

SECTION PROPERTIES

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3.1 Section Properties of Sawn Lumber and Glued Laminated Timber

3.1.1 Standard Sizes of Sawn Lumber

Details regarding the dressed sizes of various species of lumber in the grading rules of the agencies which formulate and maintain such rules. The dressed sizes in Table 1A conform to the sizes set forth in U.S. Department of Commerce Voluntary Product Standard PS 20-99 (American Softwood Lumber Standard). While these sizes are generally available on a commercial basis, it is good practice to consult the local lumber dealer to determine what sizes are on hand or can be readily secured.

Dry lumber is defined as lumber which has been seasoned to a moisture content of 19 percent or less. Green lumber is defined as lumber having a moisture content in excess of 19 percent.

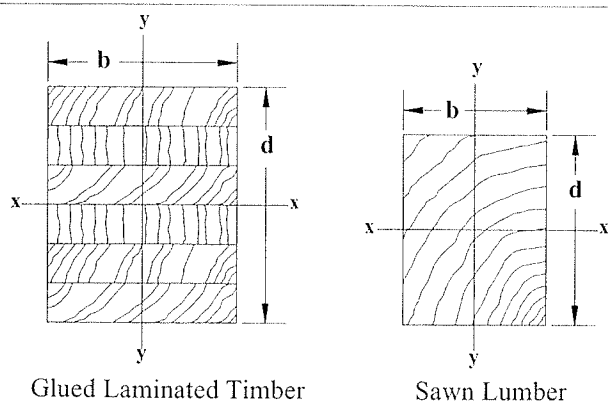
3.1.2 Properties of Standard Dressed Sizes

Certain mathematical expressions of the properties or elements of sections are used in design calculations for various member shapes and loading conditions. The section properties for selected standard sizes of boards, dimension lumber and timbers are given in Table 1B. Section properties for selected standard sizes of glued laminated timber are given in Table 1C and 1D.

3.1.3 Definitions

NEUTRAL AXIS, in the cross section of a beam, is the line on which there is neither tension nor compression stress.

Figure 1A Dimensions for Rectangular Cross Section



MOMENT OF INERTIA, I , of the cross section of a beam is the sum of the products of each of its elementary areas multiplied by the square of their distance from the neutral axis of the section.

SECTION MODULUS, S , is the moment of inertia divided by the distance from the neutral axis to the extreme fiber of the section.

CROSS SECTION is a section taken through the member perpendicular to its longitudinal axis.

The following symbols and formulas apply to rectangular beam cross sections:

X-X = neutral axis for edgewise bending (load applied to narrow face)

Y-Y = neutral axis for flatwise bending (load applied to wide face)

b = breadth of rectangular bending member, inches

d = depth of rectangular bending member, inches

$A = bd$ = area of cross section, in.²

c = distance from neutral axis to extreme fiber of cross section, inches

$I_x = bd^3/12$ = moment of inertia about the X-X axis, in.⁴

$I_y = db^3/12$ = moment of inertia about the Y-Y axis, in.⁴

$r_x = \sqrt{I_x/A} = d/\sqrt{12}$ = radius of gyration about the X-X axis, inches

$r_y = \sqrt{I_y/A} = b/\sqrt{12}$ = radius of gyration about the Y-Y axis, inches

$S_x = I_x/c = bd^2/6$ = section modulus about the X-X axis, in.³

$S_y = I_y/c = db^2/6$ = section modulus about the Y-Y axis, in.³

The following formula shall be used to determine the density in lb./ft.³ of wood:

$$\text{density} = 62.4 \left[\frac{G}{1 + G(0.009)(\text{m.c.})} \right] \left[1 + \frac{\text{m.c.}}{100} \right]$$

where:

G = specific gravity of wood (see NDS Table 8A)

m.c. = moisture content of wood, %

Table 1A Nominal and Minimum Dressed Sizes of Sawn Lumber

Item	Thickness (inches)			Face Widths (inches)		
	Nominal	Minimum dressed		Nominal	Minimum dressed	
		Dry	Green		Dry	Green
Boards	3/4	5/8	11/16	2	1-1/2	1-9/16
	1	3/4	25/32	3	2-1/2	2-9/16
	1-1/4	1	1-1/32	4	3-1/2	3-9/16
	1-1/2	1-1/4	1-9/32	5	4-1/2	4-5/8
				6	5-1/2	5-5/8
				7	6-1/2	6-5/8
				8	7-1/4	7-1/2
				9	8-1/4	8-1/2
				10	9-1/4	9-1/2
				11	10-1/4	10-1/2
				12	11-1/4	11-1/2
				14	13-1/4	13-1/2
				16	15-1/4	15-1/2
Dimension Lumber	2	1-1/2	1-9/16	2	1-1/2	1-9/16
	2-1/2	2	2-1/16	3	2-1/2	2-9/16
	3	2-1/2	2-9/16	4	3-1/2	3-9/16
	3-1/2	3	3-1/16	5	4-1/2	4-5/8
	4	3-1/2	3-9/16	6	5-1/2	5-5/8
	4-1/2	4	4-1/16	8	7-1/4	7-1/2
				10	9-1/4	9-1/2
				12	11-1/4	11-1/2
				14	13-1/4	13-1/2
				16	15-1/4	15-1/2
Timbers	5 & thicker	—	1/2 off	5 & wider	—	1/2 off

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SECTION PROPERTIES

Table 1B 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 _{xx} in ³	Moment of Inertia I _{xx} in ⁴	Section Modulus S _{yy} in ³	Moment of Inertia I _{yy} 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

DESIGN VALUES

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Table 4A Adjustment Factors**Repetitive Member Factor, C_r**

Bending design values, F_b , for dimension lumber 2" to 4" thick shall be multiplied by the repetitive member factor, $C_r = 1.15$, when such members are used as joists, truss chords, rafters, studs, planks, decking or similar members which are in contact or spaced not more than 24" on centers, are not less than 3 in number and are joined by floor, roof or other load distributing elements adequate to support the design load.

Wet Service Factor, C_M

When dimension lumber is used where moisture content will exceed 19% for an extended time period, design values shall be multiplied by the appropriate wet service factors from the following table:

Wet Service Factors, C_M

F_b	F_t	F_v	$F_{c\perp}$	F_c	E
0.85*	1.0	0.97	0.67	0.8**	0.9

* when $(F_b)(C_F) \leq 1150$ psi, $C_M = 1.0$

** when $(F_c)(C_F) \leq 750$ psi, $C_M = 1.0$

Flat Use Factor, C_{fu}

Bending design values adjusted by size factors are based on edgewise use (load applied to narrow face). When dimension lumber is used flatwise (load applied to wide face), the bending design value, F_b , shall also be multiplied by the following flat use factors:

Flat Use Factors, C_{fu}

Width (depth)	Thickness (breadth)	
	2" & 3"	4"
2" & 3"	1.0	—
4"	1.1	1.0
5"	1.1	1.05
6"	1.15	1.05
8"	1.15	1.05
10" & wider	1.2	1.1

NOTE

To facilitate the use of Table 4A, shading has been employed to distinguish design values based on a 4" nominal width (Construction, Standard and Utility grades) or a 6" nominal width (Stud grade) from design values based on a 12" nominal width (Select Structural, No.1 & Btr., No.1, No.2 and No.3 grades).

Size Factor, C_F

Tabulated bending, tension and compression parallel to grain design values for dimension lumber 2" to 4" thick shall be multiplied by the following size factors:

Size Factors, C_F

		F _b		F _t	F _c
Grades	Width (depth)	Thickness (breadth)			
		2" & 3"	4"		
Select Structural, No.1 & Btr., No.1, No.2, No.3	2", 3" & 4"	1.5	1.5	1.5	1.15
	5"	1.4	1.4	1.4	1.1
	6"	1.3	1.3	1.3	1.1
	8"	1.2	1.3	1.2	1.05
	10"	1.1	1.2	1.1	1.0
	12"	1.0	1.1	1.0	1.0
	14" & wider	0.9	1.0	0.9	0.9
Stud	2", 3" & 4"	1.1	1.1	1.1	1.05
	5" & 6"	1.0	1.0	1.0	1.0
	8" & wider	Use No.3 Grade tabulated design values and size factors			
Construction, Standard	2", 3" & 4"	1.0	1.0	1.0	1.0
Utility	4"	1.0	1.0	1.0	1.0
	2" & 3"	0.4	—	0.4	0.6

Table 4A Base Design Values for Visually Graded Dimension Lumber (2"-4" thick)^{1,2}
 (All species except Southern Pine — see Table 4B) (Tabulated design values are for normal load duration and dry service conditions. See NDS 4.3 for a comprehensive description of design value adjustment factors.)

USE WITH TABLE 4A ADJUSTMENT FACTORS

Species and commercial grade	Size classification	Design values in pounds per square inch (psi)						Grading Rules Agency
		Bending F _b	Tension parallel to grain F _t	Shear parallel to grain F _v	Compression perpendicular to grain F _{c⊥}	Compression parallel to grain F _c	Modulus of Elasticity E	
ASPEN								
Select Structural	2" & wider	875	500	120	265	725	1,100,000	NELMA NSLB WWPA
No.1		625	375	120	265	600	1,100,000	
No.2		600	350	120	265	450	1,000,000	
No.3	2" & wider	350	200	120	265	275	900,000	
Stud		475	275	120	265	300	900,000	
Construction		700	400	120	265	625	900,000	
Standard	2"-4" wide	375	225	120	265	475	900,000	
Utility		175	100	120	265	300	800,000	
BEECH-BIRCH-HICKORY								
Select Structural	2" & wider	1450	850	195	715	1200	1,700,000	NELMA
No.1		1050	600	195	715	950	1,600,000	
No.2		1000	600	195	715	750	1,500,000	
No.3	2" & wider	575	350	195	715	425	1,300,000	
Stud		775	450	195	715	475	1,300,000	
Construction		1150	675	195	715	1000	1,400,000	
Standard	2"-4" wide	650	375	195	715	775	1,300,000	
Utility		300	175	195	715	500	1,200,000	
COTTONWOOD								
Select Structural	2" & wider	875	525	125	320	775	1,200,000	NSLB
No.1		625	375	125	320	625	1,200,000	
No.2		625	350	125	320	475	1,100,000	
No.3	2" & wider	350	200	125	320	275	1,000,000	
Stud		475	275	125	320	300	1,000,000	
Construction		700	400	125	320	650	1,000,000	
Standard	2"-4" wide	400	225	125	320	500	900,000	
Utility		175	100	125	320	325	900,000	
DOUGLAS FIR-LARCH								
Select Structural	2" & wider	1500	1000	180	625	1700	1,900,000	WCLIB WWPA
No.1 & Btr		1200	800	180	625	1550	1,800,000	
No.1		1000	675	180	625	1500	1,700,000	
No.2	2" & wider	900	575	180	625	1350	1,600,000	
No.3		525	325	180	625	775	1,400,000	
Stud		700	450	180	625	850	1,400,000	
Construction	2"-4" wide	1000	650	180	625	1650	1,500,000	
Standard		575	375	180	625	1400	1,400,000	
Utility		275	175	180	625	900	1,300,000	
DOUGLAS FIR-LARCH (NORTH)								
Select Structural	2" & wider	1350	825	180	625	1900	1,900,000	NLGA
No.1/No.2		850	500	180	625	1400	1,600,000	
No.3		475	300	180	625	825	1,400,000	
Stud	2" & wider	650	400	180	625	900	1,400,000	
Construction		950	575	180	625	1800	1,500,000	
Standard		2"-4" wide	525	325	180	625	1450	
Utility	250		150	180	625	950	1,300,000	
DOUGLAS FIR-SOUTH								
Select Structural	2" & wider	1350	900	180	520	1600	1,400,000	WWPA
No.1		925	600	180	520	1450	1,300,000	
No.2		850	525	180	520	1350	1,200,000	
No.3	2" & wider	500	300	180	520	775	1,100,000	
Stud		675	425	180	520	850	1,100,000	
Construction		975	600	180	520	1650	1,200,000	
Standard	2"-4" wide	550	350	180	520	1400	1,100,000	
Utility		250	150	180	520	900	1,000,000	

Table 4A Base Design Values for Visually Graded Dimension Lumber (2"-4" thick)^{1,2}
(Cont.) (All species except Southern Pine — see Table 4B) (Tabulated design values are for normal load duration and dry service conditions. See NDS 4.3 for a comprehensive description of design value adjustment factors.)

USE WITH TABLE 4A ADJUSTMENT FACTORS

Species and commercial grade	Size classification	Design values in pounds per square inch (psi)						Grading Rules Agency
		Bending F _b	Tension parallel to grain F _t	Shear parallel to grain F _v	Compression perpendicular to grain F _{c⊥}	Compression parallel to grain F _c	Modulus of Elasticity E	
EASTERN HEMLOCK-BALSAM FIR								
Select Structural	2" & wider	1250	575	140	335	1200	1,200,000	NELMA NSLB
No.1		775	350	140	335	1000	1,100,000	
No.2		575	275	140	335	825	1,100,000	
No.3	2" & wider	350	150	140	335	475	900,000	
Stud		450	200	140	335	525	900,000	
Construction		675	300	140	335	1050	1,000,000	
Standard	2"-4" wide	375	175	140	335	850	900,000	
Utility		175	75	140	335	550	800,000	
EASTERN HEMLOCK-TAMARACK								
Select Structural	2" & wider	1250	575	170	555	1200	1,200,000	NELMA NSLB
No.1		775	350	170	555	1000	1,100,000	
No.2		575	275	170	555	825	1,100,000	
No.3	2" & wider	350	150	170	555	475	900,000	
Stud		450	200	170	555	525	900,000	
Construction		675	300	170	555	1050	1,000,000	
Standard	2"-4" wide	375	175	170	555	850	900,000	
Utility		175	75	170	555	550	800,000	
EASTERN SOFTWOODS								
Select Structural	2" & wider	1250	575	140	335	1200	1,200,000	NELMA NSLB
No.1		775	350	140	335	1000	1,100,000	
No.2		575	275	140	335	825	1,100,000	
No.3	2" & wider	350	150	140	335	475	900,000	
Stud		450	200	140	335	525	900,000	
Construction		675	300	140	335	1050	1,000,000	
Standard	2"-4" wide	375	175	140	335	850	900,000	
Utility		175	75	140	335	550	800,000	
EASTERN WHITE PINE								
Select Structural	2" & wider	1250	575	135	350	1200	1,200,000	NELMA NSLB
No.1		775	350	135	350	1000	1,100,000	
No.2		575	275	135	350	825	1,100,000	
No.3	2" & wider	350	150	135	350	475	900,000	
Stud		450	200	135	350	525	900,000	
Construction		675	300	135	350	1050	1,000,000	
Standard	2"-4" wide	375	175	135	350	850	900,000	
Utility		175	75	135	350	550	800,000	
HEM-FIR								
Select Structural	2" & wider	1400	925	150	405	1500	1,600,000	WCLIB WWPA
No.1 & Btr		1100	725	150	405	1350	1,500,000	
No.1		975	625	150	405	1350	1,500,000	
No.2	2" & wider	850	525	150	405	1300	1,300,000	
No.3		500	300	150	405	725	1,200,000	
Stud		675	400	150	405	800	1,200,000	
Construction	2"-4" wide	975	600	150	405	1550	1,300,000	
Standard		550	325	150	405	1300	1,200,000	
Utility		250	150	150	405	850	1,100,000	
HEM-FIR (NORTH)								
Select Structural	2" & wider	1300	775	145	405	1700	1,700,000	NLGA
No.1/No.2		1000	575	145	405	1450	1,600,000	
No.3		575	325	145	405	850	1,400,000	
Stud	2" & wider	775	450	145	405	925	1,400,000	
Construction		1150	650	145	405	1750	1,500,000	
Standard		650	350	145	405	1500	1,400,000	
Utility	300	175	145	405	975	1,300,000		

Table 4A Base Design Values for Visually Graded Dimension Lumber (2"-4" thick)^{1,2}
(Cont.) (All species except Southern Pine — see Table 4B) (Tabulated design values are for normal load duration and dry service conditions. See NDS 4.3 for a comprehensive description of design value adjustment factors.)

USE WITH TABLE 4A ADJUSTMENT FACTORS

Species and commercial grade	Size classification	Design values in pounds per square inch (psi)						Grading Rules Agency	
		Bending F _b	Tension parallel to grain F _t	Shear parallel to grain F _v	Compression perpendicular to grain F _{c⊥}	Compression parallel to grain F _c	Modulus of Elasticity E		
MIXED MAPLE									
Select Structural	2" & wider	1000	600	195	620	875	1,300,000	NELMA	
No.1		725	425	195	620	700	1,200,000		
No.2		700	425	195	620	550	1,100,000		
No.3	2" & wider	400	250	195	620	325	1,000,000		
Stud		550	325	195	620	350	1,000,000		
Construction		800	475	195	620	725	1,100,000		
Standard	2"-4" wide	450	275	195	620	575	1,000,000		
Utility		225	125	195	620	375	900,000		
MIXED OAK									
Select Structural	2" & wider	1150	675	170	800	1000	1,100,000	NELMA	
No.1		825	500	170	800	825	1,000,000		
No.2		800	475	170	800	625	900,000		
No.3	2" & wider	475	275	170	800	375	800,000		
Stud		625	375	170	800	400	800,000		
Construction		925	550	170	800	850	900,000		
Standard	2"-4" wide	525	300	170	800	650	800,000		
Utility		250	150	170	800	425	800,000		
NORTHERN RED OAK									
Select Structural	2" & wider	1400	800	220	885	1150	1,400,000	NELMA	
No.1		1000	575	220	885	925	1,400,000		
No.2		975	575	220	885	725	1,300,000		
No.3	2" & wider	550	325	220	885	425	1,200,000		
Stud		750	450	220	885	450	1,200,000		
Construction		1100	650	220	885	975	1,200,000		
Standard	2"-4" wide	625	350	220	885	750	1,100,000		
Utility		300	175	220	885	500	1,000,000		
NORTHERN SPECIES									
Select Structural	2" & wider	1000	450	110	350	1100	1,100,000	NLGA	
No.1/No.2		600	275	110	350	850	1,100,000		
No.3		350	150	110	350	500	1,000,000		
Stud	2" & wider	475	225	110	350	550	1,000,000		
Construction		700	300	110	350	1050	1,000,000		
Standard		2"-4" wide	400	175	110	350	875		900,000
Utility	175		75	110	350	575	900,000		
NORTHERN WHITE CEDAR									
Select Structural	2" & wider	775	450	120	370	750	800,000		NELMA
No.1		575	325	120	370	600	700,000		
No.2		550	325	120	370	475	700,000		
No.3	2" & wider	325	175	120	370	275	600,000		
Stud		425	250	120	370	300	600,000		
Construction		625	375	120	370	625	700,000		
Standard	2"-4" wide	350	200	120	370	475	600,000		
Utility		175	100	120	370	325	600,000		
RED MAPLE									
Select Structural	2" & wider	1300	750	210	615	1100	1,700,000	NELMA	
No.1		925	550	210	615	900	1,600,000		
No.2		900	525	210	615	700	1,500,000		
No.3	2" & wider	525	300	210	615	400	1,300,000		
Stud		700	425	210	615	450	1,300,000		
Construction		1050	600	210	615	925	1,400,000		
Standard	2"-4" wide	575	325	210	615	725	1,300,000		
Utility		275	150	210	615	475	1,200,000		

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DESIGN VALUES

Table 4A Base Design Values for Visually Graded Dimension Lumber (2"-4" thick)^{1,2}
(Cont.) (All species except Southern Pine — see Table 4B) (Tabulated design values are for normal load duration and dry service conditions. See NDS 4.3 for a comprehensive description of design value adjustment factors.)

USE WITH TABLE 4A ADJUSTMENT FACTORS

Species and commercial grade	Size classification	Design values in pounds per square inch (psi)						Grading Rules Agency
		Bending F _b	Tension parallel to grain F _t	Shear parallel to grain F _v	Compression perpendicular to grain F _{c⊥}	Compression parallel to grain F _c	Modulus of Elasticity E	
RED OAK								
Select Structural	2" & wider	1150	675	170	820	1000	1,400,000	NELMA
No.1		825	500	170	820	825	1,300,000	
No.2		800	475	170	820	625	1,200,000	
No.3	2" & wider	475	275	170	820	375	1,100,000	
Stud		625	375	170	820	400	1,100,000	
Construction		925	550	170	820	850	1,200,000	
Standard	2"-4" wide	525	300	170	820	650	1,100,000	
Utility		250	150	170	820	425	1,000,000	
REDWOOD								
Clear Structural	2" & wider	1750	1000	160	650	1850	1,400,000	RIS
Select Structural		1350	800	160	650	1500	1,400,000	
Select Structural, open grain		1100	625	160	425	1100	1,100,000	
No.1		975	575	160	650	1200	1,300,000	
No.1, open grain		775	450	160	425	900	1,100,000	
No.2		925	525	160	650	950	1,200,000	
No.2, open grain		725	425	160	425	700	1,000,000	
No.3		525	300	160	650	550	1,100,000	
No.3, open grain	2" & wider	425	250	160	425	400	900,000	
Stud		575	325	160	425	450	900,000	
Construction		825	475	160	425	925	900,000	
Standard	2"-4" wide	450	275	160	425	725	900,000	
Utility		225	125	160	425	475	800,000	
SPRUCE-PINE-FIR								
Select Structural	2" & wider	1250	700	135	425	1400	1,500,000	NLGA
No.1/No.2		875	450	135	425	1150	1,400,000	
No.3		500	250	135	425	650	1,200,000	
Stud	2" & wider	675	350	135	425	725	1,200,000	
Construction		1000	500	135	425	1400	1,300,000	
Standard	2"-4" wide	550	275	135	425	1150	1,200,000	
Utility		275	125	135	425	750	1,100,000	
SPRUCE-PINE-FIR (SOUTH)								
Select Structural	2" & wider	1300	575	135	335	1200	1,300,000	NELMA NSLB WCLIB WWPA
No.1		875	400	135	335	1050	1,200,000	
No.2		775	350	135	335	1000	1,100,000	
No.3	2" & wider	450	200	135	335	575	1,000,000	
Stud		600	275	135	335	625	1,000,000	
Construction		875	400	135	335	1200	1,000,000	
Standard	2"-4" wide	500	225	135	335	1000	900,000	
Utility		225	100	135	335	675	900,000	
WESTERN CEDARS								
Select Structural	2" & wider	1000	600	155	425	1000	1,100,000	WCLIB WWPA
No.1		725	425	155	425	825	1,000,000	
No.2		700	425	155	425	650	1,000,000	
No.3		400	250	155	425	375	900,000	
Stud	2" & wider	550	325	155	425	400	900,000	
Construction		800	475	155	425	850	900,000	
Standard	2"-4" wide	450	275	155	425	650	800,000	
Utility		225	125	155	425	425	800,000	

Table 4A Base Design Values for Visually Graded Dimension Lumber (2"-4" thick)^{1,2}
(Cont.) (All species except Southern Pine — see Table 4B) (Tabulated design values are for normal load duration and dry service conditions. See NDS 4.3 for a comprehensive description of design value adjustment factors.)

USE WITH TABLE 4A ADJUSTMENT FACTORS

Species and commercial grade	Size classification	Design values in pounds per square inch (psi)						Grading Rules Agency
		Bending F _b	Tension parallel to grain F _t	Shear parallel to grain F _v	Compression perpendicular to grain F _{c⊥}	Compression parallel to grain F _c	Modulus of Elasticity E	
WESTERN WOODS								
Select Structural	2" & wider	900	400	135	335	1050	1,200,000	WCLIB WWPA
No.1		675	300	135	335	950	1,100,000	
No.2		675	300	135	335	900	1,000,000	
No.3	2" & wider	375	175	135	335	525	900,000	
Stud		525	225	135	335	575	900,000	
Construction		775	350	135	335	1100	1,000,000	
Standard	2"-4" wide	425	200	135	335	925	900,000	
Utility		200	100	135	335	600	800,000	
WHITE OAK								
Select Structural	2" & wider	1200	700	220	800	1100	1,100,000	NELMA
No.1		875	500	220	800	900	1,000,000	
No.2		850	500	220	800	700	900,000	
No.3	2" & wider	475	275	220	800	400	800,000	
Stud		650	375	220	800	450	800,000	
Construction		950	550	220	800	925	900,000	
Standard	2"-4" wide	525	325	220	800	725	800,000	
Utility		250	150	220	800	475	800,000	
YELLOW POPLAR								
Select Structural	2" & wider	1000	575	145	420	900	1,500,000	NSLB
No.1		725	425	145	420	725	1,400,000	
No.2		700	400	145	420	575	1,300,000	
No.3	2" & wider	400	225	145	420	325	1,200,000	
Stud		550	325	145	420	350	1,200,000	
Construction		800	475	145	420	750	1,300,000	
Standard	2"-4" wide	450	250	145	420	575	1,100,000	
Utility		200	125	145	420	375	1,100,000	

- LUMBER DIMENSIONS.** Tabulated design values are applicable to lumber that will be used under dry conditions such as in most covered structures. For 2" to 4" thick lumber the DRY dressed sizes shall be used (see Table 1A) regardless of the moisture content at the time of manufacture or use. In calculating design values, the natural gain in strength and stiffness that occurs as lumber dries has been taken into consideration as well as the reduction in size that occurs when unseasoned lumber shrinks. The gain in load carrying capacity due to increased strength and stiffness resulting from drying more than offsets the design effect of size reductions due to shrinkage.
- STRESS-RATED BOARDS.** Stress-rated boards of nominal 1", 1¼" and 1½" thickness, 2" and wider, of most species, are permitted to use the design values shown for Select Structural, No.1 & Btr, No.1, No.2, No.3, Stud, Construction, Standard, Utility, Clear Heart Structural and Clear Structural grades as shown in the 2" to 4" thick categories herein, when graded in accordance with the stress-rated board provisions in the applicable grading rules. Information on stress-rated board grades applicable to the various species is available from the respective grading rules agencies. Information on additional design values may also be available from the respective grading agencies.

Table 4B Adjustment Factors**Size Factor, C_F**

Appropriate size adjustment factors have already been incorporated in the tabulated design values for most thicknesses of Southern Pine and Mixed Southern Pine dimension lumber. For dimension lumber 4" thick, 8" and wider (all grades except Dense Structural 86, Dense Structural 72 and Dense Structural 65), tabulated bending design values, F_b , shall be permitted to be multiplied by the size factor, $C_F = 1.1$. For dimension lumber wider than 12" (all grades except Dense Structural 86, Dense Structural 72 and Dense Structural 65), tabulated bending, tension and compression parallel to grain design values for 12" wide lumber shall be multiplied by the size factor, $C_F = 0.9$. When the depth, d , of Dense Structural 86, Dense Structural 72 or Dense Structural 65 dimension lumber exceeds 12", the tabulated bending design value, F_b , shall be multiplied by the following size factor:

$$C_F = (12/d)^{1/9}$$

Repetitive Member Factor, C_r

Bending design values, F_b , for dimension lumber 2" to 4" thick shall be multiplied by the repetitive member factor, $C_r = 1.15$, when such members are used as joists, truss chords, rafters, studs, planks, decking or similar members which are in contact or spaced not more than 24" on centers, are not less than 3 in number and are joined by floor, roof or other load distributing elements adequate to support the design load.

Flat Use Factor, C_{fu}

Bending design values adjusted by size factors are based on edgewise use (load applied to narrow face). When dimension lumber is used flatwise (load applied to wide face), the bending design value, F_b , shall also be multiplied by the following flat use factors:

Flat Use Factors, C_{fu}		
Width (depth)	Thickness (breadth)	
	2" & 3"	4"
2" & 3"	1.0	—
4"	1.1	1.0
5"	1.1	1.05
6"	1.15	1.05
8"	1.15	1.05
10" & wider	1.2	1.1

Wet Service Factor, C_M

When dimension lumber is used where moisture content will exceed 19% for an extended time period, design values shall be multiplied by the appropriate wet service factors from the following table (for surfaced dry Dense Structural 86, Dense Structural 72 and Dense Structural 65 use tabulated surfaced green design values for wet service conditions without further adjustment):

Wet Service Factors, C_M					
F_b	F_t	F_v	$F_{c\perp}$	F_c	E
0.85*	1.0	0.97	0.67	0.8**	0.9

* when $(F_b)(C_F) \leq 1150$ psi, $C_M = 1.0$

** when $(F_c) \leq 750$ psi, $C_M = 1.0$

Table 4B Design Values for Visually Graded Southern Pine Dimension Lumber (2"-4" thick)^{1,2,3,4}

(Tabulated design values are for normal load duration and dry service conditions, unless specified otherwise. See NDS 4.3 for a comprehensive description of design value adjustment factors.)

USE WITH TABLE 4B ADJUSTMENT FACTORS

Species and commercial grade	Size classification	Design values in pounds per square inch (psi)						Grading Rules Agency
		Bending F _b	Tension parallel to grain F _t	Shear parallel to grain F _v	Compression perpendicular to grain F _{c⊥}	Compression parallel to grain F _c	Modulus of Elasticity E	
SOUTHERN PINE								
Dense Select Structural	2"-4" wide	3050	1650	175	660	2250	1,900,000	SPIB
Select Structural		2850	1600	175	565	2100	1,800,000	
Non-Dense Select Structural		2650	1350	175	480	1950	1,700,000	
No.1 Dense		2000	1100	175	660	2000	1,800,000	
No.1		1850	1050	175	565	1850	1,700,000	
No.1 Non-Dense		1700	900	175	480	1700	1,600,000	
No.2 Dense		1700	875	175	660	1850	1,700,000	
No.2		1500	825	175	565	1650	1,600,000	
No.2 Non-Dense		1350	775	175	480	1600	1,400,000	
No.3 and Stud		850	475	175	565	975	1,400,000	
Construction	4" wide	1100	625	175	565	1800	1,500,000	
Standard		625	350	175	565	1500	1,300,000	
Utility		300	175	175	565	975	1,300,000	
Dense Select Structural	5"-6" wide	2700	1500	175	660	2150	1,900,000	
Select Structural		2550	1400	175	565	2000	1,800,000	
Non-Dense Select Structural		2350	1200	175	480	1850	1,700,000	
No.1 Dense		1750	950	175	660	1900	1,800,000	
No.1		1650	900	175	565	1750	1,700,000	
No.1 Non-Dense		1500	800	175	480	1600	1,600,000	
No.2 Dense		1450	775	175	660	1750	1,700,000	
No.2		1250	725	175	565	1600	1,600,000	
No.2 Non-Dense		1150	675	175	480	1500	1,400,000	
No.3 and Stud		750	425	175	565	925	1,400,000	
Dense Select Structural	8" wide	2450	1350	175	660	2050	1,900,000	
Select Structural		2300	1300	175	565	1900	1,800,000	
Non-Dense Select Structural		2100	1100	175	480	1750	1,700,000	
No.1 Dense		1650	875	175	660	1800	1,800,000	
No.1		1500	825	175	565	1650	1,700,000	
No.1 Non-Dense		1350	725	175	480	1550	1,600,000	
No.2 Dense		1400	675	175	660	1700	1,700,000	
No.2		1200	650	175	565	1550	1,600,000	
No.2 Non-Dense		1100	600	175	480	1450	1,400,000	
No.3 and Stud		700	400	175	565	875	1,400,000	
Dense Select Structural	10" wide	2150	1200	175	660	2000	1,900,000	
Select Structural		2050	1100	175	565	1850	1,800,000	
Non-Dense Select Structural		1850	950	175	480	1750	1,700,000	
No.1 Dense		1450	775	175	660	1750	1,800,000	
No.1		1300	725	175	565	1600	1,700,000	
No.1 Non-Dense		1200	650	175	480	1500	1,600,000	
No.2 Dense		1200	625	175	660	1650	1,700,000	
No.2		1050	575	175	565	1500	1,600,000	
No.2 Non-Dense		950	550	175	480	1400	1,400,000	
No.3 and Stud		600	325	175	565	850	1,400,000	
Dense Select Structural	12" wide ⁴	2050	1100	175	660	1950	1,900,000	
Select Structural		1900	1050	175	565	1800	1,800,000	
Non-Dense Select Structural		1750	900	175	480	1700	1,700,000	
No.1 Dense		1350	725	175	660	1700	1,800,000	
No.1		1250	675	175	565	1600	1,700,000	
No.1 Non-Dense		1150	600	175	480	1500	1,600,000	
No.2 Dense		1150	575	175	660	1600	1,700,000	
No.2		975	550	175	565	1450	1,600,000	
No.2 Non-Dense		900	525	175	480	1350	1,400,000	
No.3 and Stud		575	325	175	565	825	1,400,000	

4**DESIGN VALUES**

2-12" wide → 2'-4" thick

Table 4B Design Values for Visually Graded Southern Pine Dimension Lumber (2"-4" thick)^{1,2,3,4}

(Tabulated design values are for normal load duration and dry service conditions, unless specified otherwise. See NDS 4.3 for a comprehensive description of design value adjustment factors.)

USE WITH TABLE 4B ADJUSTMENT FACTORS								
Species and commercial grade	Size classification	Design values in pounds per square inch (psi)						Grading Rules Agency
		Bending F_b	Tension parallel to grain F_t	Shear parallel to grain F_v	Compression perpendicular to grain $F_{c\perp}$	Compression parallel to grain F_c	Modulus of Elasticity E	
SOUTHERN PINE		(Surfaced Dry - Used in dry service conditions — 19% or less moisture content)						
Dense Structural 86	2" & wider	2600	1750	175	660	2000	1,800,000	SPIB
Dense Structural 72		2200	1450	175	660	1650	1,800,000	
Dense Structural 65		2000	1300	175	660	1500	1,800,000	
SOUTHERN PINE		(Surfaced Green - Used in any service condition)						
Dense Structural 86	2-1/2" & wider 2-1/2"- 4" thick	2100	1400	165	440	1300	1,600,000	SPIB
Dense Structural 72		1750	1200	165	440	1100	1,600,000	
Dense Structural 65		1600	1050	165	440	1000	1,600,000	
MIXED SOUTHERN PINE								
Select Structural No.1	2"-4" wide	2050	1200	175	565	1800	1,600,000	SPIB
No.2		1450	875	175	565	1650	1,500,000	
No.3 and Stud		1300	775	175	565	1650	1,400,000	
		750	450	175	565	950	1,200,000	
Construction Standard	4" wide	1000	600	175	565	1700	1,300,000	
Utility		550	325	175	565	1450	1,200,000	
		275	150	175	565	950	1,100,000	
Select Structural No.1	5"-6" wide	1850	1100	175	565	1700	1,600,000	
No.2		1300	750	175	565	1550	1,500,000	
No.3 and Stud		1150	675	175	565	1550	1,400,000	
		675	400	175	565	875	1,200,000	
Select Structural No.1	8" wide	1750	1000	175	565	1600	1,600,000	
No.2		1200	700	175	565	1450	1,500,000	
No.3 and Stud		1050	625	175	565	1450	1,400,000	
		625	375	175	565	850	1,200,000	
Select Structural No.1	10" wide	1500	875	175	565	1600	1,600,000	
No.2		1050	600	175	565	1450	1,500,000	
No.3 and Stud		925	550	175	565	1450	1,400,000	
		525	325	175	565	825	1,200,000	
Select Structural No.1	12" wide	1400	825	175	565	1550	1,600,000	
No.2		975	575	175	565	1400	1,500,000	
No.3 and Stud		875	525	175	565	1400	1,400,000	
		500	300	175	565	800	1,200,000	

- LUMBER DIMENSIONS.** Tabulated design values are applicable to lumber that will be used under dry conditions such as in most covered structures. For 2" to 4" thick lumber the DRY dressed sizes shall be used (see Table 1A) regardless of the moisture content at the time of manufacture or use. In calculating design values, the natural gain in strength and stiffness that occurs as lumber dries has been taken into consideration as well as the reduction in size that occurs when unseasoned lumber shrinks. The gain in load carrying capacity due to increased strength and stiffness resulting from drying more than offsets the design effect of size reductions due to shrinkage.
- STRESS-RATED BOARDS.** Information for various grades of Southern Pine stress-rated boards of nominal 1", 1 1/4" and 1 1/2" thickness, 2" and wider is available from the Southern Pine Inspection Bureau (SPIB) in the "Standard Grading Rules for Southern Pine Lumber."
- SPRUCE PINE.** To obtain recommended design values for Spruce Pine graded to SPIB rules, multiply the appropriate design values for Mixed Southern Pine by the corresponding conversion factor shown below and round to the nearest 100,000 psi for E ; to the next lower multiple of 5 psi for F_v and $F_{c\perp}$; to the next lower multiple of 50 psi for F_b , F_t and F_c if 1000 psi or greater, 25 psi otherwise.
- SIZE FACTOR.** For sizes wider than 12", use size factors for F_b , F_t , and F_c specified for the 12" width. Use 100% of the F_v , $F_{c\perp}$ and E specified for the 12" width.

CONVERSION FACTORS FOR DETERMINING DESIGN VALUES FOR SPRUCE PINE

	Bending F_b	Tension parallel to grain F_t	Shear parallel to grain F_v	Compression perpendicular to grain $F_{c\perp}$	Compression parallel to grain F_c	Modulus of Elasticity E
Conversion Factor	0.78	0.78	0.98	0.73	0.78	0.82