dry	1/2	1/2
16% MC or greater	1/2	1/6

4.5 Moisture Effect Factor, C_M

Design capacities apply to panels under moisture conditions which are continuously dry in service; that is, where equilibrium moisture content is less than 16%.

Adjustment factors for conditions where the panel moisture content in service is expected to be 16% or greater are as follows (see *NDS* Section 9.3.3):

Table 4.4 Moisture Effect Factor, C_M

Reference Capacity	C_M
Strength (F_bS , F_tA , F_cA , $F_s(Ib/Q)$, F_vt_v)	0.75
Stiffness (EI, EA, G_vt_v)	0.85

4.6 Preservative Treatment

Capacities given in Tables 3.1 through 3.4 apply without adjustment to plywood pressure-impregnated with preservative chemicals and redried in accordance with American Wood Preservers Association (AWPA) Specification C-9 or Specification C-22. However, due to the

absence of applicable treating industry standards, OSB and COM-PLY panels are not currently recommended for applications requiring pressure-preservative treating.

4.7 Fire Retardant Treatment

The information provided in this Supplement does not apply to fire-retardant-treated panels. All capacities and end-use conditions for fire-retardant-treated panels shall be in accordance with the recommendations of the company providing the treating and redrying service.

4.8 Panel Size Factor, C_s

Strength capacity in bending and tension are appropriate for panels 24 inches or greater in width (w , dimension perpendicular to the applied stress). For panels less than 24 inches in width used in applications where failure could endanger human life, the adjustment in Table 4.5 shall be made (see *NDS* Section 9.3.4).

Single strips less than 8 inches wide used in stressed applications shall be chosen such that they are relatively free of surface defects.

Table 4.5 Panel Size Factor, C_s

Panel Width, w	C_s
$w \leq 8$ inches	0.5
8 inches $< w < 24$ inches	$\frac{(8+w)}{32}$
$w \geq 24$ inches	1.0

4.9 Temperature Factor, C_t

The temperature factor, C_t shall be applied when wood structural panels are exposed to in-service sustained temperatures. In the range of 100° to 200°F, the temperature effect factor is applicable only when moisture content of wood structural panels at the elevated temperature can be expected to remain at 16% or greater for wet-use (moisture content 16% or greater) conditions or at 12% or above for dry-use conditions (moisture content below 16%).

The temperature factor shall be computed according to the following equation (see *NDS* Section 9.3.3):

$$C_t = 1.0 - \alpha_t (T - 100)$$

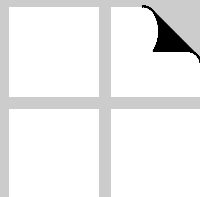
where:

- α_t = temperature effect coefficient
= 0.005 for wood structural panels
- T = temperature (°F)

This factor is applicable to the capacities given in Tables 3.1 through 3.4 of this Supplement.

SECTION PROPERTIES

5.1	General	SP-24
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Table 5.1	Panel Section Properties	SP-24
Table 5.2	Relationship Between Span Rating and Nominal Thickness	SP-24



5.1 General

Section properties are provided in Section 5.2. Nominal panel thicknesses tabulated in Table 5.1 were used to calculate section properties. The tabulated section properties were calculated assuming homogeneous rectangular cross sections of 1-ft. width.

Relationships between nominal thickness and span rating are provided in Table 5.2. The predominant nomi-

nal thickness available for each span rating is designated by the letter “P”. The predominant nominal thickness is also the appropriate thickness for establishing section properties for design.

Design stresses may be calculated by dividing design capacities in Tables 3.1 through 3.4 by applicable section properties from Table 5.1.

5.2 Panel Section Properties

Table 5.1 Panel Section Properties^a

Nominal Thickness (in.)	Approximate Weight ^b (psf)	Thickness t (in.)	Area A (in. ² /ft.)	Moment of Inertia I (in. ⁴ /ft.)	Section Modulus S (in. ³ /ft.)	Statical Moment Q (in. ³ /ft.)	Shear Constant Ib/Q (in. ² /ft.)
3/8	1.1	0.375	4.500	0.053	0.281	0.211	3.000
7/16	1.3	0.437	5.250	0.084	0.383	0.287	3.500
15/32	1.4	0.469	5.625	0.103	0.440	0.330	3.750
1/2	1.5	0.500	6.000	0.125	0.500	0.375	4.000
19/32	1.8	0.594	7.125	0.209	0.705	0.529	4.750
5/8	1.9	0.625	7.500	0.244	0.781	0.586	5.000
23/32	2.2	0.719	8.625	0.371	1.033	0.775	5.750
3/4	2.3	0.750	9.000	0.422	1.125	0.844	6.000
7/8	2.6	0.875	10.500	0.670	1.531	1.148	7.000
1	3.0	1.000	12.000	1.000	2.000	1.500	8.000
1-1/8	3.3	1.125	13.500	1.424	2.531	1.898	9.000

^a Properties based on rectangular cross section of 1-ft. width.

^b Approximate plywood weight for calculating actual dead loads. For OSB and COM-PLY panels, increase tabulated weights by 10%.

Table 5.2 Relationship Between Span Rating and Nominal Thickness

Span Rating	Nominal Thickness (in.)										
	3/8	7/16	15/32	1/2	19/32	5/8	23/32	3/4	7/8	1	1-1/8
Sheathing											
24/0	P	A	A	A							
24/16		P	A	A							
32/16			P	A	A	A					
40/20					P	A	A	A			
48/24							P	A	A		
Single Floor											
16 oc					P	A					
20 oc					P	A					
24 oc							P	A			
32 oc									P	A	
48 oc											P

P = Predominant nominal thickness for each span rating.

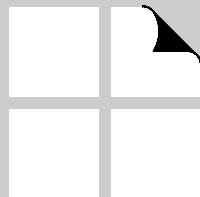
A = Alternative nominal thickness that may be available for each span rating. Check with suppliers regarding availability.

OTHER CONSIDERATIONS

6.1	Fastening (Nailing) Schedules	SP-26
6.2	Panel Spacing	SP-26
6.3	Panel Edge Support	SP-27
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Table 6.1 Minimum Nailing Recommendations for
Wood Structural Panel Applications SP-26

Table 6.2 Panel Edge Support SP-27



6.1 Fastening (Nailing) Schedules

Table 6.1 Minimum Nailing Recommendations for Wood Structural Panel Applications

Application	Recommended Nail Size & Type	Nail Spacing (in.)	
		Panel Edges	Intermediate Supports
Single Floor—Glue-nailed installation		Ring- or screw-shank	
16, 20, 24 oc, 3/4-in. thick or less	6d ^a	12	12
24 oc, 7/8-in. or 1-in. thick	8d ^a	6	12
32, 48 oc, 32-in. span (c-c)	8d ^a	6	12
48 oc, 48-in. span (c-c)	8d ^b	6	6
Single Floor—Nailed-only installation		Ring- or screw-shank	
16, 20, 24 oc, 3/4-in. thick or less	6d	6	12
24 oc, 7/8-in. or 1-in. thick	8d	6	12
32, 48 oc, 32-in. span	8d ^b	6	12
48 oc, 48-in. span	8d ^b	6	6
Sheathing—Subflooring		Common smooth, ring- or screw-shank^c	
7/16-in. to 1/2-in. thick	6d	6	12
7/8-in. thick or less	8d	6	12
Thicker panels	10d	6	6
Sheathing—Wall sheathing		Common smooth, ring- or screw-shank or galvanized box^c	
1/2-in. thick or less	6d	6	12
Over 1/2-in. thick	8d	6	12
Sheathing—Roof sheathing		Common smooth, ring- or screw-shank^c	
5/16-in. to 1-in. thick	8d	6	12 ^d
Thicker panels	8d ring- or screw-shank or 10d common smooth	6	12 ^d

^a 8d common nails may be substituted if ring- or screw-shank nails are not available.

^b 10d ring-shank, screw-shank, or common nails may be substituted if supports are well seasoned.

^c Other code-approved fasteners may be used.

^d For spans 48 in. or greater, space nails 6 in. at all supports.

6.2 Panel Spacing

Wood-based panel products expand and contract slightly as a natural response to changes in panel moisture content. To provide for in-plane dimensional changes, panels should be installed with a 1/8-inch spacing at all panel end and edge joints. A standard 10d box nail may be used to check panel edge and panel end spacing.

6.3 Panel Edge Support

For certain span ratings, the maximum recommended roof span for sheathing panels is dependent upon panel edge support. Although edge support may be provided by lumber blocking, panel clips are typically used when edge support is required. Table 6.2 summarizes the relationship between panel edge support and maximum recommended spans.

Table 6.2 Panel Edge Support

Sheathing Span Rating	Maximum Recommended Span (in.)	
	With Edge Support	Without Edge Support
24/0	24	20 ^a
24/16	24	24
32/16	32	28
40/20	40	32
48/24	48	36

^a 20 in. for 3/8-in. and 7/16-in. panels, 24 in. for 15/32-in. and 1/2-in. panels.

6.4 Panel Specification

General

Wood structural panel recommendations provided in this design supplement are applicable to panels produced in accordance with one or more of the standards listed in Section 2.1 and which bear the trademark of a qualified inspection and testing agency. Design recommendations are based on structural capacities associated with specific panel classifications. Wood structural panels are classified by span ratings.

Designers must specify wood structural panels by the span ratings, nominal thicknesses, grades, and constructions associated with tabulated design recommendations. Exposure durability classification must also be identified.

Single Floor panels may have tongue-and-groove or square edges. If square edge Single Floor panels are specified, the specification shall require lumber blocking between supports.

Further information regarding specification of wood structural panels is provided in the following references.

References – Wood Structural Panels

A partial listing of references for further information on wood structural panels and panel applications follows. Additional information is available from organizations providing trademarking and quality assurance services.

APA - The Engineered Wood Association

7011 South 19th Street
P.O. Box 11700
Tacoma, Washington 98411-0700
Phone: 253-565-6600
Fax: 253-565-7265
Internet Address: www.apawood.org

Professional Services Industries, Inc.

Pittsburgh Testing Laboratory Division
2710 West 5th Ave.
Eugene, OR 97402
Phone: 541-484-9212
Fax: 541-344-2735
Internet Address: www.psiousa.com

TECO

2402 Daniels St.
Madison, WI 53718
Phone: 608-221-3361
Fax: 608-226-0885
Internet Address: www.tecotested.com

Publications

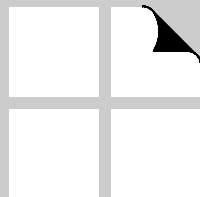
The following publications provide information on wood structural panels and panel applications:

- Performance Standards and Policies for Wood Structural Panels, APA PRP-108 and TECO PRP-133
- Voluntary Product Standard PS 1 — Construction and Industrial Plywood

- Voluntary Product Standard PS 2— Performance Standard for Wood-Based Structural-Use Panels
- APA Panel Handbook & Grade Glossary
- Residential & Commercial, APA Design/Construction Guide
- Diaphragms & Shear Walls, APA Design/Construction Guide
- Fire Rated Systems, APA Design/Construction Guide
- Nonresidential Roof Systems, APA Design/Construction Guide
- Performance Rated Panels, APA Product Guide
- Sanded Plywood, APA Product Guide

SUPPLEMENTAL DESIGN ASSISTANCE

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7.1 Uniform Loads for Wood Structural Panels

Computation of uniform-load capacity of wood structural panels shall be as outlined in this section for such applications as roofs, floors, and walls. The design capacities are subject to adjustment as specified in Section 4.

Three basic span conditions are presented for computing uniform-load capacities of wood structural panels. For normal framing practice and a standard panel size (4x8 ft.), the following assumptions are used in computing recommendations for load-span tables. When the panel strength axis is perpendicular to the supports, the three-span condition is assumed for support spacing up to and including 32 inches. The two-span condition is assumed for support spacing greater than 32 inches.

When the panel strength axis is placed parallel to the supports, the three-span condition is assumed for supports spacing up to and including 16 inches, the two-span condition is assumed when the support spacing is greater than 16 inches up to 24 inches, and a single-span condition is assumed for spans greater than 24 inches.

Two-inch-nominal framing is assumed for support spacing less than 48 inches. Four-inch-nominal framing is assumed for support spacing of 48 inches or greater.

The equations presented in this section are standard beam formulas altered to accept the mixed units noted. These formulas are provided for computing uniform loads on wood structural panels over conventional framing. Because it is assumed that no blocking is used, the formulas are for one-way “beam” action, rather than two-way “plate” action. The resulting loads are assumed to be applied to full-sized panels in standard sheathing-type applications. Loads are for the panels only, and in no way account for the design of the framing supports.

Further consideration should be given to concentrated loads, in compliance with local building codes and with maximum span recommendations.

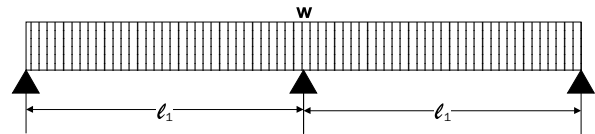
Uniform Loads Based on Bending Strength

The following formulas shall be used for computing loads based on design bending strength capacity ($F_b S$).

For a single span:

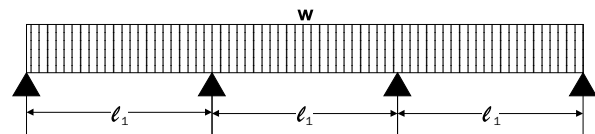
$$w_b = \frac{96F_b S}{\ell_1^2}$$

For a two-span condition:



$$w_b = \frac{96F_b S}{\ell_1^2}$$

For a three-span condition:



$$w_b = \frac{120F_b S}{\ell_1^2}$$

where:

w_b = uniform load based on bending strength (psf)

$F_b S$ = design bending strength capacity (lb-in./ft.)

ℓ_1 = span (in., center-to-center of supports)

Uniform Loads Based on Shear Strength

The following formulas shall be used for computing loads based on design shear strength capacity ($F_s [Ib/Q]$).

For a single span:

$$w_s = \frac{24F_s (Ib/Q)}{\ell_2}$$

For a two-span condition:

$$w_s = \frac{19.2F_s (Ib/Q)}{\ell_2}$$

For a three-span condition:

$$w_s = \frac{20F_s (Ib/Q)}{\ell_2}$$

where:

w_s = uniform load based on shear strength (psf)

$F_s(\text{lb}/Q)$ = design shear strength capacity (lb.-in./ft.)

ℓ_2 = clear span (in., center-to-center of supports
minus support width)

Uniform Loads Based on Deflection Requirements

The following formulas shall be used for computing deflection under uniform load, or allowable loads based on deflection requirements.

For a single span:

$$\Delta = \frac{w\ell_3^4}{921.6EI}$$

For a two-span condition:

$$\Delta = \frac{w\ell_3^4}{2220EI}$$

For a three-span condition:

$$\Delta = \frac{w\ell_3^4}{1743EI}$$

where:

Δ = deflection (in.)

w = uniform load (psf)

EI = design bending stiffness capacity (lb.-in.²/ft.)

ℓ_3 = clear span + SW (in.)

SW = support width factor, equal to 0.25 inch for 2-inch nominal lumber framing and 0.625 inch for 4-inch-nominal lumber framing. For additional information on this factor see APA Research Report 120.

For uniform load based on deflection requirements, compute bending deflection with a uniform load (w) equal to 1 psf. The allowable uniform load based on the allowable deflection is then computed as:

$$w_d = \frac{\Delta_{all}}{\Delta}$$

where:

w_d = uniform load based on deflection requirement (psf)

Δ_{all} = allowable deflection (in.)

Δ = computed deflection with a uniform load (w) equal to 1 psf, using either of the above three formulas whichever is applicable

7.2 Load-Span Tables

The following load-span tables apply to wood structural panels manufactured in accordance with one or more of the standards listed in Section 2.1 and bearing the trademark of a qualified inspection and testing agency. Loads are provided for applications where the panel strength axis is applied perpendicular to supports and parallel to supports. For each combination of span and span rating, or span and Group 1 sanded panel grade, loads are given for deflections of $L/360$, $L/240$, $L/180$, and maximum load controlled by bending and shear capacity.

The values given in Tables 7.1 and 7.2 represent the maximum allowable loads without regard to panel type. These values may be adjusted for panel type using Table 7.4, Adjustments to Allowable Load Capacities Based on Panel Grade and Construction. Once the allowable loads have been adjusted for panel type, they should be further adjusted for application conditions using Table 7.5.

Note: Spans shown in the tables may be in excess of the maximum recommended span (or span rating) for a specific application, since other factors such as concentrated loads may be more critical than uniform load. Always check the maximum recommended floor and roof spans for wood structural panels before making a final panel selection for these applications.

Table 7.1 Uniform Load (psf) on Sheathing

(Multi-Span, Normal Duration of Load, Dry Conditions)

Span Rating	Load Governed By	Span, Center-to-Center Supports (in.)												
		Strength Axis Perpendicular to Supports										Strength Axis Parallel to Supports		
		12	16	19.2	24	30	32	36	40	48	60	12	16	24
24/0	L/360	261	98	54	26	13	10	9				16	6	
	L/240	392	147	81	39	19	16	14				23	9	
	L/180	522	196	107	52	26	21	18				31	12	
	Bending	208	117	81	52	33	29	19				45	25	
	Shear	248	179	147	116	91	85	72				248	179	
24/16	L/360	339	128	70	34	17	14	12	9			23	9	
	L/240	509	191	105	51	25	20	18	13			34	13	
	L/180	679	255	140	68	33	27	24	17			45	17	
	Bending	267	150	104	67	43	38	24	19			53	30	
	Shear	286	207	169	133	105	98	83	75			286	207	
32/16	L/360	500	188	103	50	24	20	18	13			35	13	4
	L/240	750	282	154	75	37	30	26	19			53	20	7
	L/180	1001	376	206	100	49	40	35	25			70	27	9
	Bending	308	173	120	77	49	43	27	22			77	43	15
	Shear	314	228	186	147	116	108	92	82			314	228	141
40/20	L/360	979	368	201	98	48	39	34	25	16		78	29	10
	L/240	1468	552	302	146	72	58	51	37	24		117	44	15
	L/180	1958	736	403	195	96	78	69	49	32		157	59	20
	Bending	521	293	203	130	83	73	46	38	26		125	70	25
	Shear	390	283	232	182	144	134	114	102	88		390	283	175
48/24	L/360	1740	655	358	174	85	69	61	44	29	14	128	48	16
	L/240	2610	982	537	260	128	104	91	66	43	21	193	72	24
	L/180	3480	1309	716	347	170	139	122	88	57	28	257	97	33
	Bending	704	396	275	176	113	99	63	51	35	23	188	105	38
	Shear	476	345	282	222	175	164	139	125	108	85	476	345	213

Table 7.2 Uniform Load (psf) on Single Floor

(Multi-Span, Normal Duration of Load, Dry Conditions)

Span Rating	Load Governed By	Span, Center-to-Center Supports (in.)												
		Strength Axis Perpendicular to Supports										Strength Axis Parallel to Supports		
		12	16	19.2	24	30	32	36	40	48	60	12	16	24
16 oc	L/360	653	245	134	65	32	26	23	16	11		48	18	6
	L/240	979	368	201	98	48	39	34	25	16		72	27	9
	L/180	1305	491	269	130	64	52	46	33	21		96	36	12
	Bending	346	195	135	86	55	49	31	25	17		83	47	17
	Shear	390	283	232	182	144	134	114	102	88		390	283	175
20 oc	L/360	914	344	188	91	45	36	32	23	15		57	21	7
	L/240	1370	516	282	137	67	55	48	34	22		85	32	11
	L/180	1827	687	376	182	89	73	64	46	30		113	43	14
	Bending	400	225	156	100	64	56	36	29	20		117	66	23
	Shear	390	283	232	182	144	134	114	102	88		390	283	175
24 oc	L/360	1305	491	269	130	64	52	46	33	21	10	113	43	14
	L/240	1958	736	403	195	96	78	69	49	32	16	170	64	22
	L/180	2610	982	537	260	128	104	91	66	43	21	226	85	29
	Bending	533	300	208	133	85	75	47	38	27	17	179	101	36
	Shear	476	345	282	222	175	164	139	125	108	85	476	345	213
32 oc	L/360	2828	1064	582	282	138	113	99	71	46	23	326	123	41
	L/240	4242	1596	873	473	207	169	148	107	70	34	489	184	62
	L/180	5656	2128	1164	564	276	225	198	142	93	45	653	245	83
	Bending	725	408	283	181	116	102	64	52	36	23	317	178	63
	Shear	571	414	339	267	211	197	167	150	129	102	571	414	256
48 oc	L/360	5003	1882	1030	499	244	199	175	126	82	40	696	262	88
	L/240	7505	2823	1545	748	367	299	263	189	123	60	1044	393	133
	L/180	10006	3764	2060	998	489	399	350	252	164	80	1392	524	177
	Bending	1333	750	521	333	213	188	119	96	67	43	567	319	113
	Shear	733	531	435	342	270	252	214	192	166	131	733	531	329

Table 7.3 Uniform Load (psf) on Group 1 Sanded Panels

(Multi-Span, Normal Duration of Load, Dry Conditions)

Nom Thick (in.)	Load Governed By	Span, Center-to-Center Supports (in.)												
		Strength Axis Perpendicular to Supports										Strength Axis Parallel to Supports		
		12	16	19.2	24	30	32	36	40	48	60	12	16	24
11/32	L/360	148	56	30	15	7	6	5				8	3	1
	L/240	222	83	46	22	11	9	8				11	4	1
	L/180	296	111	61	29	14	12	10				15	6	2
	Bending	129	73	50	32	21	18	11				22	12	4
	Shear	276	200	164	129	102	95	81				257	186	115
3/8	L/360	213	80	44	21	10	8	7				12	5	2
	L/240	320	120	66	32	16	13	11				18	7	2
	L/180	426	160	88	43	21	17	15				24	9	3
	Bending	171	96	67	43	27	24	15				31	17	6
	Shear	314	228	186	147	116	108	92				352	255	158
15/32	L/360	522	196	107	52	26	21	18	13	9		48	18	6
	L/240	783	295	161	78	38	31	27	20	13		72	27	9
	L/180	1,044	393	215	104	51	42	37	26	17		96	36	12
	Bending	296	166	116	74	47	42	26	21	15		92	52	18
	Shear	419	303	249	196	154	144	122	110	95		248	179	111
1/2	L/360	609	229	125	61	30	24	21	15	10		67	25	9
	L/240	914	344	188	91	45	36	32	23	15		101	38	13
	L/180	1,218	458	251	121	60	49	43	31	20		135	51	17
	Bending	325	183	127	81	52	46	29	23	16		121	68	24
	Shear	448	324	266	209	165	154	131	117	101		276	200	124
19/32	L/360	892	336	184	89	44	36	31	22	15	7	163	61	21
	L/240	1,338	503	275	133	65	53	47	34	22	11	245	92	31
	L/180	1,784	671	367	178	87	71	62	45	29	14	326	123	41
	Bending	433	244	169	108	69	61	39	31	22	14	188	105	38
	Shear	552	400	328	258	204	190	161	145	125	99	286	207	128
5/8	L/360	1,001	376	206	100	49	40	35	25	16	8	211	79	27
	L/240	1,501	565	309	150	73	60	53	38	25	12	317	119	40
	L/180	2,001	753	412	200	98	80	70	50	33	16	422	159	54
	Bending	467	263	182	117	75	66	41	34	23	15	225	127	45
	Shear	590	428	350	276	218	203	173	155	134	105	314	228	141
23/32	L/360	1,392	524	287	139	68	55	49	35	23	11	394	148	50
	L/240	2,088	786	430	208	102	83	73	53	34	17	591	222	75
	L/180	2,784	1,047	573	278	136	111	97	70	46	22	787	296	100
	Bending	538	302	210	134	86	76	48	39	27	17	317	178	63
	Shear	667	483	395	311	246	230	195	175	151	119	381	276	171
3/4	L/360	1,544	581	318	154	75	62	54	39	25	12	500	188	64
	L/240	2,317	871	477	231	113	92	81	58	38	19	750	282	95
	L/180	3,089	1,162	636	308	151	123	108	78	51	25	1,001	376	127
	Bending	567	319	221	142	91	80	50	41	28	18	392	220	78
	Shear	686	497	407	320	253	236	200	180	155	122	410	297	183
7/8	L/360	2,175	818	448	217	106	87	76	55	36	17	805	303	102
	L/240	3,263	1,227	672	325	159	130	114	82	54	26	1,207	454	153
	L/180	4,351	1,637	895	434	213	173	152	109	71	35	1,610	606	204
	Bending	708	398	277	177	113	100	63	51	35	23	542	305	108
	Shear	810	586	480	378	298	279	237	212	183	144	514	372	230
1	L/360	3,306	1,244	681	330	162	132	116	83	54	26	1,436	540	182
	L/240	4,960	1,866	1,021	495	242	198	174	125	81	40	2,154	810	273
	L/180	6,613	2,488	1,361	659	323	263	231	166	109	53	2,871	1,080	365
	Bending	917	516	358	229	147	129	81	66	46	29	813	457	163
	Shear	895	648	531	418	330	308	262	234	203	160	714	517	320
1-1/8	L/360	4,285	1,612	882	427	209	171	150	108	70	34	2,132	802	271
	L/240	6,428	2,418	1,323	641	314	256	225	162	105	51	3,198	1,203	406
	L/180	8,571	3,224	1,764	855	419	341	300	216	141	68	4,264	1,604	541
	Bending	1,125	633	439	281	180	158	100	81	56	36	1,042	586	208
	Shear	1000	724	593	467	368	344	292	262	227	178	848	614	380

Table 7.4 Adjustments to Allowable Load Capacities Based on Panel Grade and Construction, C_G

	Strength Axis ^a			
	Perpendicular to Supports		Parallel to Supports	
	Other	Structural I	Other	Structural I
Stiffness (L/360, L/240, L/180)				
Rated Panels				
3-Ply Plywood	1.1	1.1	1.0	1.5
4-Ply Plywood, COM-PLY	1.1	1.1	2.2	3.3
5-Ply Plywood ^b	1.1	1.1	3.1	5.2
OSB	1.0	1.0	3.1	5.2
Sanded Plywood				
A-A, A-C	1.0	1.0	1.0	1.4
Marine	1.0	1.0	1.4	1.4
Other	1.0	1.0	1.0	1.4
Bending				
Rated Panels				
3-Ply Plywood	1.0	1.0	1.0	1.3
4-Ply Plywood	1.1	1.1	1.2	1.7
COM-PLY	1.2	1.2	1.2	1.7
5-Ply Plywood ^b , OSB	1.2	1.2	1.8	2.8
Sanded Plywood				
A-A, A-C	1.2	1.3	1.2	1.7
Marine	1.1	1.1	1.4	1.4
Other	1.0	1.1	1.0	1.4
Shear				
Rated Panels				
3-Ply Plywood	1.2	1.7	2.1	3.0
4-Ply Plywood	1.2	1.7	2.9	4.1
5-Ply Plywood ^b	1.3	1.9	1.0	1.0
OSB, COM-PLY	1.0	1.0	1.0	1.0
Sanded Plywood				
A-A, A-C	1.0	1.3	1.0	1.4
Marine	1.3	1.3	1.4	1.4
Other	1.0	1.3	1.0	1.4

^a The strength axis is the long panel dimension unless otherwise identified.

^b Adjustments apply to plywood with 5 or more layers; for 5-ply/3-layer plywood, use adjustments for 4-ply.

Table 7.5 Application Adjustment Factors

Duration of Load, C_D (Applies to Bending and Shear Only)	
Permanent load (over 10 years)	0.90
2 months, as for snow	1.15
7 days	1.25
Wind or Earthquake	1.60 ^a
Impact	2.00
Span Adjustment	
2-span to 1-span	
Deflection	0.42
Bending	1.00
Shear	1.25
3-span to 1-span	
Deflection	0.53
Bending	0.80
Shear	1.20
Wet or Damp Locations, C_M (Moisture Content 16% or more)	
Deflection	0.85
Bending	0.75
Shear	0.75

^a Check local building code.

7.3 Design Examples

Example 1: Conventional Roof

A 4-ply plywood, single floor 24 oc panel with tongue-and-groove edges was inadvertently installed over 4-in.-nominal roof supports 48 in. on center. The long dimension (strength axis) of the panel was placed perpendicular to supports. The local building code requires that the panel support a 25-psf snow load.

Bending Strength

From Table 3.1, a single floor 24 oc panel with stress applied parallel to the strength axis (long panel dimension perpendicular to supports) has a bending strength capacity ($F_b S$) of 640 lb.-in./ft. This capacity is adjusted by a C_G factor of 1.1 as shown in Table 3.1.1 for 4-ply plywood and by duration-of-load factor (C_D) of 1.15 (see Section 4.3). From Section 7.1, a two-span condition is assumed.

$$\begin{aligned}
 w_b &= \frac{96F_b S}{\ell_1^2} \\
 &= \frac{96(640 \times 1.1 \times 1.15)}{48^2} \\
 &= 34 \text{ psf}
 \end{aligned}$$

Shear Strength in the Plane

From Table 3.3, a single floor 24 oc panel with stress applied parallel to the strength axis has shear strength in the plane (F_s [Ib/Q]) of 250 lb./ft. This capacity is adjusted by a C_G factor of 1.2 as shown in Table 3.3.1 for 4-ply plywood and by a duration-of-load factor (C_D) of 1.15 (see Section 4.3).

$$\begin{aligned}
 w_s &= \frac{19.2 F_s (\text{Ib/Q})}{\ell_2} \\
 &= \frac{19.2(250 \times 1.2 \times 1.15)}{(48 - 3.5)} \\
 &= 149 \text{ psf}
 \end{aligned}$$

Bending Stiffness

From Table 3.1, a single floor 24 oc panel with stress applied parallel to the strength axis has a dry stiffness capacity (EI) of 300,000 lb.-in.²/ft. This capacity is adjusted by a C_G factor of 1.1 for 4-ply plywood as shown in Table 3.1.1. The deflection limit for live load is $\ell/240$.

$$\begin{aligned}\Delta &= \frac{W\ell_3^4}{2220 EI} \\ &= \frac{1.0(48-3.5+0.625)^4}{2,220(300,000 \times 1.1)} \\ &= 5.71 \times 10^{-3} \text{ in.} \\ w_d &= \frac{\Delta_{\text{all}}}{\Delta} = \frac{48/240}{5.71 \times 10^{-3}} = 35 \text{ psf}\end{aligned}$$

Bending strength controls (provides the lowest capacity) for this application. The bending strength capacity of 34 psf represents total load, from which dead load is subtracted to arrive at live load capacity. The bending stiffness capacity of 35 psf represents live load only. Here, if dead load (panel weight plus roofing) is no more than 9 psf, the 25-psf snow load capacity is achieved. The tongue-and-groove edges provide required edge supports.

Example 2: Panelized Roof

An oriented strand board (OSB) sheathing 32/16 panel is to be used in a panelized roof system over 2-in.-nominal framing members 24 in. on center. The long panel dimension (strength axis) of the panel will be placed parallel to supports.

Bending Strength

From Table 3.1, a sheathing 32/16 panel with stress applied perpendicular to strength axis (long panel dimension parallel to supports) has a bending strength capacity ($F_b S$) equal to 92 lb.-in./ft. This capacity is adjusted by a C_G factor of 2.8 for OSB Structural I (Table 3.1.1) and by a duration-of-load factor (C_D) of 1.15 (see Section 4.3). This duration-of-load factor is normally associated with snow loads for roof structures. From Section 7.1., a two-span condition is assumed.

$$\begin{aligned}w_b &= \frac{96F_b S}{\ell_1^2} \\ &= \frac{96(92 \times 2.8 \times 1.15)}{24^2} \\ &= 49 \text{ psf}\end{aligned}$$

Shear Strength in the Plane

From Table 3.3, a sheathing 32/16 panel with stress applied perpendicular to strength axis has shear strength in the plane (F_s [Ib/Q]) of 165 lb./ft. This capacity is adjusted by a C_G factor of 1.0 for OSB Structural I (Table 3.3.1) and by a duration-of-load factor (C_D) of 1.15 (see Section 4.3).

$$\begin{aligned}w_s &= \frac{19.2F_s(\text{Ib/Q})}{\ell_2} \\ &= \frac{19.2(165 \times 1.0 \times 1.15)}{(24-1.5)} \\ &= 162 \text{ psf}\end{aligned}$$

Bending Stiffness

From Table 3.1, a sheathing 32/16 panel with stress applied perpendicular to strength axis (long panel dimension parallel to supports) has a dry stiffness capacity (EI) of 8,100 lb.-in.²/ft. This capacity is adjusted by a C_G factor of 5.2 for OSB Structural I as shown in Table 3.1.1. The deflection limit for live load is $\ell/240$.

$$\begin{aligned}\Delta &= \frac{W\ell_3^4}{2,220 EI} \\ &= \frac{1.0(24-1.5+0.25)^4}{2,220(8,100 \times 5.2)} \\ &= 2.865 \times 10^{-3} \text{ in.} \\ w_d &= \frac{\Delta_{\text{all}}}{\Delta} = \frac{24/240}{2.865 \times 10^{-3}} = 35 \text{ psf}\end{aligned}$$

Example 3: Floor

A COM-PLY single floor 24 oc panel is to be used in a floor system over supports 24 in. on center. The panels will be placed with the long panel dimension (strength axis) perpendicular to supports. Supports are 2-in.-nominal framing members. The capacity of the panel will be computed based on bending strength, shear strength in the plane and bending stiffness.

Bending Strength

From Table 3.1, a single floor 24 oc panel with stress applied parallel to the strength axis (long panel dimension perpendicular to supports) has a bending strength capacity ($F_b S$) of 640 lb.-in./ft. This capacity is adjusted by a C_G factor of 1.2 as shown in Table 3.1.1 for COM-PLY. From Section 7.1, a three-span condition is assumed.

$$\begin{aligned}
 w_b &= \frac{120F_b S}{\ell_1^2} \\
 &= \frac{120(640 \times 1.2)}{24^2} \\
 &= 160 \text{ psf}
 \end{aligned}$$

Shear Strength in the Plane

From Table 3.3, a single floor 24 oc panel with stress applied parallel to the strength axis has shear strength in the plane (F_s [lb/Q]) equal to 250 lb./ft. This capacity is adjusted by a C_G factor of 1.0 as shown in Table 3.3.1 for COM-PLY.

$$\begin{aligned}
 w_s &= \frac{20 F_s (\text{lb/Q})}{\ell_2} \\
 &= \frac{20(250 \times 1.0)}{(24 - 1.5)} \\
 &= 222 \text{ psf}
 \end{aligned}$$

Bending Stiffness

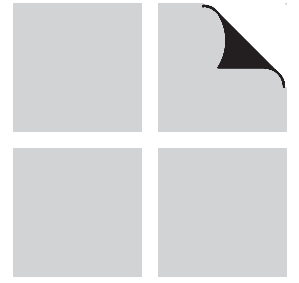
From Table 3.1, a single floor 24 oc panel with stress applied parallel to the strength axis has a dry stiffness capacity (EI) of 300,000 lb.-in.²/ft. This capacity is adjusted by a C_G factor of 1.1 as shown in Table 3.1.1 for COM-PLY. The deflection limit for live load is $\ell/360$.

$$\begin{aligned}
 \Delta &= \frac{w \ell^3}{1,743 EI} \\
 &= \frac{1.0(24 - 1.5 + 0.25)^4}{1,743(300,000 \times 1.1)} \\
 &= 4.657 \times 10^{-4} \text{ in.} \\
 w_d &= \frac{\Delta_{\text{all}}}{\Delta} = \frac{24/360}{4.657 \times 10^{-4}} = 143 \text{ psf}
 \end{aligned}$$

While the above calculations would indicate that this single floor construction has a live load capacity of 143 psf (limited by bending stiffness), it is important to note that some structural panel applications are not controlled by uniform load. Residential floors, commonly designed for 40 psf live load, are a good example. The calculated allowable load is greatly in excess of the typical design load.

This excess does not mean that floor spans for single floor panels can be increased, but only that there is considerable reserve strength and stiffness for uniform loads. Recommended maximum spans for structural panel floors are based on deflection under concentrated loads, how the “floor” responds to passing foot traffic, and other subjective factors which relate to user acceptance. Always check the maximum floor and roof spans for structural panels before making a final selection for these applications.

SUPPLEMENT
**Wood Structural
Panel Shear Wall
and Diaphragm**

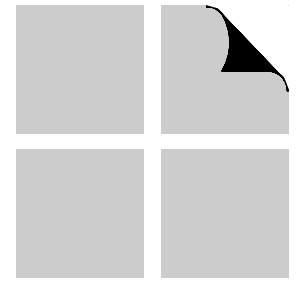


A S D

ALLOWABLE | STRESS | DESIGN

**MANUAL FOR ENGINEERED
WOOD CONSTRUCTION**

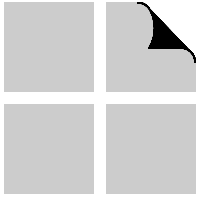
SUPPLEMENT
Wood Structural
Panel Shear Wall
and Diaphragm



A S D

A L L O W A B L E S T R E S S D E S I G N

MANUAL FOR ENGINEERED
WOOD CONSTRUCTION



Preface

This Supplement contains tabulated recommended shear values for wood structural panel diaphragms and shear walls framed with lumber, required to design in the ASD format. The Supplement also contains methods by which diaphragm and shear wall deflection can be calculated, as well as design examples illustrating various aspects of the document. Design shear values are based on data from testing conducted by APA—The Engineered Wood Association. Application recommendations given herein have been developed by APA through field experience and laboratory testing over more than 50 years.

The tabulated recommended shear values for diaphragms and shear walls in this Supplement are used in conjunction with the design methodologies provided in

ANSI/AF&PA NDS-2001, *National Design Specification® (NDS®) for Wood Construction*.

The tabulated recommended shear values for diaphragms and shear walls are to be used within the reference end-use conditions defined therein. When the end-use conditions fall outside the range of the reference conditions in the tables, the design capacities shall be adjusted by the product of the applicable factors defined in this Supplement or contact one of the inspection and testing agencies included in Section 2.4 of this Supplement.

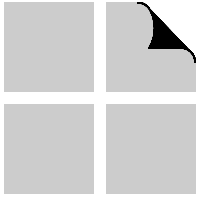
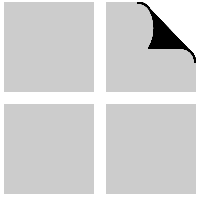


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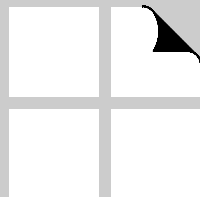
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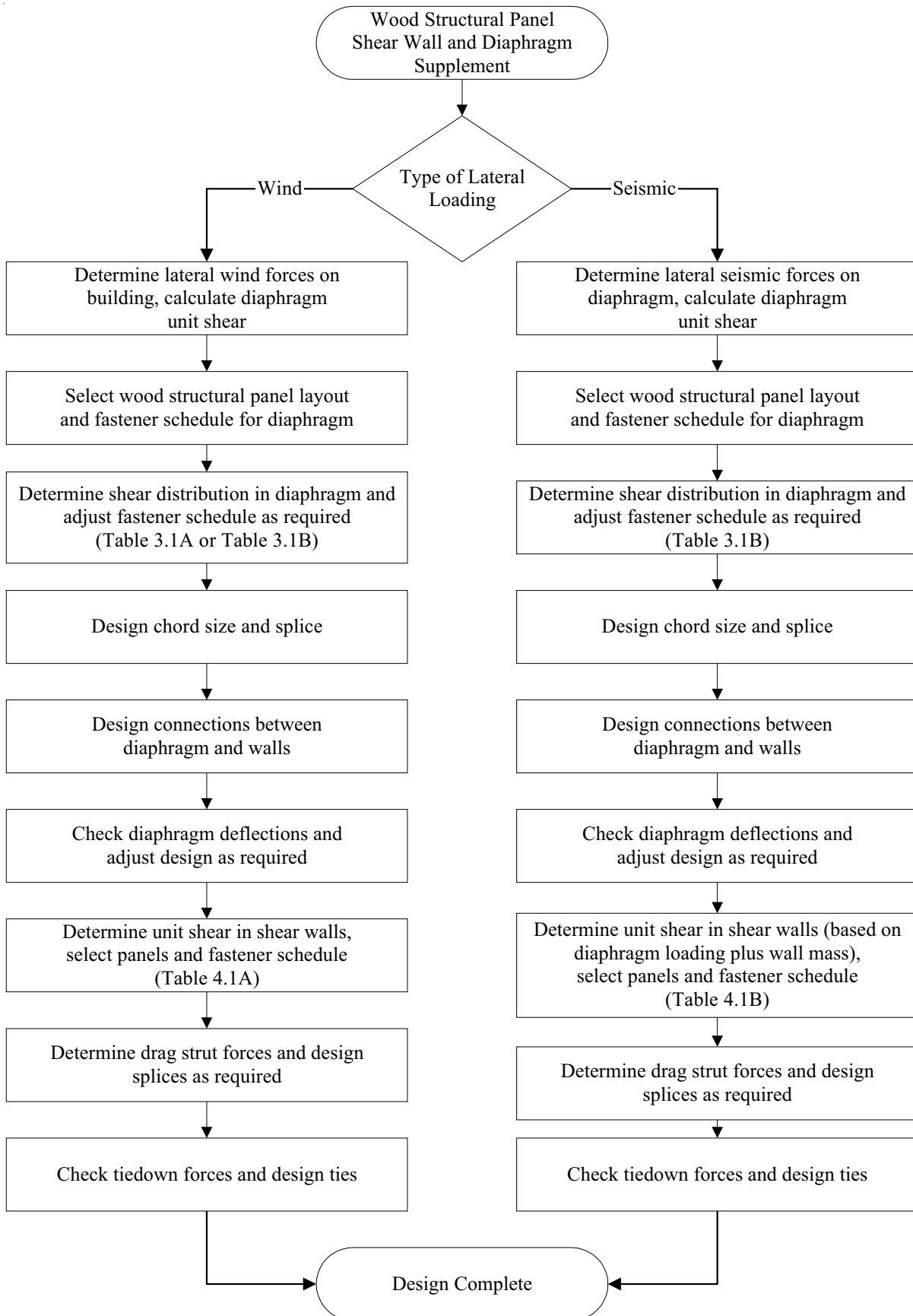
DESIGNER FLOWCHART

1.1 Flowchart

SW-2

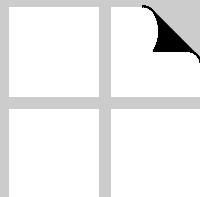


1.1 Flowchart



INTRODUCTION

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2.1 Scope

This Supplement addresses the design of wood framed wood structural panel sheathed diaphragms and shear walls. The Supplement does not cover the method in which lateral loads are determined, nor cover “prescriptive requirements” for non-engineered wall and roof construction, as these topics are addressed in complete detail by the applicable model building codes.

2.2 Terminology

Base Shear – the total reaction at the base of a wall parallel to the axis of the wall or structure due to an applied lateral load; a “sliding” force.

Boundary Element – Diaphragm and shear wall boundary members to which sheathing transfers forces. Boundary elements include chords and drag struts at diaphragm and shear wall perimeters, interior openings, discontinuities and re-entrant corners.

Box-type Structure – when diaphragms and shear walls are used as the lateral force resisting system of a building, the structural system is called a “box system.”

Chord – A boundary element perpendicular to the applied load that is assumed to resist axial stresses due to the induced moment.

Collector – A diaphragm or shear wall element parallel and in line with the applied force that collects and transfers diaphragm shear forces to the vertical elements of the lateral force-resisting system and/or distributes forces within the diaphragm.

Diaphragm – A roof, floor or other membrane bracing system acting to transmit lateral forces to the vertical resisting elements. When the term “diaphragm” is used, it includes horizontal bracing systems.

Diaphragm, Blocked – A diaphragm in which all adjacent sheathing edges are fastened to either common framing or common blocking.

Diaphragm, Flexible – A diaphragm is flexible for the purpose of distribution of story shear and torsional moment when the computed maximum in-plane deflection of the diaphragm itself under lateral load is greater than two times the average deflection of adjoining vertical elements of the lateral force resisting system of the associated story under equivalent tributary lateral load.

Diaphragm, Unblocked – A diaphragm that has edge nailing at supporting members only. Blocking between supporting structural members at panel edges is not included. Diaphragm panels are field nailed to supporting members.

Drag Strut – a structural building component that distributes the diaphragm shear from one building element to another; typically served by the double top plate. Drag struts are oriented parallel to the applied load. Also known as a collector.

Lateral Load – horizontal forces that result from wind or seismic forces. Wind forces act on the side of the building and on sloped roofs. Seismic forces result from ground accelerations causing inertial forces to act on the structural mass.

Load Path – the path taken by a force acting on a building. Loads are transferred by the elements in the building and by the connections between those elements into the foundation.

Overturning – the resulting “tip-over” force when a lateral force acts on a wall or structure and the wall is restrained from sliding.

Shear Wall – a vertical, cantilevered diaphragm that is constructed to resist lateral shear loads by fastening wood structural panels over wood wall framing. This structural system transfers lateral forces from the top of the wall to the bottom of the wall and eventually transfers the lateral loads to the foundation.

Shear Wall Segment – a portion of the shear wall that runs from the diaphragm above to the diaphragm/foundation below; also known as “full-height segments”. Shear wall segments occur between building wall discontinuities such as doors, windows or corners in the shear wall.

Subdiaphragm – A portion of a larger wood diaphragm designed to anchor and transfer local forces to primary diaphragm struts and the main diaphragm.

Tie-Down (Hold-Down) – A device used to resist uplift of the chords of shear walls.

Wall Bracing – a building element that resists lateral loads in conventional (non-engineered) applications; the configuration and connections are prescribed by the building codes for light-framed wood structures.

Wood Structural Panel – A panel manufactured from veneers; or wood strands or wafers; or a combination of veneer and wood strands or wafers; bonded together with waterproof synthetic resins or other suitable bonding systems. Examples of wood structural panels are plywood, oriented strand board (OSB), or composite panels.

2.3 Background

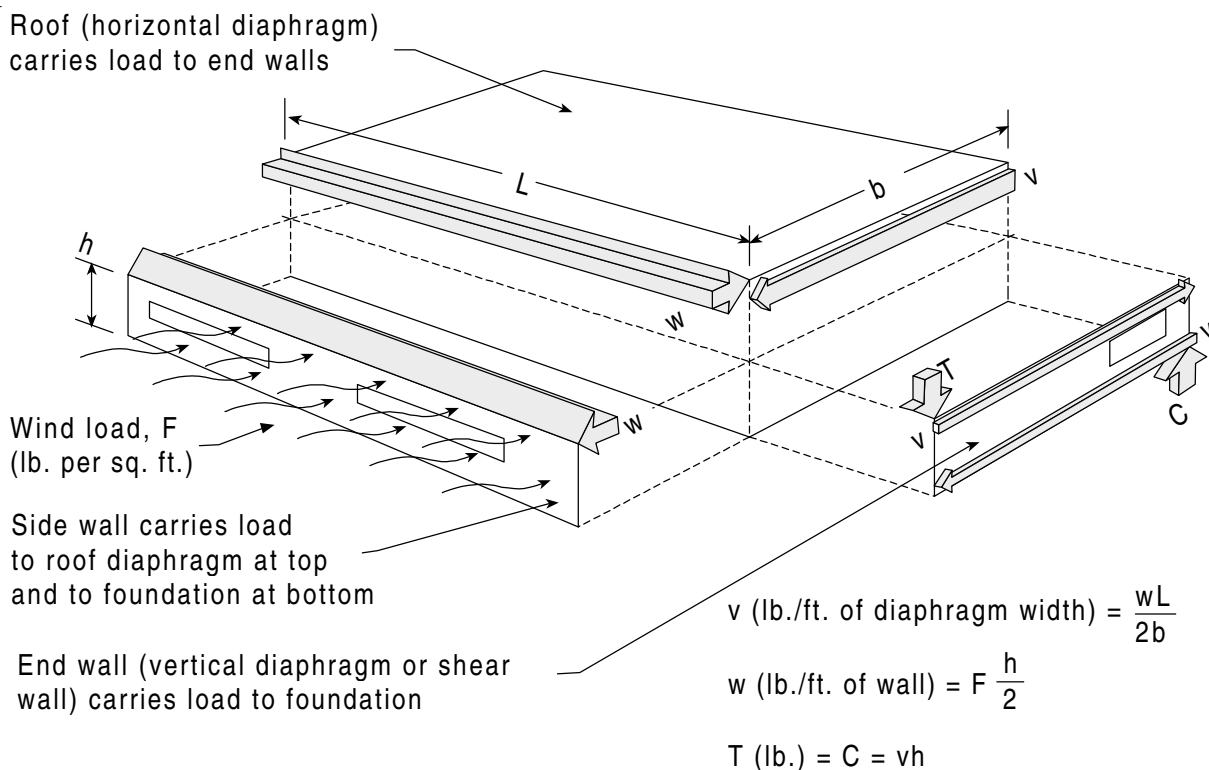
Shear walls and diaphragms are designed to transfer in-plane forces. When using these two assemblies to resist lateral design forces of buildings, the structural system is sometimes referred to as a “box system”. The shear walls provide reactions for the roof and floor diaphragms, and transmit the forces into the foundation (see Figure 2.1).

With ordinary good construction practice, any sheathed element in a building adds considerable strength to the

structure. Thus, if the walls and roofs are sheathed with panels and are adequately tied together, and tied to the foundation, many of the requirements of a diaphragm structure are met. This fact explains the durability of wood structural panel sheathed buildings in hurricane and earthquake conditions even when they have not been engineered as diaphragms or shear walls per se.

There are various textbooks and other resources which provide in-depth coverage of this topic (see section A.2).

Figure 2.1 Distribution of Lateral Loads on Buildings (Wind Illustrated)



For the purposes of this Supplement, the following assumptions are made:

- These assemblies act as deep beams.
- In-plane shear resistance is provided by the wood structural panels.
- Axial tension and compression resistance is provided by the chord members (flange action).
- Nailed assemblies, as shown in Tables 3.1A, 3.1B, 4.1A and 4.1B, exhibit ductile, energy absorbing behavior.

While shear resistance of these assemblies can be computed by principles of engineering mechanics (see Tissell and Elliot, 1997), it is recommended that designers use Tables 3.1A, 3.1B, 4.1A and 4.1B for typical design purposes. In addition to eliminating labor intensive calculations, these tables limit configurations to those that have proven to exhibit the aforementioned ductile behavior by demonstration via structural testing and years of successful in-use performance.

2.4 Inspection and Testing Agencies

Additional information is available from organizations providing trademarking and quality assurance services:

APA - The Engineered Wood Association

7011 South 19th Street

P.O. Box 11700

Tacoma, WA 98411-0700

Phone: 253-565-6600

Fax: 253-565-7265

Internet Address: www.apawood.org

APA Product Support Help Desk

Phone 253-620-7400

E-mail help@apawood.org

Professional Services Industries, Inc.

Pittsburgh Testing Laboratory Division

2710 West 5th Ave.

Eugene, OR 97402

Phone: 541-484-9212

Fax: 541-344-2735

Internet Address: www.psiusa.com

TECO

2402 Daniels St.

Madison, WI 53718

Phone: 608-221-3361

Fax: 608-226-0885

Internet Address: www.tecotested.com

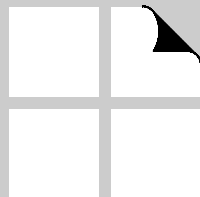
DIAPHRAGMS

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**Table 3.1A Recommended Shear (pounds per foot)
For Horizontal Wood Structural Panel
Diaphragms with Framing of Douglas
fir-Larch or Southern Pine for Wind
Loading Only SW-10**

**Table 3.1B Recommended Shear (pounds per foot)
For Horizontal Wood Structural Panel
Diaphragms with Framing of Douglas
fir-Larch or Southern Pine for Seismic
Loading SW-11**

**Table 3.2 “e_n” Values (inches) For Use In
Calculating Shear Wall and Diaphragm
Deflection Due to Nail Slip (Structural I) .. SW-12**



3.1 General

Panel diaphragms have been used extensively for roofs, floors and walls, for new construction and rehabilitation of older buildings. A complete diaphragm analysis includes analyzing chord forces, connections and, if applicable, cross ties and drag struts.

A diaphragm acts in a manner analogous to a deep beam or girder where the panels act as a “web” resisting shear while the diaphragm edge members perform the function of “flanges” resisting axial stresses. These edge members are commonly called chords in diaphragm design, and may be joists, ledgers, trusses, bond beams, studs, etc.

Due to the great depth of most diaphragms in the directions parallel to application of load, and to their means of assembly, their behavior differs slightly from that of the usual, relatively shallow beam. Shear stresses have been shown to be essentially uniform across the depth of the diaphragm rather than showing significant parabolic distribution as in the web of a shallow beam. Similarly, chords in a diaphragm carry all “flange” stresses acting in simple tension and compression rather than sharing these stresses significantly with the web. As in any beam, consideration must be given to bearing stiffeners, continuity of webs and chords, and to web buckling which is normally resisted by framing members.

Diaphragms vary considerably in load-carrying capacity, depending on whether they are “blocked” or “unblocked” (see Figure 3.1). Blocking consists of lightweight nailers, usually 2x4s, framed between the joists or other primary structural supports for the specific purpose of connecting the edges of the panels. Systems which provide support framing at all panel edges, such as panelized roofs, are also considered blocked. The reason for blocking in diaphragms is to allow connection of panels at all edges for better shear transfer. Design loads for unblocked diaphragms may be limited by buckling of the unsupported

panel edges. Additional nailing will have little effect on the buckling performance of the unblocked diaphragm. For the same nail spacing, design load on a blocked diaphragm can be designed to be as high as twice the design load of its unblocked counterpart.

Figure 3.1 Blocking

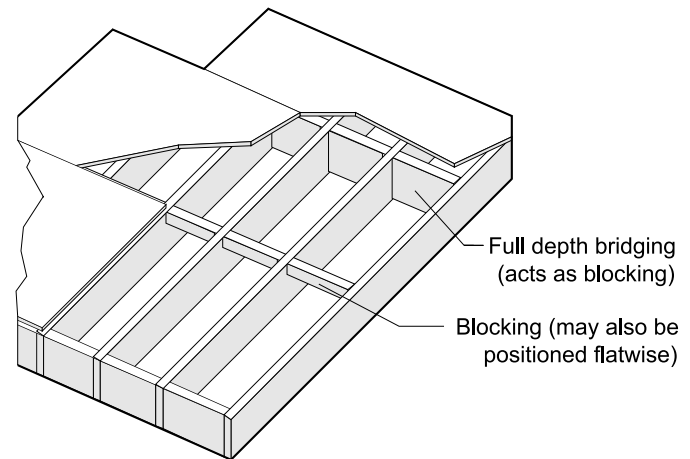


Table 3.1A and 3.1B present the tabulated values for both blocked diaphragms and unblocked diaphragms for wind loading and seismic loading, respectively. Some model building codes have adopted a 40% increase for allowable diaphragm resistance when subjected to wind loading. For the convenience of the user of this Supplement, Table 3.1A reflects the 40% increase that may be permissible. **The designer should confirm that the increase is applicable under the local code; if not applicable, use Table 3.1B.** The basis for the increase is a change in design philosophy for estimating wind forces. In addition, the increase helps to account for better understanding of wind loads and the historical excellent performance of diaphragms subjected to high wind events.

3.2 Using Diaphragm Tables

Example One:

Given:

- residential roof diaphragm
- wind loading
- trussed roof
- unblocked diaphragm required
- required diaphragm capacity is 250 lb./ft.
- panel orientation is unknown

Find:

Panel thickness, nail size and nailing schedule

Solution:

Using Table 3.1A, refer to the “Unblocked Diaphragm” area of the table. As panel orientation is unknown, use the “All other configurations...” column since these values will be conservative. Check “SHEATHING...” rows first since Structural I may not be readily available in all

areas. Similarly, check only rows with 2-inch minimum nominal framing width as the framing is made up of trusses. From the table, see that 8d nails with 15/32-inch sheathing over 2x framing yields a capacity of 250 lb./ft. with the standard 6- and 12-inch nail spacing. As 250 lb./ft. is equal to the required 250 lb./ft. capacity, this selection is OK for use.

Example Two:

Given:

- commercial roof diaphragm
- seismic loading
- trussed roof
- required diaphragm capacity is 350 lb./ft.
- Case 1 panel orientation

Find:

Panel thickness, nail size and nailing schedule

Solution:

Using Table 3.1B, refer to the “Unblocked Diaphragm” area of the table first. You will find that no solution is possible. Next, check the “Blocked Diaphragm” area of the table. Check “SHEATHING...” rows first. Similarly, check only rows with 2-inch minimum nominal framing width as the framing is made up of trusses. From the table, see that 8d nails with 15/32-inch Sheathing over 2x framing yields a capacity of 360 lb./ft. Nails must be placed 4 inches oc at all diaphragm boundaries and 6 inches oc at all other panel edges. As 360 lb./ft. is greater than 350 lb./ft., this selection is OK for use.

Table 3.1A Recommended Shear (pounds per foot) For Horizontal Wood Structural Panel Diaphragms with Framing of Douglas fir-Larch or Southern Pine^a for Wind Loading Only

					Blocked Diaphragms				Unblocked Diaphragms			
					Nail Spacing (in.) at diaphragm boundaries (all cases), at continuous panel edges parallel to load (Cases 3 & 4), and at all panel edges (Cases 5 & 6) ^b				Nails Spaced 6 in. max. at Supported Edges ^b			
					6	4	2-1/2 ^c	2 ^c				
Panel Grade	Common Nail Size	Minimum Nail Penetration in Framing (in.)	Minimum Nominal Panel Thickness (in.)	Minimum Nominal Width of Framing Member (in.)	Nail Spacing (in.) at other panel edges (Cases 1, 2, 3 & 4) ^b				Case 1 (No Unblocked edges or continuous joints parallel to load)	All other configurations (Cases 2, 3, 4, 5 & 6)		
					6	6	4	3				
Structural I grades	6d ^e	1-1/4	5/16	2	260	350	525	590	230	175		
				3	295	390	590	665	260	195		
	8d	1-3/8	3/8	2	380	505	740	840	335	250		
				3	420	560	840	945	370	280		
10d ^d	1-1/2	15/32	2	450	595	895	1020	400	300			
			3	505	670	1010	1150	450	335			
Sheathing, Single-Floors and other structural-use panel grades	6d ^e	1-1/4	5/16	2	240	315	470	530	210	155		
				3	265	350	530	600	240	175		
			3/8	2	260	350	525	590	230	175		
				3	295	390	590	665	260	195		
	8d	1-3/8	3/8	2	335	450	670	765	300	225		
				3	380	505	755	855	335	250		
			7/16	2	355	475	705	805	322	240		
				3	400	530	800	905	375	265		
	15/32	1-1/2	15/32	2	380	505	740	840	335	250		
				3	420	560	840	945	370	280		
			10d ^d	1-1/2	15/32	2	405	540	805	915	355	265
						3	455	600	910	1030	405	300
19/32	1-1/2	19/32	2	450	595	895	1020	400	300			
			3	505	670	1010	1150	450	335			

^a For framing of other species: (1) Find specific gravity for species of framing lumber in the *NDS*. (2) Find shear value from table above for nail size of actual grade. (3) Multiply value by the following adjustment factor = [1 - (0.5 - G)], where G = specific gravity of the framing lumber. This adjustment factor shall not be greater than 1.

^b Space nails maximum 12 in. oc along intermediate framing members (6 in. oc when supports are spaced 48 in. oc).

^c Framing at adjoining panel edges shall be 3 in. nominal or wider, and nails shall be staggered where nails are spaced 2 in. o.c. or 2-1/2 in. oc

^d Framing at adjoining panel edges shall be 3-in. nominal or wider, and nails shall be staggered where 10d nails having penetration into framing of more than 1-5/8 in. are spaced 3 in. oc.

^e 8d is recommended minimum for roofs due to negative pressures of high winds.

Notes: Design for diaphragm stresses depends on direction of continuous panel joints with reference to load, not on direction of long dimension of sheet. Continuous framing may be in either direction for blocked diaphragms.

The recommended shears presented in Table 3.1A are based on the historically used design stresses for diaphragms which are listed in Table 3.1B multiplied by 1.4. Some building codes, including the 2000 *International Building Code*, have provided for this increase due to the better understanding of wind loading. The designer should confirm that the increase is applicable under the local code.

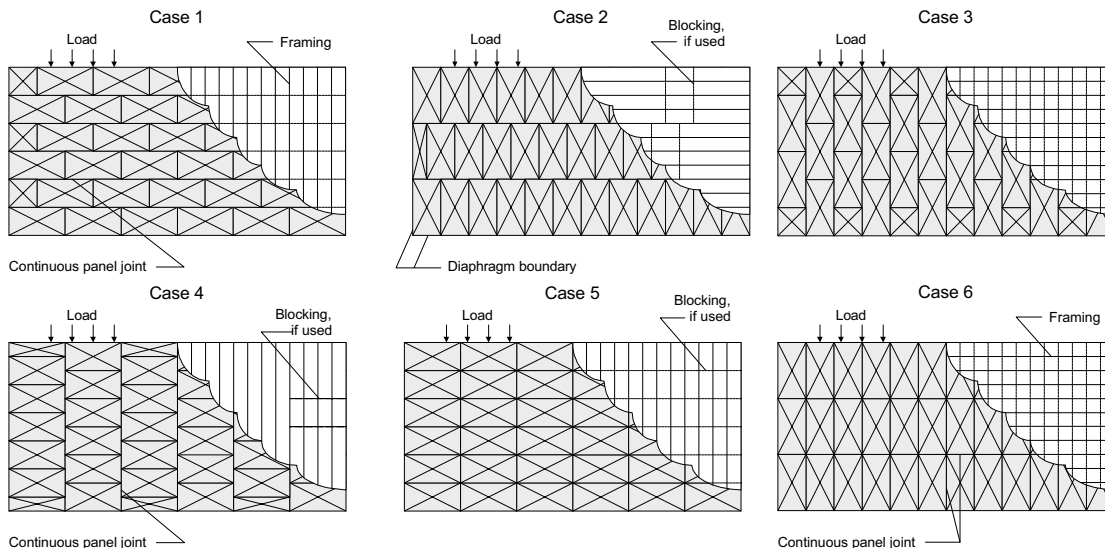


Table 3.1B Recommended Shear (pounds per foot) For Horizontal Wood Structural Panel Diaphragms with Framing of Douglas fir-Larch or Southern Pine^a for Seismic Loading

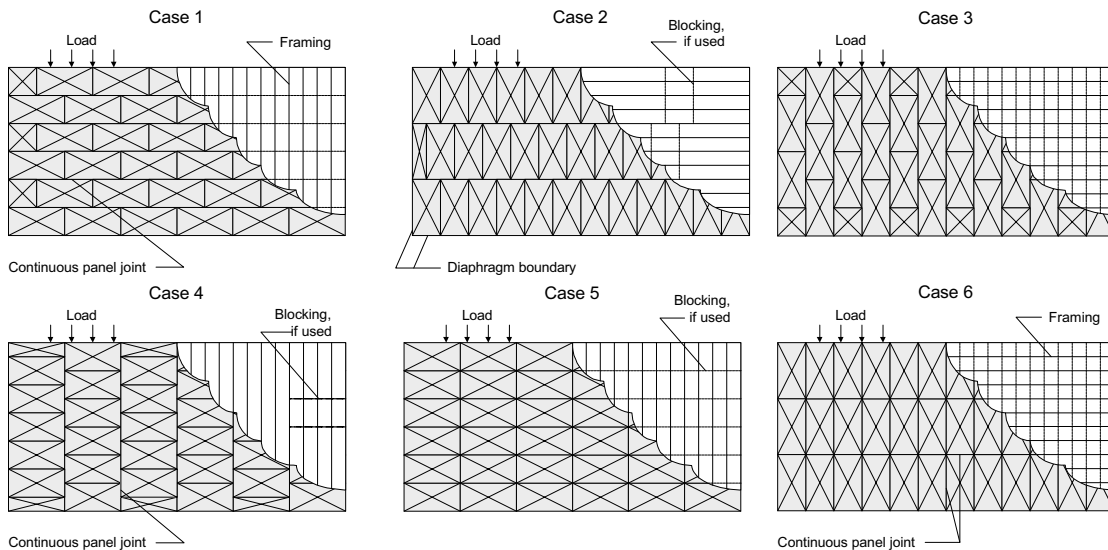
SEISMIC LOADING

Panel Grade	Common Nail Size	Minimum Nail Penetration in Framing (in.)	Minimum Nominal Panel Thickness (in.)	Minimum Nominal Width of Framing Member (in.)	Blocked Diaphragms				Unblocked Diaphragms		
					Nail Spacing (in.) at diaphragm boundaries (all cases), at continuous panel edges parallel to load (Cases 3 & 4), and at all panel edges (Cases 5 & 6) ^b				Nails Spaced 6 in. max. at Supported Edges ^b		
					6	4	2-1/2 ^c	2 ^c			
					Nail Spacing (in.) at other panel edges (Cases 1, 2, 3 & 4) ^b			Case 1 (No Unblocked edges or continuous joints parallel to load)	All other configurations (Cases 2, 3, 4, 5 & 6)		
					6	6	3				
Structural I Grades	6d ^e	1-1/4	5/16	2	185	250	375	420	165	125	
				3	210	280	420	475	185	140	
	8d	1-3/8	3/8	2	270	360	530	600	240	180	
				3	300	400	600	675	265	200	
	10d ^d	1-1/2	15/32	2	320	425	640	730	285	215	
				3	360	480	720	820	320	240	
Sheathing, Single-Floor and other structural-use panel grades	6d ^e	1-1/4	5/16	2	170	225	335	380	150	110	
				3	190	250	380	430	170	125	
				3/8	2	185	250	375	420	165	125
				3	210	280	420	475	185	140	
	8d	1-3/8	3/8	2	240	320	480	545	215	160	
				3	270	360	540	610	240	180	
				2	255	340	505	575	230	170	
				3	285	380	570	645	255	190	
	10d ^d	1-1/2	15/32	2	270	360	530	600	240	180	
				3	300	400	600	675	265	200	
2				290	385	575	655	255	190		
3				325	430	650	735	290	215		
			19/32	2	320	425	640	730	285	215	
			3	360	480	720	820	320	240		

^a For framing of other species: (1) Find specific gravity for species of framing lumber in the *NDS*.
 (2) Find shear value from table above for nail size of actual grade.
 (3) Multiply value by the following adjustment factor = [1 - (0.5 - G)], where G = specific gravity of the framing lumber. This adjustment factor shall not be greater than 1.
^b Space nails maximum 12 in. o.c. along intermediate framing members (6 in. o.c. when supports are spaced 48 in. o.c.).
^c Framing at adjoining panel edges shall be 3 in. nominal or wider, and nails shall be staggered where nails are spaced 2 in. o.c. or 2-1/2 in. o.c.

^d Framing at adjoining panel edges shall be 3-in. nominal or wider, and nails shall be staggered where 10d nails having penetration into framing of more than 1-5/8 in. are spaced 3 in. o.c.
^e 8d is recommended minimum for roofs due to negative pressures of high winds.

Notes: Design for diaphragm stresses depends on direction of continuous panel joints with reference to load, not on direction of long dimension of sheet. Continuous framing may be in either direction for blocked diaphragms



3.3 Diaphragm Deflection

Calculations for diaphragm deflection shall account for the usual bending and shear components as well as many other factors, such as nail deformation, which will contribute to the deflection.

The deflection (Δ) of a blocked wood structural panel diaphragm uniformly nailed throughout may be estimated by use of the following formula.

$$\Delta = \frac{5vL^3}{8EAb} + \frac{vL}{4Gt} + 0.188Le_n + \frac{\sum(\Delta_c X)}{2b}$$

where:

- A = area of chord cross section, in.²
- b = diaphragm width, ft.
- E = elastic modulus of chords, psi
- e_n = nail deformation, in. (see Table 3.2).
- G = modulus of rigidity of wood structural panels, psi (see Wood Structural Panel Supplement).
- L = diaphragm length, ft.
- t = effective thickness of wood structural panels for shear, in. (see Wood Structural Panel Supplement).

v = maximum shear due to design loads in direction under consideration, pounds per linear foot.

Δ = the calculated deflection, in.

$\sum(\Delta_c X)$ = sum of individual chord-splice slip values of the diaphragm, each multiplied by its distance to the nearest support, in.

A review of diaphragm tests suggests that the deflection of an unblocked diaphragm at its tabulated allowable shear capacity will be about 2.5 times the calculated deflection of a blocked diaphragm of similar construction and dimensions, at the same shear capacity. If diaphragm framing is spaced more than 24 inches oc, testing indicates a further increase in deflection of about 20% for unblocked diaphragms (e.g., to 3 times the deflection on a comparable blocked diaphragm). This relationship can be used to develop an estimate of the deflection of unblocked diaphragms.

Table 3.2 “e_n” Values (inches) For Use In Calculating Shear Wall and Diaphragm Deflection Due to Nail Slip (Structural I)^a

Fastener	Minimum Penetration (in.)	For Maximum Loads Up to (lb.)	Appropriate Slip, e _n (in.) ^{a,b}	
			Green/Dry	Dry/Dry
6d common nail	1-1/4	180	$(V_n/434)^{2.314}$	$(V_n/456)^{3.144}$
8d common nail	1-3/8	220	$(V_n/857)^{1.869}$	$(V_n/616)^{3.018}$
10d common nail	1-1/2	260	$(V_n/977)^{1.894}$	$(V_n/769)^{3.276}$
14-ga staple	1 to 2	140	$(V_n/902)^{1.464}$	$(V_n/596)^{1.999}$
14-ga staple	2	170	$(V_n/674)^{1.873}$	$(V_n/461)^{2.776}$

^a Fabricated green/tested dry (seasoned); fabricated dry/tested dry. V_n = Fastener Load (lb./nail).

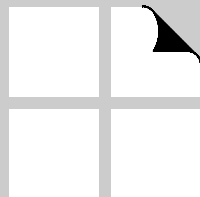
^b Values based on Structural I plywood fastened to lumber with a specific gravity of 0.50 or greater. Increase slip by 20% when plywood is not Structural I.

SHEAR WALLS

4.1	General	SW-14
4.2	Using Shear Wall Tables	SW-14
4.3	Shear Wall Deflection	SW-17

**Table 4.1A Recommended Shear (pounds per foot)
For Wood Structural Panel Shear Walls
with Framing of Douglas fir-Larch or
Southern Pine For Wind Loading Only ... SW-15**

**Table 4.1B Recommended Shear (pounds per foot)
For Wood Structural Panel Shear Walls
with Framing of Douglas fir-Larch or
Southern Pine For Seismic Loading SW-16**



4.1 General

A shear wall behaves similar to a horizontal diaphragm. In fact, a shear wall is simply a cantilevered diaphragm to which load is applied at the top of the wall and is transferred to the foundation along the bottom of the wall. This creates a potential for overturning which must be accounted for, and any over-turning force is typically resisted by hold-downs, or tension ties, at each end of the shear wall segments.

Tables 4.1A and 4.1B present the tabulated values for wood structural panel sheathed wood frame shear walls for wind loading and seismic loading, respectively. Some model building codes have adopted a 40% increase for

allowable shear wall resistance when subjected to wind loading. For the convenience of the user of this Supplement, Table 4.1A reflects the 40% increase that may be permissible. **The designer should confirm that the increase is applicable under the local code; if not applicable, use Table 4.1B.** The basis for the increase is a change in design philosophy for estimating wind forces. In addition, the increase helps to account for better understanding of wind loads and the historical excellent performance of shear walls subjected to high wind events.

4.2 Using Shear Wall Tables

Example One:

Given:

- commercial building
- wind loading
- wall requires 5/8-inch gypsum sheathing on the exterior of the building for 1-hour fire separation
- required shear wall capacity is 670 lb./ft.

Find:

Panel thickness, nail size and nailing schedule

Solution:

Ensure that the locally accepted building code allows the 40% increase for wind load incorporated in Table 4.1A. Using Table 4.1A, check the “Panels applied over 1/2-inch or 5/8-inch gypsum sheathing” area of table. Check “SHEATHING...” rows first since Structural I may not be readily available in all areas. From the table, see that 10d nails with a 3- and 12-in. nail spacing and any thickness of Sheathing will provide a capacity of 685 lb./ft. provided that the framing at adjoining panel edges is 3-inch nominal or wider. As 685 lb./ft. is greater than 670 lb./ft., this selection is OK for use.

Example Two:

Given:

- residential building
- seismic loading
- typical wall sheathing thickness of 7/16 inch
- typical nail size of 8d common
- wall stud spacing of 24 inches oc.
- required shear wall capacity is 435 lb./in.

Find:

Required nail spacing

Solution:

Using Table 4.1B, check the “Panels applied direct to framing” area of table. Check “SHEATHING...” rows first because Structural I may not be readily available in all areas. From the table, see that 7/16-inch structural-use panels, 8d nails with a 3- and 6-in. nail spacing (see footnote b) will provide a capacity of 450 lb./ft. As 450 lb./ft. is greater than 435 lb./ft., this selection is OK for use.

Table 4.1A Recommended Shear (pounds per foot) For Wood Structural Panel Shear Walls with Framing of Douglas fir-Larch or Southern Pine^a For Wind Loading Only^b

WIND LOADING ONLY												
Panel Grade	Minimum Nominal Panel Thickness (in.)	Minimum Nail Penetration in Framing (in.)	Panels Applied Direct to Framing					Panels Applied Over 1/2 in. or 5/8 in. Gypsum Sheathing				
			Nail Size (common or Galvanized box)	Nail Spacing at Panel Edges (in.)				Nail Size (common or Galvanized box)	Nail Spacing at Panel Edges (in.)			
				6	4	3	2 ^e		6	4	3	2 ^e
Structural I grades	5/16	1-1/4	6d	280	420	545	715	8d	280	420	545	715
	3/8	1-3/8	8d	320 ^d	505 ^d	645 ^d	855 ^d	10d	390	600	770 ^f	1020
	7/16			355 ^d	555 ^d	705 ^d	940 ^d					
	15/32			390	600	770	1020					
15/32	1-1/2	10d	480	715	930 ^f	1220	-	-	-	-		
Sheathing, Plywood Siding ^g and other structural-use panel grades	5/16 or 1/4 ^c	1-1/4	6d	250	270	490	630	8d	250	380	490	630
	3/8			280	420	545	715		280	420	545	715
	3/8	1-3/8	8d	310 ^d	450 ^d	575 ^d	740 ^d	10d	365	530	685 ^f	895
	7/16			335 ^d	490 ^d	630 ^d	820 ^d					
	15/32			365	530	685	895					
15/32	1-1/2	10d	435	645	840 ^f	1080	-	-	-	-		
19/32			475	715	930 ^f	1220	-	-	-	-		
Plywood Siding ^g and other structural-use panel grades			Nail Size (galvanized casing)				Nail Size (galvanized casing)					
	5/16 ^c	1-1/4	6d	195	295	385	505	8d	195	295	385	505
	3/8	1-1/2	8d	225	335	435	575	10d	225	335	435 ^f	575

- ^a For framing of other species: (1) Find specific gravity for species of framing lumber in the *NDS*. (2) Find shear value from table above for nail size of actual grade. (3) Multiply value by the following adjustment factor = $[1 - (0.5 - G)]$, where G = specific gravity of the framing lumber. This adjustment factor shall not be greater than 1.
- ^b All panel edges backed with 2-in. nominal or wider framing. Install panels either horizontally or vertically. Space nails maximum 6 inches o.c. along intermediate framing members for 3/8-in. and 7/16-in. panels installed on studs spaced 24 in. o.c. For other conditions and panel thickness, space nails maximum 12 in. o.c. on intermediate supports.
- ^c 3/8-in. or Plywood Siding 16 o.c. is minimum recommended when applied direct to framing as exterior siding.
- ^d Shears may be increased to values shown for 15/32-in. sheathing with same nailing provided (1) studs are spaced a maximum of 16 in. o.c., or (2) if panels are applied with long dimension across studs.
- ^e Framing at adjoining panel edges shall be 3-in. nominal or wider, and nails shall be staggered where nails are spaced 2 in. o.c.

- ^f Framing at adjoining panel edges shall be 3-in. nominal or wider, and nails shall be staggered where 10d nails having penetration into framing of more than 1-5/8 in. are spaced 3 in. o.c.
- ^g Values apply to all-veneer plywood Siding panels only. Other Plywood Siding panels may also qualify on a proprietary basis. Plywood Siding 16 o.c. plywood may be 11/32-in., 3/8-in. or thicker. Thickness at point of nailing on panel edges governs shear values.

Notes:
 The recommended shears presented in Table 4.1A are based on the historically used design stresses for shear walls which are listed in Table 4.1B multiplied by 1.4. Some building codes, including the 2000 *International Building Code*, have provided for this increase due to the better understanding of wind loading. The designer should confirm that the increase is applicable under the local code.

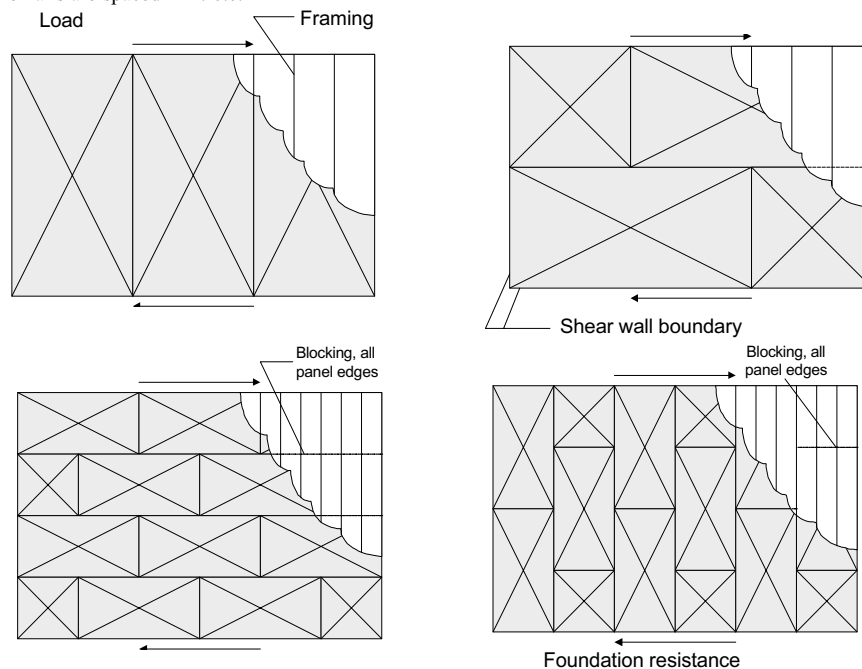
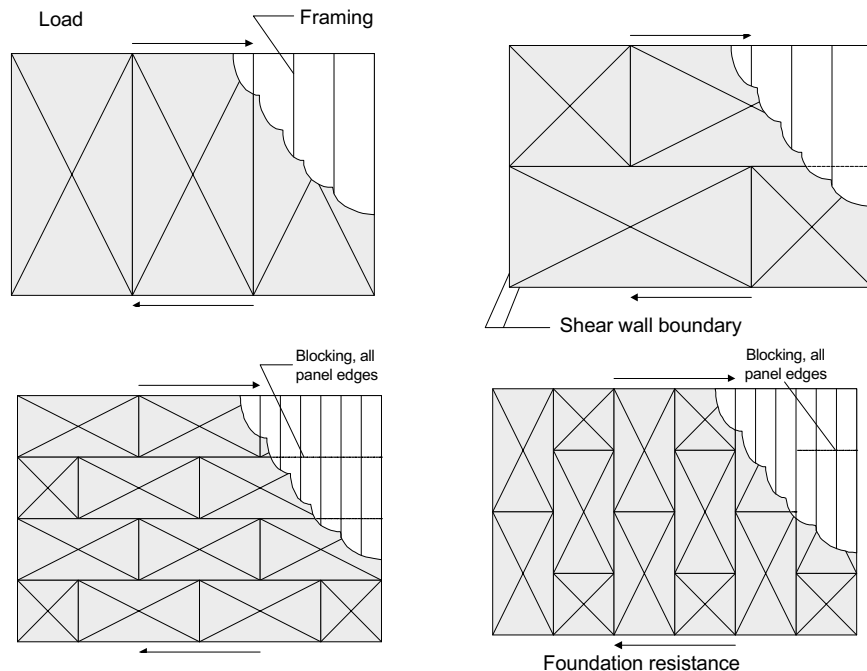


Table 4.1B Recommended Shear (pounds per foot) For Wood Structural Panel Shear Walls with Framing of Douglas fir-Larch or Southern Pine^a For Seismic Loading^b

SEISMIC LOADING												
Panel Grade	Minimum Nominal Panel Thickness (in.)	Minimum Nail Penetration in Framing (in.)	Panels Applied Direct to Framing				Panels Applied Over 1/2 in. or 5/8 in. Gypsum Sheathing					
			Nail Size (common or Galvanized box)	Nail Spacing at Panel Edges (in.)				Nail Size (common or Galvanized box)	Nail Spacing at Panel Edges (in.)			
				6	4	3	2 ^e		6	4	3	2 ^e
Structural I grades	5/16	1-1/4	6d	200	300	390	510	8d	200	300	390	510
	3/8	1-3/8	8d	230 ^d	360 ^d	460 ^d	610 ^d	10d	280	430	550 ^f	730
	7/16			255 ^d	395 ^d	505 ^d	670 ^d					
	15/32			280	430	550	730					
15/32	1-1/2	10d	340	510	665 ^f	870	-	-	-	-		
Sheathing, Plywood Siding ^g and other structural-use panel grades	5/16 or 1/4 ^c	1-1/4	6d	180	270	350	450	8d	180	270	350	450
	3/8			200	300	390	510		200	300	390	510
	3/8	1-3/8	8d	220 ^d	320 ^d	410 ^d	530 ^d	10d	260	380	490 ^f	640
	7/16			240 ^d	350 ^d	450 ^d	585 ^d					
15/32	260			380	490	640						
15/32	1-1/2	10d	310	460	600 ^f	770	-	-	-	-		
19/32			340	510	665 ^f	870	-	-	-	-		
Plywood Siding ^g and other structural-use panel grades			Nail Size (galvanized casing)				Nail Size (galvanized casing)					
	5/16 ^c	1-1/4	6d	140	210	275	360	8d	140	210	275	360
	3/8	1-3/8	8d	160	240	310	410	10d	160	240	310 ^f	410

^a For framing of other species: (1) Find specific gravity for species of framing lumber in the *NDS*.
 (2) Find shear value from table above for nail size of actual grade.
 (3) Multiply value by the following adjustment factor = $[1 - (0.5 - G)]$, where G = specific gravity of the framing lumber. This adjustment factor shall not be greater than 1.
^b All panel edges backed with 2-in. nominal or wider framing. Install panels either horizontally or vertically. Space nails maximum 6 inches o.c. along intermediate framing members for 3/8-in. and 7/16-in. panels installed on studs spaced 24 in. o.c. For other conditions and panel thickness, space nails maximum 12 in. o.c. on intermediate supports.
^c 3/8-in. or Plywood Siding 16 o.c. is minimum recommended when applied direct to framing as exterior siding.

^d Shears may be increased to values shown for 15/32-in. sheathing with same nailing provided (1) studs are spaced a maximum of 16 in. o.c., or (2) if panels are applied with long dimension across studs.
^e Framing at adjoining panel edges shall be 3-in. nominal or wider, and nails shall be staggered where nails are spaced 2 in. o.c.
^f Framing at adjoining panel edges shall be 3-in. nominal or wider, and nails shall be staggered where 10d nails having penetration into framing of more than 1-5/8 in. are spaced 3 in. o.c.
^g Values apply to all-veneer plywood Siding panels only. Other Plywood Siding panels may also qualify on a proprietary basis. Plywood Siding 16 o.c. plywood may be 11/32-in., 3/8-in. or thicker. Thickness at point of nailing on panel edges governs shear values.



4.3 Shear Wall Deflection

The deflection (Δ) of a blocked shear wall uniformly nailed throughout may be estimated by use of the following formula:

$$\Delta = \frac{8vh^3}{EAb} + \frac{vh}{Gt} + 0.75he_n + \frac{h}{b}d_a$$

where:

- A = area of boundary element cross section
(vertical member at shear wall boundary), in.²
- b = wall width, ft.
- d_a = deflection due to vertical anchorage
deformation (rotation and slip at tie-down
bolts), in.

E = elastic modulus of boundary element (vertical member at shear wall boundary), psi

e_n = nail deformation (see Table 3.2), in.

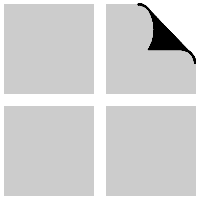
G = modulus of rigidity of wood structural panel
(see Wood Structural Panel Supplement), psi

h = wall height, ft.

t = effective panel thickness for shear (see Wood Structural Panels Supplement), in.

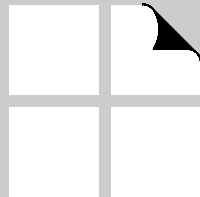
v = maximum shear due to design loads at the top of the wall, plf

Δ = the calculated deflection, in.



OTHER CONSIDERATIONS

5.1	Drag Struts/Collectors	SW-20
5.2	Chords	SW-21
5.3	Subdiaphragms	SW-22
5.4	Shear Wall Overturning	SW-23



5.1 Drag Struts/Collectors

As defined in Section 2.2, the load path for a box-type structure is from the diaphragm into the shear walls running parallel to the direction of the load (i.e., the diaphragm loads the shear walls that support it). Because the diaphragm acts like a long, deep beam, it loads each of the supporting shear walls evenly along the length of the walls. The problem lies with the fact that seldom is each shear wall solid throughout its full length. Typically a wall contains windows and doors.

The traditional model used to analyze shear walls only recognizes full height wall segments as shear wall segments. This means that at locations with windows or doors, a structural element is needed to distribute the diaphragm shear over the top of the opening and into the full height segments adjacent to it. This element is called a drag strut.

In residential construction, the double top-plates existing in most stud walls will serve as a drag strut. It may be necessary to detail the double top plate such that no splices occur in critical zones. Or, it may be necessary to specify the use of a tension strap at butt joints to transfer these forces.

The maximum force seen by drag struts is generally equal to the diaphragm design shear in the direction of the shear wall multiplied by the distance between the shear wall segments.

Drag struts are also used to tie together different parts of an irregularly shaped building.

To simplify design, irregularly shaped buildings (such as “L” or “T” shaped) are typically divided into simple rectangles. When the structure is “reassembled” after the individual designs have been completed, drag struts are used to provide the necessary continuity between these individual segments to insure that the building will act as a whole.

The following figures and generalized equations provide methods to calculate the drag strut forces.

$$\text{Unit shear above opening} = \frac{V}{L} = v_a$$

$$\text{Unit shear below opening} = \frac{V}{L - L_o} = v_b$$

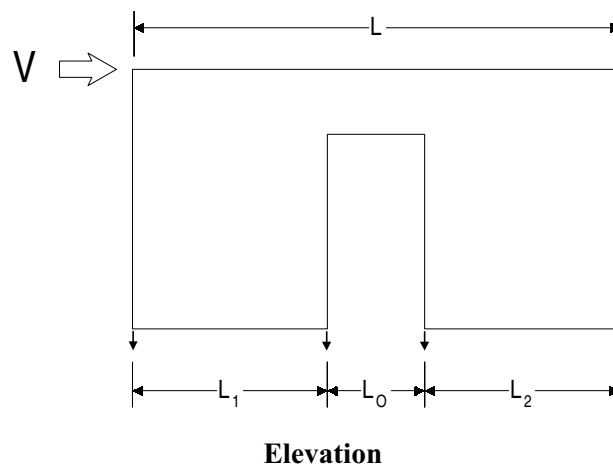
Max. force in drag strut = greater of

$$\frac{V}{L} L_o L_1 = \frac{v_a L_o L_1}{(L - L_o)}$$

or

$$\frac{V}{L} L_o L_2 = \frac{v_a L_o L_2}{(L - L_o)}$$

Figure 5.1 Shear Wall Drag Strut

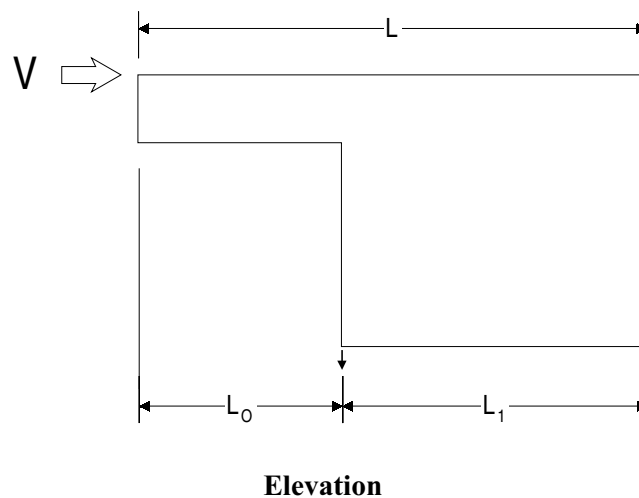


$$\text{Unit shear above opening} = \frac{V}{L} = v_a$$

$$\text{Unit shear below opening} = \frac{V}{L - L_o} = v_b$$

$$\text{Max. force in drag strut} = L_o v_a$$

Figure 5.2 Shear Wall Special Case Drag Strut



$$\text{Unit shear along } L_3 = \frac{W_1 L_1}{2L_3}$$

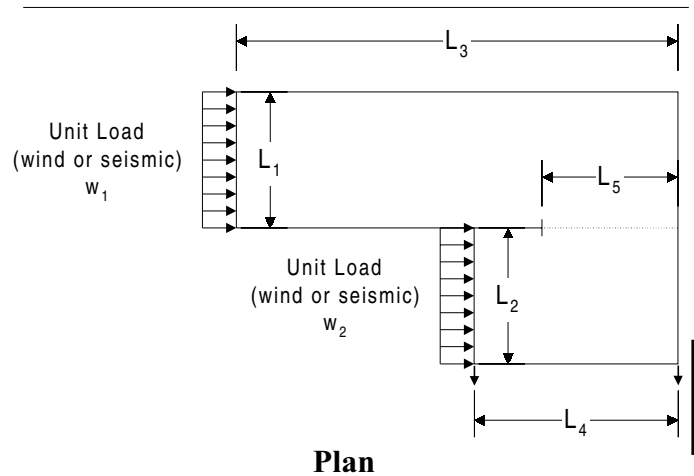
$$\text{Force in drag strut from } L_3 \text{ structure} = \frac{W_1 L_1 (L_5)}{2L_3}$$

$$\text{Unit shear along } L_4 = \frac{W_2 L_2}{2L_4}$$

$$\text{Force in drag strut from } L_4 \text{ structure} = \frac{W_2 L_2 (L_5)}{2L_4}$$

$$\text{Maximum force in drag strut} = \frac{L_5}{2} \left(\frac{W_1 L_1}{L_3} + \frac{W_2 L_2}{L_4} \right)$$

Figure 5.3 Diaphragm Drag Strut
(Drag strut parallel to loads)



5.2 Chords

Diaphragms are assumed to act like long deep beams. This model assumes that shear forces are accommodated by the structural-use panel web of the “beam” and that moment forces are carried by the tension or compression forces in the flanges, or chords of the “beam.” These chord forces are often assumed to be carried by the double top-plate of the supporting perimeter walls. Given the magnitude of the forces involved in most light framed wood construction projects, the double top-plate has sufficient capacity to resist the tensile and compressive forces assuming adequate detailing at the splice locations. A problem lies in wall lines that make a continuous diaphragm chord impossible.

Because shear walls are little more than blocked, cantilevered diaphragms, they too develop chord forces and require chords. The chords in a shear wall are the double studs that are required at the end of each shear wall. Just as the chords need to be continuous in a diaphragm, the chords in a shear wall also need to maintain their continuity. This is accomplished by the tension ties (hold-downs) that are required at each end of each shear wall and between the chords of stacked shear walls to provide overturning restraint.

$$\text{Diaphragm reaction} = \frac{Lw}{2}$$

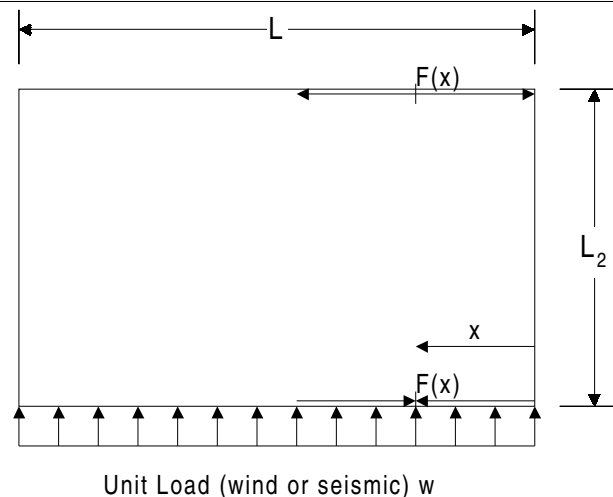
$$\text{Diaphragm unit shear} = \frac{Lw}{2L_2}$$

$$\text{Diaphragm moment} = \frac{wL^2}{8}$$

$$\text{Max. chord force} = \frac{wL^2}{8L_2}$$

$$\text{Chord force at point } x, F(x) = \frac{wLx}{2L_2} - \frac{wx^2}{2L_2}$$

Figure 5.4 Diaphragm Chord Forces



Plan

5

OTHER CONSIDERATIONS

5.3 Subdiaphragms

After the San Fernando earthquake of 1971, a number of code changes were introduced to the *Uniform Building Code* that require continuous cross-ties. These and other code changes that require minimum attachment of concrete and masonry walls to wood diaphragms were proposed and enacted to improve the seismic performance of large flat-roofed structures using flexible structural-use panel diaphragms.

Since the enactment of these code changes, the subdiaphragm (also known as the mini-diaphragm) concept has been recognized and extensively used to provide a method of meeting the wall attachment and continuous cross-tie code requirements while minimizing the number and length of ties required to achieve continuity between chords. A formal definition of a subdiaphragm can be found in the 2000 *International Building Code*, “SUBDIAPHRAGM portion of a larger wood diaphragm designed to anchor and transfer local forces to primary diaphragm struts and the main diaphragm.”

In practice, the subdiaphragm approach is used to concentrate and transfer local lateral forces to main structural members that support the roof vertical loads. The subdiaphragm approach is often an economical solution to code required cross-ties for the following reasons:

- Main structural members are already present
- Main structural members generally span the full length and width of the buildings with few connectors.
- Main structural members are large enough to easily accommodate loads.
- Main structural members are large enough to allow “room” for requisite connections.

In general, the bigger the roof, the greater the savings that can be made by using subdiaphragms.

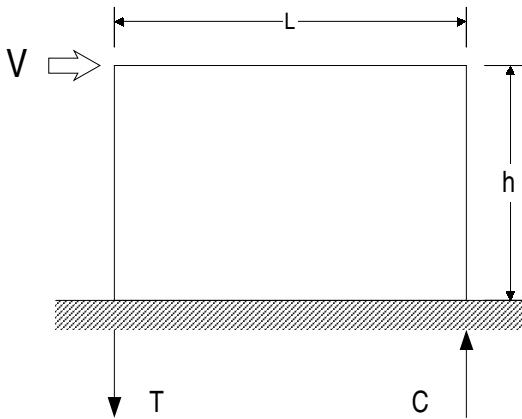
Each subdiaphragm must meet all applicable diaphragm requirements provided in the applicable building code. As such, each subdiaphragm must have chords, continuous tension ties, and sufficient sheathing thickness and attachment to transfer the shear stresses generated within the diaphragm sheathing by the subdiaphragm. In addition, building codes may contain aspect ratios that are specific to subdiaphragms.

The subdiaphragm is actually the same structure as the main roof diaphragm, thus the subdiaphragm utilizes the same roof sheathing to transfer shear stresses as the main diaphragm. As such, sheathing nailing and thickness requirements of the roof diaphragm may not be sufficient for the subdiaphragm requirements. In this case, the subdiaphragm requirements would control and dictate the roof sheathing and fastening requirements in the subdiaphragm locations. Fortunately, the portion of the main diaphragm that is utilized as a subdiaphragm is a choice left to the designer; thus the dimensions of the subdiaphragm can be chosen to minimize potential discontinuities in sheathing thicknesses or nail schedules. Similarly, the roof diaphragm requirements may be more stringent than those for the subdiaphragm. For more information on the subdiaphragm concept and a design example, see APA Form EWS Z350 - Lateral Connection Details for Low-Slope Roofs.

5.4 Shear Wall Overturning

Overturning moments result from shear walls being loaded by horizontal forces. The overturning moments are resisted by force couples. The tension couple is typically achieved by a hold-down. Figure 5.5 and the below equations present a method for calculating overturning forces for a non-load bearing wall. Figure 5.6 and the equations below present a method for calculating overturning forces for a load-bearing wall. Overturning forces for load bearing walls can utilize the dead load as overturning restraint. To effectively resist uplift forces, the holddown restraints are required to show very little slip relative to the chord (end post). FEMA 303 presents a detailed discussion on this topic.

Figure 5.5 Overturning Forces (no dead load)

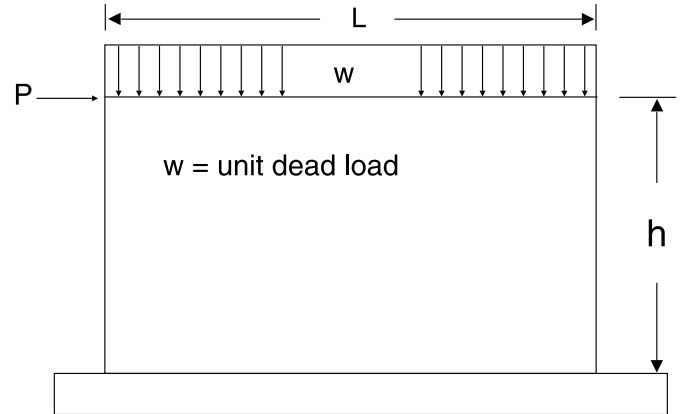


Elevation

$$\text{Unit shear} = \frac{V}{L} = v$$

$$\text{Overturning force} = \text{chord force} = \frac{Vh}{L}$$

Figure 5.6 Overturning Force (with dead load)



Elevation

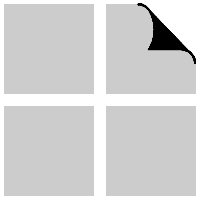
$$\text{Overturning moment} = Ph$$

$$\text{Dead load restraining moment}^* = \frac{wL^2}{2}$$

$$\text{Net overturning moment} = Ph - \frac{wL^2}{2}$$

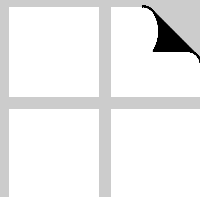
$$\text{Net overturning force} - \text{chord force} = \frac{Ph - \frac{wL^2}{2}}{L} = \frac{Ph}{L} - \frac{wL}{2}$$

* Some building codes require a reduction to the dead load restraining moment to insure an appropriate load factor for overturning.



APPENDICES

A.1	Design Example	SW-26
A.2	Diaphragm and Shear Wall Design References	SW-37

A

A.1 Design Example

Basic Design

Wood structural panel diaphragms and shear walls in one-story building seismic and wind loadings. 25 psf roof design snow load

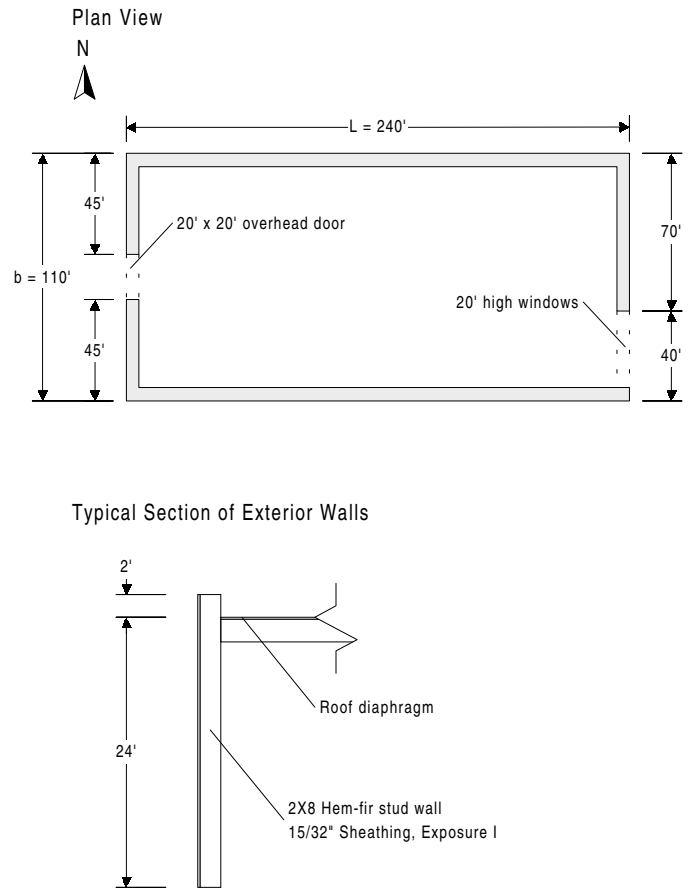
Given:

In Figure A.1, building dimensions and openings as shown. Exterior walls consist of light-framed wood-sheathed shear walls. All framing members are hem-fir lumber unless noted otherwise. The floor is framed with 11-7/8-inch I-joists and interior post-and-beam system. Interior posts are supported by pad footing and exterior walls are supported by continuous concrete wall footings.

Determine:

1. Seismic load and wind load on roof diaphragm along each direction (determined in another analysis).
2. Design unit shear in roof diaphragm along each direction.
3. Roof structural panel layout and fastener schedule.
4. Calculate chord forces.
5. Connections between roof diaphragm and walls.
6. Diaphragm deflection (N-S direction only).
7. Shear in shear walls and shear panel fastener schedule (East and West walls only).
8. Drag strut forces and drag strut connections (East and West walls only).
9. Hold-down forces and hold-down connections (East and West walls only).

Figure A.1 Building Plan View and Typical Section of Exterior Walls



Step 1. Seismic Load and Wind Load on Roof Diaphragm Along Each Direction

Detailed seismic force and wind force calculations are beyond the scope of this Supplement.

For this example, assume the following:

$$V_{\text{seismic } N-S} = 53,768 \text{ lb.}$$

$$V_{\text{seismic } E-W} = 37,752 \text{ lb.}$$

$$V_{\text{wind } N-S} = 61,519 \text{ lb.}$$

$$V_{\text{wind } E-W} = 28,196 \text{ lb.}$$

Step 2. Design Unit Shear in Roof Diaphragm Along Each Direction

The diaphragm is considered flexible if its maximum lateral deformation is more than two times the average shear wall deflection of the associated story. Without further calculations, assume a flexible diaphragm here:

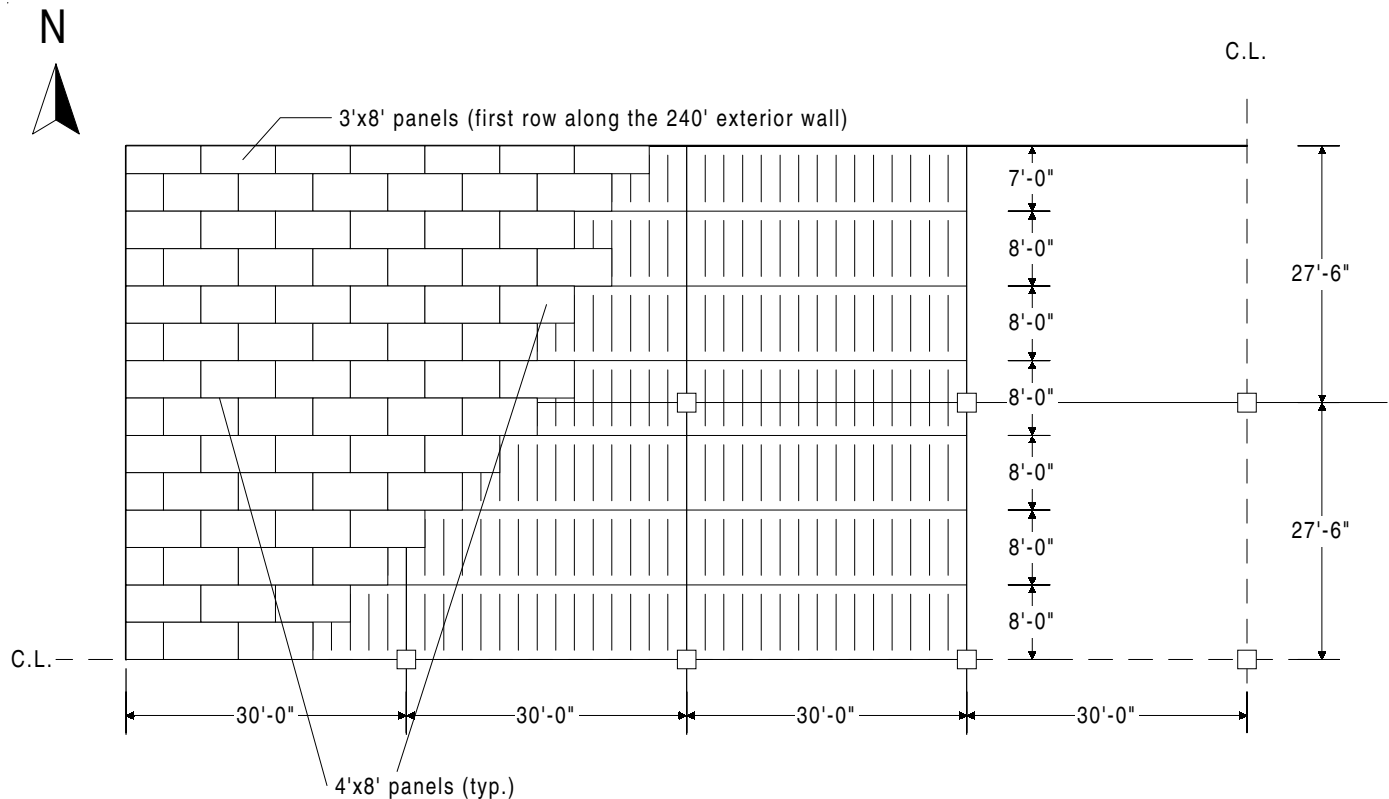
			Total Diaphragm Design Load ¹		Diaphragm Design Unit Shear (lb./ft.)
N-S	$V_{\text{seismic N-S}}$	=	53,768 lb.	$\div 2 \div 110 \text{ ft.} =$	250
	$V_{\text{wind N-S}}$	=	61,519 lb.	$\div 2 \div 110 \text{ ft.} =$	280
E-W	$V_{\text{seismic E-W}}$	=	37,752 lb.	$\div 2 \div 240 \text{ ft.} =$	79
	$V_{\text{wind E-W}}$	=	28,196 lb.	$\div 2 \div 240 \text{ ft.} =$	59

¹ Determined in Step 1, these numbers came from a specific design with certain assumptions.

Step 3. Roof Structural Panel Layout and Fastener Schedule

Roof sheathing thickness has been previously selected based on snow load requirements.

Figure A.2 Roof Framing and Sheathing Layout (Northwest Quadrant)



All framing members to be Hem-fir and sheathing to be 15/32" wood structural panels with 8d common nails.

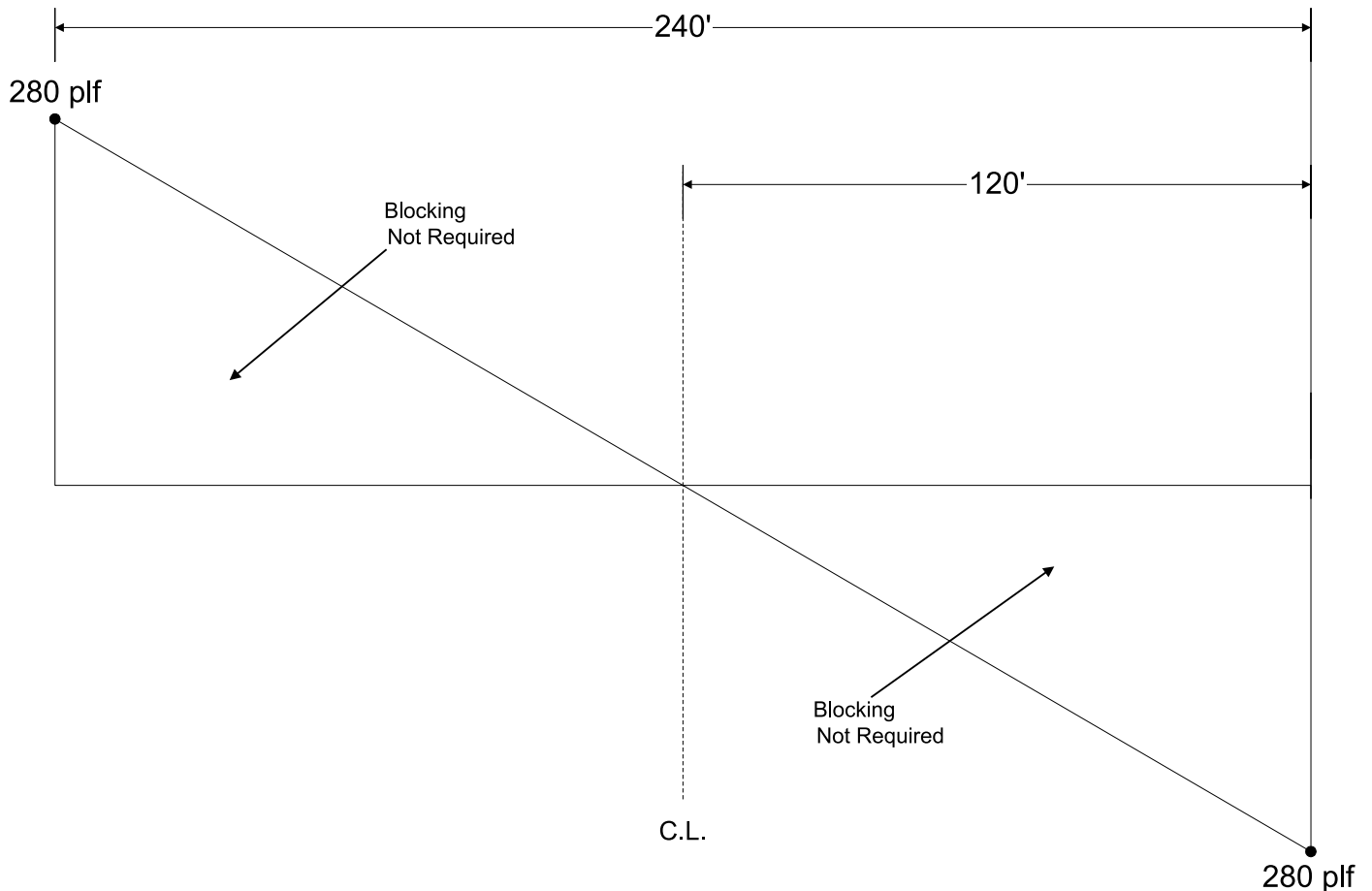
Based upon the sheathing panel layout as shown, the diaphragm is Case 1 for the N-S direction and Case 3 for the E-W direction. The shear capacities for wind loading per Table 3.1A and seismic load per Table 3.1B (in parentheses) are:

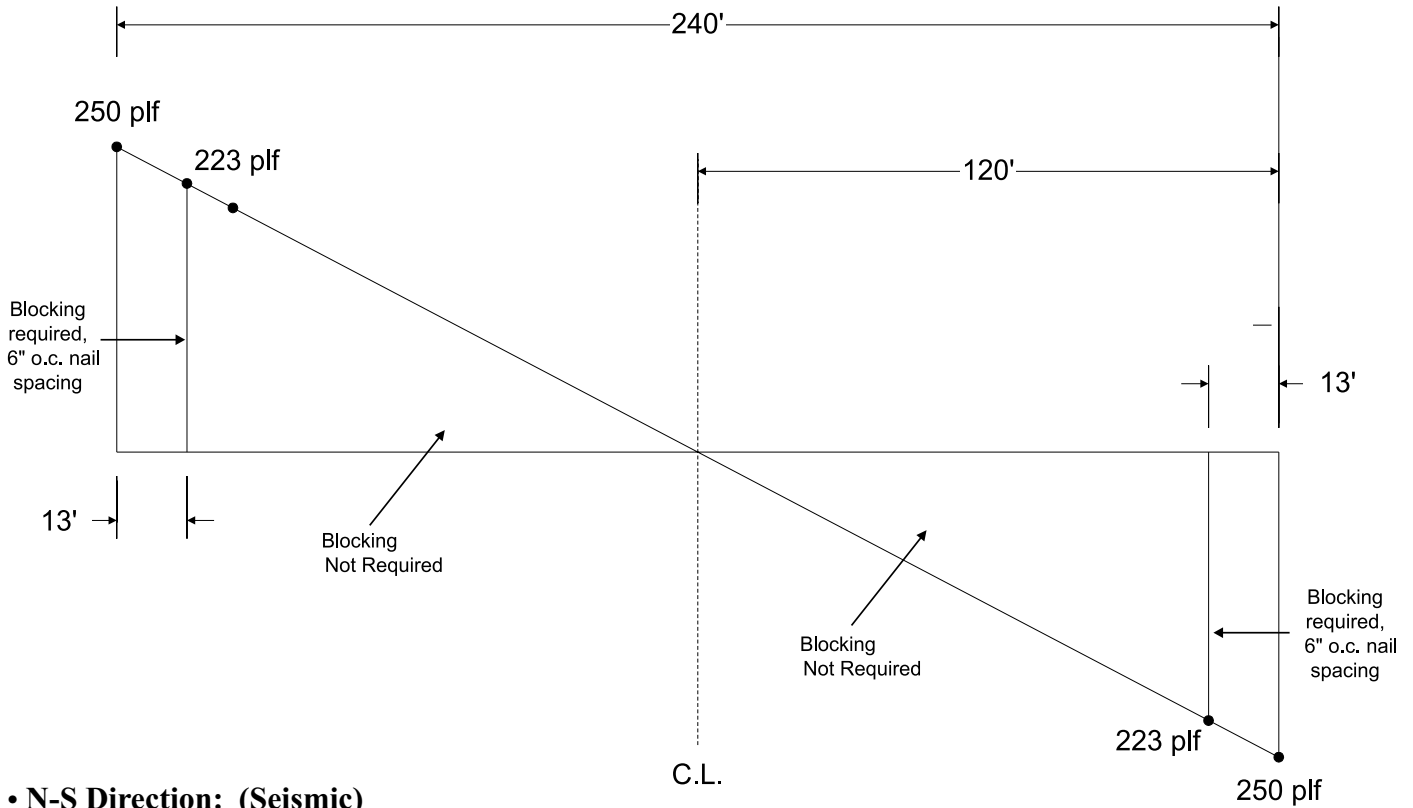
Panel Grade	Common Nail	Min. Penetration in Framing (in.)	Min. Panel Thickness (in.)	Min. Framing Member Width (in.)	Blocked Diaphragm (lb./ft.) Nail Spacing Boundary/Other Edges								Unblocked Diaphragm (lb./ft.)			
					6/6		4/6		2.5/4		2/3		Case 1		Case 2-6	
Rated Sheathing	8d	1-3/8	15/32	2	380	(270)	505	(360)	740	(530)	840	(600)	335	(240)	250	(180)
Shear Capacities for Hem-Fir Framing Members:					<u>x.93</u>	<u>x.93</u>	<u>x.93</u>	<u>x.93</u>	<u>x.93</u>	<u>x.93</u>	<u>x.93</u>	<u>x.93</u>	<u>x.93</u>	<u>x.93</u>	<u>x.93</u>	<u>x.93</u>
					353	(251)	470	(335)	688	(493)	781	(558)	311	(223)	233	(167)

Note that the table values are only valid for framing members (including blocking) with specific gravity greater than 0.49. For framing members with specific gravity greater than or equal to 0.42 but less than 0.49 such as Hem-fir (specific gravity = 0.43), a factor of $(1 - (0.50 - 0.43)) = 0.93$ must be applied to the table values.

• **N-S Direction: (Wind)**

Below is the shear distribution along the length of the building. Plotting the shear distribution aids in optimizing the nailing (and blocking) along the length of the diaphragm. For a Case 1 unblocked diaphragm, the maximum shear capacity for wind is 311 plf. As 311 plf is greater than 280 plf, blocking is not required for wind in this direction.





• **N-S Direction: (Seismic)**

$$\frac{250}{120} = \frac{223}{120 - X_1} X_1 = 13' \text{ Say } 16'$$

• **E-W Direction: (Wind)**

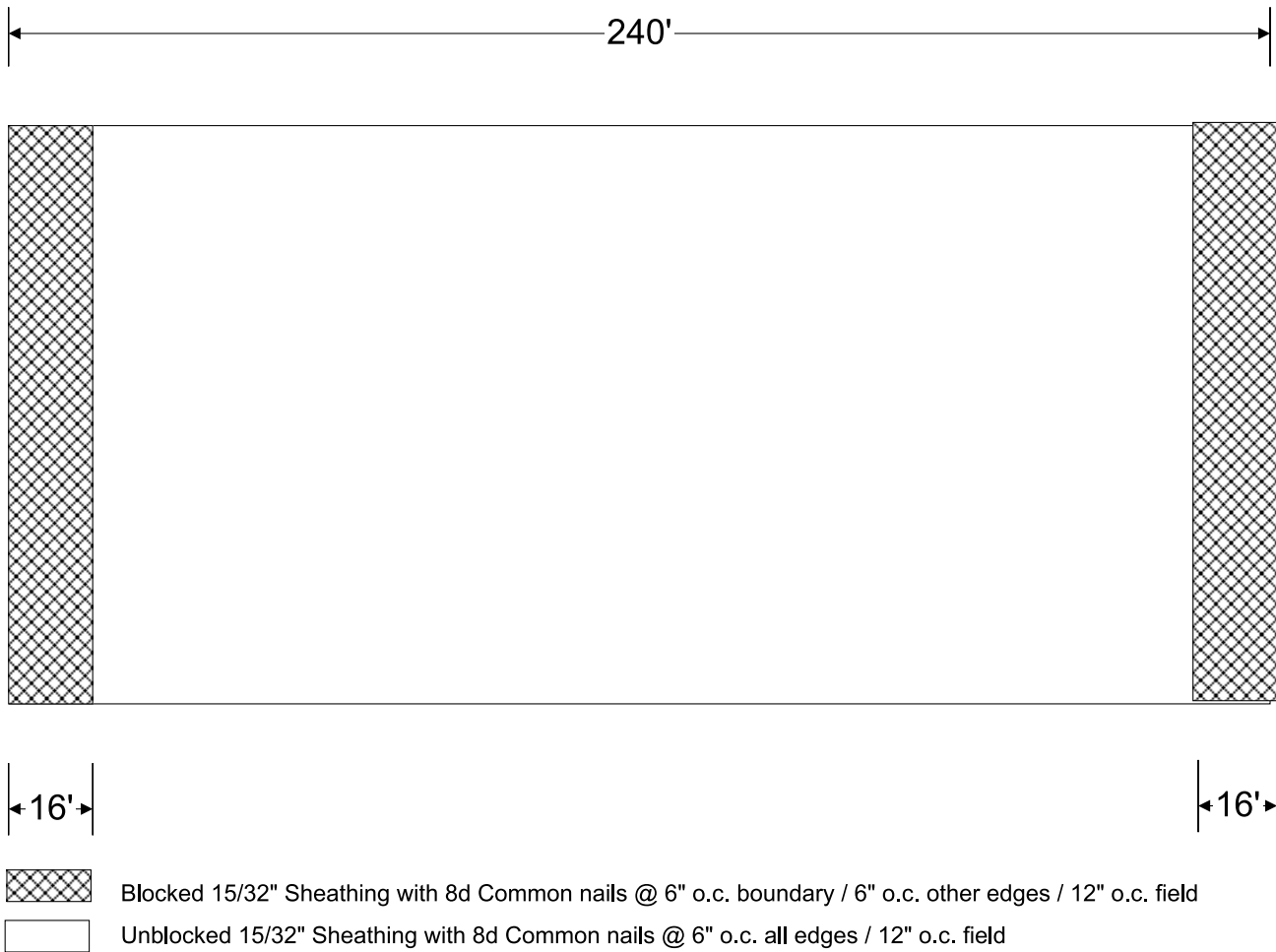
59 lb./ft. < 233 lb./ft. Unblocked Case 3 o.k.

• **E-W Direction: (Seismic)**

79 lb./ft. < 167 lb./ft. Unblocked Case 3 o.k.

A
APPENDICES

Roof Diaphragm Nailing and Blocking Plan



Step 4. Calculate Chord Forces

The chord forces must be calculated to size the chords and design the splices. The chord and splice design is beyond the scope of this Supplement, but the chord forces are shown below.

Since the chord must be continuous, it must be spliced, and at least 2 layers of 2x lumber will be required. For

this building, use double 2x8 top plates as the diaphragm chord. For high tension forces, it is usually most efficient to splice the chord members with metal side plates (top and bottom) and bolts acting in double shear. For low chord forces, splicing can often be achieved by nailing.

		Total Design Load (lb.)	L	Moment (ft.-lb.)	b	Chord Force (lb.) At Centerline
N-S	$V_{\text{seismic N-S}}$	= 53,768	x 240'	÷ 8 = 1,613,040	÷ 110'	= 14,664
	$V_{\text{wind N-S}}$	= 61,519	x 240'	÷ 8 = 1,845,570	÷ 110'	= 16,778
E-W	$V_{\text{seismic E-W}}$	= 37,752	x 110'	÷ 8 = 519,090	÷ 240'	= 2,163
	$V_{\text{wind E-W}}$	= 28,196	x 110'	÷ 8 = 387,695	÷ 240'	= 1,615

Step 5. Connections Between Roof Diaphragm and Walls

a. Wall Anchorage to Prevent Walls From Moving Away From Diaphragm:

From a more complete wind analysis, the following wind forces were calculated:

$$F_w = 249.2 \text{ lb./ft. } \textcircled{1} \text{ outward typical}$$

$$= 312.2 \text{ lb./ft. } \textcircled{2} \text{ outward within 10' of building corners}$$

A similar procedure should be conducted for seismic, but is beyond the scope of this example.

Use metal angles to anchor the top plate to either the rafters (North and South walls) or the blocking between the rafters (East and West walls) spaced 2'-0" o.c.

Note: The listed capacities in most manufacturers' catalogs are for Douglas fir-Larch only and the listed types of connections may not be identical to the installation here which is parallel to grain of rafters (or blocking) and perpendicular to grain of top plates. If not tabulated, design values must be obtained from the manufacturer.

- ① 249.2 lb./ft. x 2' = 498.4 lb./connection
 - ② 312.2 lb./ft. x 2' = 624.4 lb./connection
- | | | |
|-----------------------|---|---|
| Connection
spacing | } | Required connection
lateral capacity |
|-----------------------|---|---|

Note: To minimize the possibility of field installation errors, it would be common practice to standardize on one item with a capacity of at least 625 lb./connection for all wall anchorage connections.



b. Wall to Diaphragm Connection:

Diaphragm Design Unit Shear:

$$V_{\text{wind N-S}} = 280 \text{ lb./ft. for East and West Walls}$$

$$V_{\text{seismic E-W}} = 79 \text{ lb./ft. for North and South Walls}$$

East and West Walls - Hem-fir 2x blocking to Douglas fir-Larch 2x top plates (in a more complete design example it was determined that Douglas fir-Larch top plates were required to resist chord forces):

$$V_{\text{16d Common toenail}} = 113 \text{ lb.} \times 0.83 \times 1.6 = 150 \text{ lb./fastener}$$

\swarrow Load Duration Factor
 \swarrow Toenail Factor (C_{tn}) per NDS
 \swarrow NDS Table 11N for $t_s = 1"$, Hem-fir

280 lb./ft. + 150 lb./fastener = 1.9 fasteners/ft. ∴ Provide 16d common toenails spaced 6" o.c. or use appropriate code-approved metal framing devices.

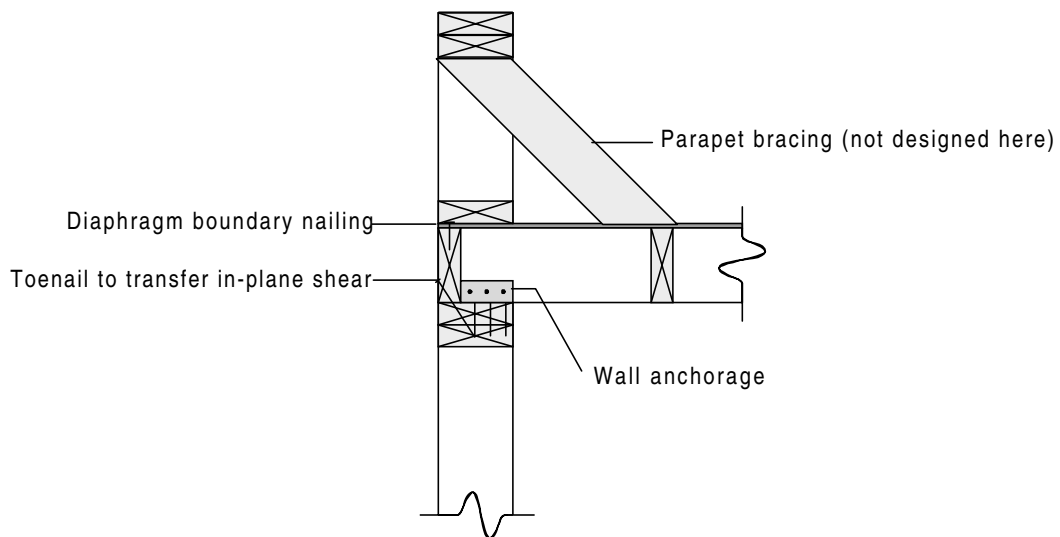
North and South Walls - Hem-fir 2x blocking to Hem-fir 2x top plates:

$$V_{\text{16d Common toenail}} = 113 \text{ lb.} \times 0.83 \times 1.6 = 150 \text{ lb./fastener}$$

\swarrow Load Duration Factor
 \swarrow Toenail Factor (C_{tn}) per NDS
 \swarrow NDS Table 11N for $t_s = 1"$

79 lb./ft. + 150 lb./fastener = 0.5 fasteners/ft. ∴ Provide 16d common toenails spaced no greater than 24" o.c.

Wall to Diaphragm Connection Detail



Step 6. Diaphragm Deflection (N-S Direction)

$$\Delta_{Diaphragm} = \frac{5vL^3}{8Eab} + \frac{vL}{4Gt} + 0.188Le_n + \frac{\sum(D_cX)}{2b}$$

For N-S direction:

$$v = 61,519 \text{ lb} \div 2 \div 110' = 280 \text{ lb./ft.}$$

$$L = 240 \text{ ft.}$$

$$E = 1,700,000 \text{ psi} \quad (\text{for Douglas fir-Larch No. 1 2x8s})$$

$$A = 21.75 \text{ sp. in.} \quad (\text{cross-sectional area for (2) 2x8s})$$

$$b = 110 \text{ ft.}$$

$$G = 90,000 \text{ psi} \quad (\text{for Sheathing grade})$$

$$t = 0.298 \text{ in.} \quad (\text{for 15/32" unsanded panels})$$

$$v_{sd} = 280 \div 2 = 140 \text{ lb./nail} \quad (8d \text{ spaced } 6" \text{ o.c., at interior panel edges near East and West boundary})$$

$$e_n = 0.0338 \times 1.2 = 0.041 \quad (\text{Table 3.2; 20\% increase for non-Structural I})$$

$$\Delta_{Diaphragm N-S} = \Delta_{bending} + \Delta_{shear} + \Delta_{nail slip} + \Delta_{chord splice slip}$$

$$\Delta_{Diaphragm} = \frac{5vL^3}{8EAb} + \frac{vL}{4Gt} + 0.188Le_n + \frac{\sum(D_cX)}{2b}$$

$$= \frac{5(280)(240)^3}{8(1,700,000)(21.75)(110)} + \frac{(280)(240)}{4(90,000)(0.298)} + 0.188(240)(0.041) + \frac{4(1/32)(20+40+60+80+100) + 2(1/32)(120)}{2(110)}$$

$$= 0.595" + 0.626" + 1.832" + 0.204"$$

$$= 3.257"$$

Note: The average chord splice slip on each side of the splice, is assumed to be 1/32 inch (which is half of the 1/16 inch allowable oversize for the bolt hole, for both tension and compression chords) and these splices are assumed to be located at 20 feet on center along the North and South walls.

Since the base of the wall is essentially a pinned connection, the diaphragm deflection causes little, if any, out-of-plane bending of the wall. The calculated deflection at the top of the wall should be used to evaluate potential vertical instability caused by horizontal deformation ($P\Delta$ effects). If necessary, diaphragm deflection can be reduced in a number of ways, such as additional nailing, the use of Structural I panels, etc.

Step 7. Shear Panel Fastener Schedule (East and West Walls Only)

Allowable Shear from Tables 4.1A and 4.1B

Panel grade	Common Nail	Min. Penetration in Framing (in.)	Panel t (in.)	Shear Wall Panels Nail Spacing at Panel Edges (lb./ft.)			
				6"	4"	3"	2"
Rated Sheathing	8d	1-3/8	15/32	365 x .93 340	530 x .93 493	685 x .93 637	895 x .93 832
Shear Capacities for Hem-fir studs:				(242)	(353)	(456)	(595)

Note: Table values are only good for studs and blocking with specific gravity greater than 0.49. For studs and blocking with specific gravity greater than or equal to 0.42 but less than 0.49 such as Hem-fir (specific gravity = 0.43), a factor of (1 - (0.50 - 0.43)) = 0.93 is used to multiply the table values by.

Design Wall for Wind Load

Total shear to be resisted by East exterior wall	=	Total shear to be resisted by West exterior wall	=
	=	61,519 lb. ÷ 2	=
	=	30,760 lb.	=
Total shear wall length in East exterior wall	=	70 ft.	=
Total shear wall length in West exterior wall	=	45 ft. + 45 ft. = 90 ft.	=
Unit shear in East wall	=	30,760 lb. ÷ 70 ft.	=
	=	439 lb./ft.	=
	=	∴ Use 15/32" sheathing with 8d common nails spaced 4 in. o.c. at all edges, 6 in. o.c. field which is good for 493 lb./ft.	=
Unit shear in West wall	=	30,760 lb. ÷ 90 ft.	=
	=	342 lb./ft.	=
	=	∴ Use 15/32" sheathing with 8d common nails spaced 4 in. o.c. at all edges, 6 in. o.c. field which is good for 493 lb./ft.	=

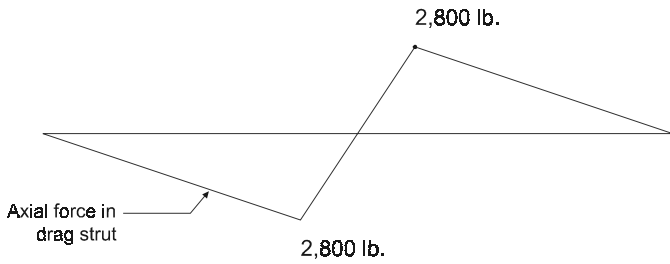
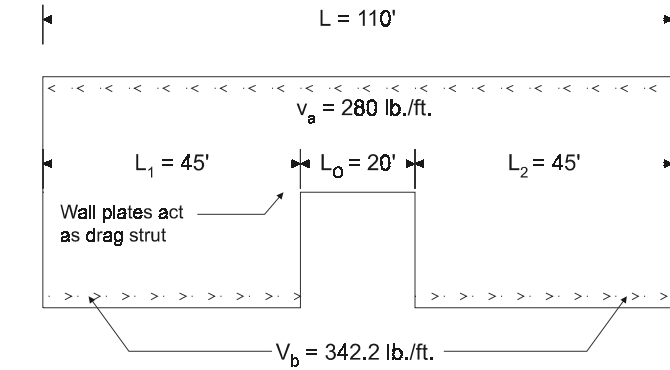
Design Wall for Seismic Load

Total shear to be resisted by East exterior wall	=	Total shear to be resisted by West exterior wall	=
	=	53,768 lb. ÷ 2	=
	=	26,884 lb.	=
Total shear wall length in East exterior wall	=	70 ft.	=
Total shear wall length in West exterior wall	=	45 ft. + 45 ft. = 90 ft.	=
Unit shear in East wall	=	26,884 lb. ÷ 70 ft.	=
	=	384 lb./ft.	=
	=	∴ Use 15/32" sheathing with 8d common nails spaced 3 in. o.c. at all edges, 6 in. o.c. field which is good for 456 lb./ft.	=
Unit shear in West wall	=	26,884 lb. ÷ 90 ft.	=
	=	299 lb./ft.	=
	=	∴ Use 15/32" sheathing with 8d common nails spaced 4 in. o.c. at all edges, 6 in. o.c. field which is good for 353 lb./ft.	=

Step 8. Drag Strut Forces and Drag Connections (East & West Walls Only)

Drag struts are required where there are openings in the shear walls to distribute forces from the diaphragm to the shear walls. The force in the drag strut equals the difference between the applied diaphragm shear and the resisting wall shear.

West Wall



Drag force is maximum of:

$$\frac{V_a L_0 L_1}{L - L_0} = \frac{(280)(20)(45)}{110 - 20}$$

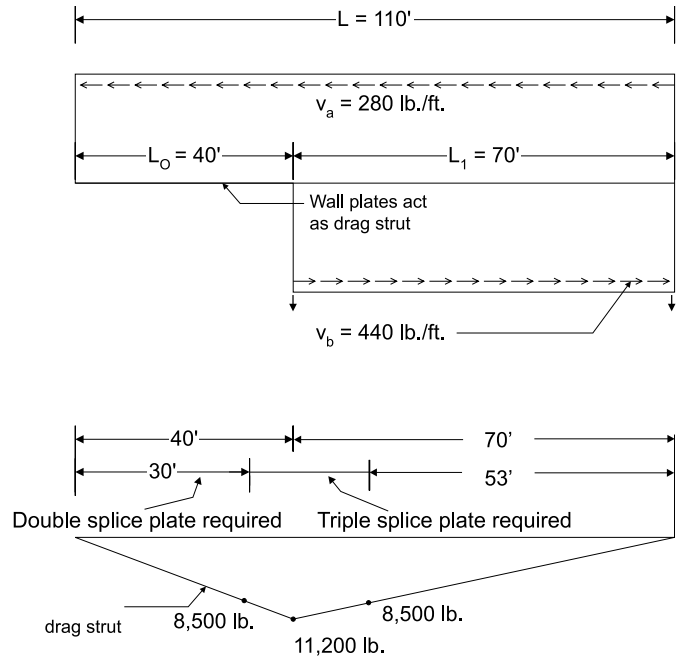
= 2,800 lb. for two 2x8s

$$\frac{V_a L_0 L_2}{L - L_0} = \frac{(280)(20)(45)}{110 - 20}$$

= 2,800 lb. for two 2x8s

= 1,400 lb. per 2x8

East Wall



Maximum force in Drag Strut:

$$280 \times 40 = 11,200 \text{ lb.}$$

Given that the maximum tensile capacity of a single 2x8 wall plate is 8,500 lb., this is the maximum capacity at the splice of a double top plate of 2x8s. If the tensile stress exceeds 8,500 lb. at a splice location, then an additional (a third) 2x8 plate must be used. This will increase the allowable tensile capacity at the splice to 17,000 lb. For this example, the following is used to determine the location along the wall plate where three 2x8s are required.

On the South end of the East wall:

$$\frac{8,500}{x} = \frac{11,200}{40}, x = 30 \text{ ft.}$$

On the North end of the East wall:

$$\frac{8,500}{x} = \frac{11,200}{70}, x = 53 \text{ ft.}$$

In lieu of multiple 2x8s to provide continuity between wall plates, framing anchors/straps may be used. A single 2x8 with straps at butt joints may be used above, with double 2x8s required only when the axial load is greater than 8,500 lb. and less than 17,000 lb. Where 2x8s are doubled up, straps are required at splice locations.

Be sure there is no more than one butt joint at each splice location. Space joints at least twice length of splice (or about 5 feet minimum).

Step 9. Hold-down Design for East and West Walls

LOAD ON WALLS:

		Total Diaphragm Load to be Resisted by Lateral System			Distributed Lateral Load Along East and West Walls		
V_{seismic}	=	53,768 lb.	÷	2	=	26,884 lb.	
V_{wind}	=	61,519 lb.	÷	2	=	30,760 lb.	

LATERAL LOADS:

				At Roof Level	Contribution From Wall Weight	=	At Mid-Story Level
East wall (70 ft.)	Seismic			26,884 lb.	0.2 x (8 psf x 70'x26')	=	2,912 lb.
	Wind			30,760 lb.			
West wall (45 ft.)	Seismic	=		26,884 lb.	0.2 x (8 psf x 45'x26')	=	1,872 lb.
	Wind	=		30,760 lb.			

OVERTURNING MOMENTS:

		Due to Distributed Lateral Loads		+	Due to Self-Weight		=	Total Overturning
East wall (70 ft.)	Seismic	26,884 lb. x 24'			2,912 lb. x 13'			683,072 ft.-lb.
	Wind	30,760 lb. x 24'						738,240 ft.-lb.
West wall (45 ft.)	Seismic	26,884 lb. x 24'			1,872 lb. x 13'			669,552 ft.-lb.
	Wind	30,760 lb. x 24'						738,840 ft.-lb.

RESISTING LOADS:

East wall (70 ft.)	Roof	10 psf x 15'	=	150 lb./ft.	x 70' =	10,500 lb.	at center
	Wall	8 psf x 26'	=	208 lb./ft.	x 70' =	14,560 lb.	at center
	Header	10 psf x 15'	x	40'	÷ 2 =	3,000 lb.	at int. wall end
West wall (45 ft.)	Roof	10 psf x 15'	=	150 lb./ft.	x 45' =	6,750 lb.	at center
	Wall	8 psf x 26'	=	208 lb./ft.	x 45' =	9,360 lb.	at center
	Header	10 psf x 15'	x	20'	÷ 2 =	1,500 lb.	at int. wall end

RESISTING MOMENTS:

East wall (70 ft.)	w/o header	(10,500 lb. + 14,560 lb.) x 35'	=	877,100 ft.-lb.
	header	3,000 lb. x 70'	=	210,000 ft.-lb.
West wall (45 ft.)	w/o header	(6,750 lb. + 9,360 lb.) x 22.5'	=	362,475 ft.-lb.
	header	1,500 lb. x 45'	=	67,500 ft.-lb.

NET UPLIFT AT THE ENDS OF SHEAR WALLS AND HOLD-DOWN REQUIREMENTS:

		Gross Overturning (ft.-lb.)		Reduction Factor DL	Gross Resisting (ft.-lb.)	Design Resisting (ft.-lb.)	Net Resisting (lb.)	Net Uplift (lb.)
East wall (70 ft.)	Seismic	interior	683,072	0.85 x	1,087,100	= 924,035	N/A ÷ 70'	N/A
		corner	683,072	0.85 x	877,100	= 745,535	N/A ÷ 70'	N/A
	Wind	interior	738,240	2/3 x	1,087,100	= 724,733	13,507 ÷ 70'	193
		corner	738,240	2/3 x	877,100	= 584,733	153,507 ÷ 70'	2,193
West wall (45 ft.)	Seismic	interior	669,552	0.85 x	429,975	= 369,479	300,073 ÷ 45'	6,668
		corner	669,552	0.85 x	362,475	= 308,104	361,448 ÷ 45'	8,032
	Wind	interior	738,240	2/3 x	429,975	= 286,650	451,590 ÷ 45'	10,035
		corner	738,240	2/3 x	362,475	= 241,650	496,590 ÷ 45'	11,035

A.2 Diaphragm and Shear Wall Design References

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