

3.1 Section Properties of Sawn Lumber and Structural 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% or less. Green lumber is defined as lumber having a moisture content in excess of 19%.

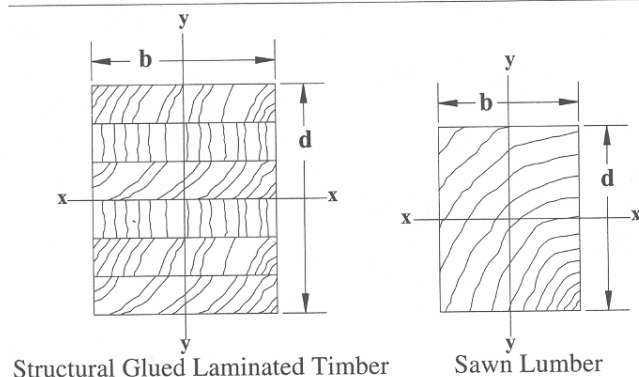
3.1.2 Properties of Standard Dressed Sizes

Certain mathematical expressions of the properties of 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 structural 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, in.

d = depth of rectangular bending member, in.

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

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

$I_x = bd^3/12$ = 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, in.

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

$S_x = I_x/c = bd^2/6$ = 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 11.3.2A)

m.c. = moisture content of wood, %

Table 1A Nominal and Minimum Dressed Sizes of Sawn Lumber

Item	Thickness (in.)			Face Widths (in.)		
	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

Table 4.3.1 Applicability of Adjustment Factors for Sawn Lumber

		ASD only	ASD and LRFD										LRFD only		
		Load Duration Factor	Wet Service Factor	Temperature Factor	Beam Stability Factor	Size Factor	Flat Use Factor	Incising Factor	Repetitive Member Factor	Column Stability Factor	Buckling Stiffness Factor	Bearing Area Factor	Format Conversion Factor	Resistance Factor	Time Effect Factor
$F_b' = F_b$	x	C_D	C_M	C_t	C_L	C_F	C_{fu}	C_i	C_r	-	-	-	K_F	ϕ_b	λ
$F_t' = F_t$	x	C_D	C_M	C_t	-	C_F	-	C_i	-	-	-	-	K_F	ϕ_t	λ
$F_v' = F_v$	x	C_D	C_M	C_t	-	-	-	C_i	-	-	-	-	K_F	ϕ_v	λ
$F_{c\perp}' = F_{c\perp}$	x	-	C_M	C_t	-	-	-	C_i	-	-	-	C_b	K_F	ϕ_c	λ
$F_c' = F_c$	x	C_D	C_M	C_t	-	C_F	-	C_i	-	C_p	-	-	K_F	ϕ_c	λ
$E' = E$	x	-	C_M	C_t	-	-	-	C_i	-	-	-	-	-	-	-
$E_{min}' = E_{min}$	x	-	C_M	C_t	-	-	-	C_i	-	-	C_T	-	K_F	ϕ_s	-

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 center, 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 and E_{min}
0.85*	1.0	0.97	0.67	0.8**	0.9

* when $(F_b)(C_F) \leq 1,150$ 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

Grades		F_b		F_t	F_c
		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 Reference Design Values for Visually Graded Dimension Lumber (2" - 4" thick)^{1,2,3}
(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	E _{min}	
EASTERN HEMLOCK-TAMARACK									
Select Structural	2" & wider	1,250	575	170	555	1,200	1,200,000	440,000	NELMA NSLB
No.1		775	350	170	555	1,000	1,100,000	400,000	
No.2		575	275	170	555	825	1,100,000	400,000	
No.3		350	150	170	555	475	900,000	330,000	
Stud	2" & wider	450	200	170	555	525	900,000	330,000	
Construction	2" - 4" wide	675	300	170	555	1,050	1,000,000	370,000	
Standard		375	175	170	555	850	900,000	330,000	
Utility		175	75	170	555	550	800,000	290,000	
EASTERN SOFTWOODS									
Select Structural	2" & wider	1,250	575	140	335	1,200	1,200,000	440,000	NELMA NSLB
No.1		775	350	140	335	1,000	1,100,000	400,000	
No.2		575	275	140	335	825	1,100,000	400,000	
No.3		350	150	140	335	475	900,000	330,000	
Stud	2" & wider	450	200	140	335	525	900,000	330,000	
Construction	2" - 4" wide	675	300	140	335	1,050	1,000,000	370,000	
Standard		375	175	140	335	850	900,000	330,000	
Utility		175	75	140	335	550	800,000	290,000	
EASTERN WHITE PINE									
Select Structural	2" & wider	1,250	575	135	350	1,200	1,200,000	440,000	NELMA NSLB
No.1		775	350	135	350	1,000	1,100,000	400,000	
No.2		575	275	135	350	825	1,100,000	400,000	
No.3		350	150	135	350	475	900,000	330,000	
Stud	2" & wider	450	200	135	350	525	900,000	330,000	
Construction	2" - 4" wide	675	300	135	350	1,050	1,000,000	370,000	
Standard		375	175	135	350	850	900,000	330,000	
Utility		175	75	135	350	550	800,000	290,000	
HEM-FIR									
Select Structural	2" & wider	1,400	925	150	405	1,500	1,600,000	580,000	WCLIB WWPA
No.1 & Btr		1,100	725	150	405	1,350	1,500,000	550,000	
No.1		975	625	150	405	1,350	1,500,000	550,000	
No.2		850	525	150	405	1,300	1,300,000	470,000	
No.3	2" & wider	500	300	150	405	725	1,200,000	440,000	
Stud		675	400	150	405	800	1,200,000	440,000	
Construction		975	600	150	405	1,550	1,300,000	470,000	
Standard	2" - 4" wide	550	325	150	405	1,300	1,200,000	440,000	
Utility		250	150	150	405	850	1,100,000	400,000	
HEM-FIR (NORTH)									
Select Structural	2" & wider	1,300	775	145	405	1,700	1,700,000	620,000	NLGA
No.1 & Btr		1,200	725	145	405	1,550	1,700,000	620,000	
No.1/No.2		1,000	575	145	405	1,450	1,600,000	580,000	
No.3		575	325	145	405	850	1,400,000	510,000	
Stud	2" & wider	775	450	145	405	925	1,400,000	510,000	
Construction	2" - 4" wide	1,150	650	145	405	1,750	1,500,000	550,000	
Standard		650	350	145	405	1,500	1,400,000	510,000	
Utility		300	175	145	405	975	1,300,000	470,000	
MIXED MAPLE									
Select Structural	2" & wider	1,000	600	195	620	875	1,300,000	470,000	NELMA
No.1		725	425	195	620	700	1,200,000	440,000	
No.2		700	425	195	620	550	1,100,000	400,000	
No.3		400	250	195	620	325	1,000,000	370,000	
Stud	2" & wider	550	325	195	620	350	1,000,000	370,000	
Construction	2" - 4" wide	800	475	195	620	725	1,100,000	400,000	
Standard		450	275	195	620	575	1,000,000	370,000	
Utility		225	125	195	620	375	900,000	330,000	

Table 4D Adjustment Factors



Size Factor, C_F

When the depth, d , of a beam, stringer, post, or timber exceeds 12", the tabulated bending design value, F_b , shall be multiplied by the following size factor:

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

When beams and stringers are subjected to loads applied to the wide face, tabulated design values shall be multiplied by the following size factors:

Size Factors, C_F

Grade	F_b	E and E_{min}	Other Properties
Select Structural	0.86	1.00	1.00
No.1	0.74	0.90	1.00
No.2	1.00	1.00	1.00

Wet Service Factor, C_M

When timbers are 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 Southern Pine and Mixed Southern Pine use tabulated design values without further adjustment):

Wet Service Factors, C_M

F_b	F_t	F_v	$F_{c\perp}$	F_c	E and E_{min}
1.00	1.00	1.00	0.67	0.91	1.00

Table 4D Reference Design Values for Visually Graded Timbers (5" x 5" and larger)^{1,3}
(Cont.) (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 4D 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 _{cL}	Compression parallel to grain F _c	Modulus of Elasticity		
							E	E _{min}	
DOUGLAS FIR-LARCH (NORTH)									
Select Structural No.1 No.2	Beams and Stringers	1,600 1,300 875	950 675 425	170 170 170	625 625 625	1,100 925 600	1,600,000 1,600,000 1,300,000	580,000 580,000 470,000	NLGA
Select Structural No.1 No.2	Posts and Timbers	1,500 1,200 725	1,000 825 475	170 170 170	625 625 625	1,150 1,000 700	1,600,000 1,600,000 1,300,000	580,000 580,000 470,000	
DOUGLAS FIR-SOUTH									
Select Structural No.1 No.2	Beams and Stringers	1,550 1,300 825	900 625 425	165 165 165	520 520 520	1,000 850 550	1,200,000 1,200,000 1,000,000	440,000 440,000 370,000	WWPA
Select Structural No.1 No.2	Posts and Timbers	1,450 1,150 675	950 775 450	165 165 165	520 520 520	1,050 925 650	1,200,000 1,200,000 1,000,000	440,000 440,000 370,000	
EASTERN HEMLOCK									
Select Structural No.1 No.2	Beams and Stringers	1,350 1,150 750	925 775 375	155 155 155	550 550 550	950 800 550	1,200,000 1,200,000 900,000	440,000 440,000 330,000	NELMA NSLB
Select Structural No.1 No.2	Posts and Timbers	1,250 1,050 600	850 700 400	155 155 155	550 500 550	1,000 875 400	1,200,000 1,200,000 900,000	440,000 440,000 330,000	
EASTERN HEMLOCK-TAMARACK									
Select Structural No.1 No.2	Beams and Stringers	1,400 1,150 750	925 775 375	155 155 155	555 555 555	950 800 500	1,200,000 1,200,000 900,000	440,000 440,000 330,000	NELMA NSLB
Select Structural No.1 No.2	Posts and Timbers	1,300 1,050 600	875 700 400	155 155 155	555 555 555	1,000 875 400	1,200,000 1,200,000 900,000	440,000 440,000 330,000	
EASTERN HEMLOCK-TAMARACK (N)									
Select Structural No.1 No.2	Beams and Stringers	1,450 1,200 775	850 600 400	165 165 165	555 555 555	950 800 500	1,300,000 1,300,000 1,100,000	470,000 470,000 400,000	NLGA
Select Structural No.1 No.2	Posts and Timbers	1,350 1,100 650	900 725 425	165 165 165	555 555 555	1,000 875 600	1,300,000 1,300,000 1,100,000	470,000 470,000 400,000	
EASTERN SPRUCE									
Select Structural No.1 No.2	Beams and Stringers	1,050 900 575	725 600 275	135 135 135	390 390 390	750 625 375	1,400,000 1,400,000 1,000,000	510,000 510,000 370,000	NELMA NSLB
Select Structural No.1 No.2	Posts and Timbers	1,000 800 450	675 550 300	135 135 135	390 390 390	775 675 300	1,400,000 1,400,000 1,000,000	510,000 510,000 370,000	
EASTERN WHITE PINE									
Select Structural No.1 No.2	Beams and Stringers	1,050 875 575	700 600 275	125 125 125	350 350 350	675 575 400	1,100,000 1,100,000 900,000	400,000 400,000 330,000	NELMA NSLB
Select Structural No.1 No.2	Posts and Timbers	975 800 450	650 525 300	125 125 125	350 350 350	725 625 325	1,100,000 1,100,000 900,000	400,000 400,000 330,000	

Table 4D Reference Design Values for Visually Graded Timbers (5" x 5" and larger)^{1,3}
(Cont.) (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 4D 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 _{cL}	Compression parallel to grain F _c	Modulus of Elasticity			
							E	E _{min}		
HEM-FIR										
Select Structural No.1 No.2	Beams and Stringers	1,300 1,050 675	750 525 350	140 140 140	405 405 405	925 750 500	1,300,000 1,300,000 1,100,000	470,000 470,000 400,000	WCLIB WWPA	
Select Structural No.1 No.2	Posts and Timbers	1,200 975 575	800 650 375	140 140 140	405 405 405	975 850 575	1,300,000 1,300,000 1,100,000	470,000 470,000 400,000		
HEM-FIR (NORTH)										
Select Structural No.1 No.2	Beams and Stringers	1,250 1,000 675	725 500 325	135 135 135	405 405 405	900 750 475	1,300,000 1,300,000 1,100,000	470,000 470,000 400,000		NLGA
Select Structural No.1 No.2	Posts and Timbers	1,150 925 550	775 625 375	135 135 135	405 405 405	950 850 575	1,300,000 1,300,000 1,100,000	470,000 470,000 400,000		
MIXED MAPLE										
Select Structural No.1 No.2	Beams and Stringers	1,150 975 625	700 500 325	180 180 180	620 620 620	725 600 375	1,100,000 1,100,000 900,000	400,000 400,000 330,000	NELMA	
Select Structural No.1 No.2	Posts and Timbers	1,100 875 500	725 600 350	180 180 180	620 620 620	750 650 300	1,100,000 1,100,000 900,000	400,000 400,000 330,000		
MIXED OAK										
Select Structural No.1 No.2	Beams and Stringers	1,350 1,150 725	800 550 375	155 155 155	800 800 800	825 700 450	1,000,000 1,000,000 800,000	370,000 370,000 290,000		NELMA
Select Structural No.1 No.2	Posts and Timbers	1,250 1,000 575	850 675 400	155 155 155	800 800 800	875 775 350	1,000,000 1,000,000 800,000	370,000 370,000 290,000		
MIXED SOUTHERN PINE ²		(Wet Service Conditions)								
Select Structural No.1 No.2	5"x5" and Larger	1,500 1,350 850	1,000 900 550	165 165 165	375 375 375	900 800 525	1,300,000 1,300,000 1,000,000	470,000 470,000 370,000	SPIB	
MOUNTAIN HEMLOCK										
Select Structural No.1 No.2	Beams and Stringers	1,350 1,100 725	775 550 375	170 170 170	570 570 570	875 725 475	1,100,000 1,100,000 900,000	400,000 400,000 330,000		WCLIB WWPA
Select Structural No.1 No.2	Posts and Timbers	1,250 1,000 625	825 675 400	170 170 170	570 570 570	925 800 550	1,100,000 1,100,000 900,000	400,000 400,000 330,000		
NORTHERN PINE										
Select Structural No.1 No.2	Beams and Stringers	1,250 1,050 675	850 700 350	135 135 135	435 435 435	850 725 450	1,300,000 1,300,000 1,000,000	470,000 470,000 370,000	NELMA NSLB	
Select Structural No.1 No.2	Posts and Timbers	1,150 950 550	800 650 375	135 135 135	435 435 435	900 800 375	1,300,000 1,300,000 1,000,000	470,000 470,000 370,000		
NORTHERN RED OAK										
Select Structural No.1 No.2	Beams and Stringers	1,600 1,350 875	950 675 425	205 205 205	885 885 885	950 800 500	1,300,000 1,300,000 1,000,000	470,000 470,000 370,000		NELMA
Select Structural No.1 No.2	Posts and Timbers	1,500 1,200 700	1,000 800 475	205 205 205	885 885 885	1,000 875 400	1,300,000 1,300,000 1,000,000	470,000 470,000 370,000		