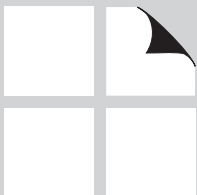


SAWN LUMBER

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4.1 General

4.1.1 Scope

Chapter 4 applies to engineering design with sawn lumber. Design procedures, reference design values, and other information herein apply only to lumber complying with the requirements specified below.

4.1.2 Identification of Lumber

4.1.2.1 When the reference design values specified herein are used, the lumber, including end-jointed or edge-glued lumber, shall be identified by the grade mark of, or certificate of inspection issued by, a lumber grading or inspection bureau or agency recognized as being competent (see Reference 31). A distinct grade mark of a recognized lumber grading or inspection bureau or agency, indicating that joint integrity is subject to qualification and quality control, shall be applied to glued lumber products.

4.1.2.2 Lumber shall be specified by commercial species and grade names, or by required levels of design values as listed in Tables 4A, 4B, 4C, 4D, 4E, and 4F (published in the Supplement to this Specification).

4.1.3 Definitions

4.1.3.1 Structural sawn lumber consists of lumber classifications known as “Dimension,” “Beams and Stringers,” “Posts and Timbers,” and “Decking,” with design values assigned to each grade.

4.1.3.2 “Dimension” refers to lumber from 2" to 4" (nominal) thick, and 2" (nominal) or more in width. Dimension lumber is further classified as Structural Light Framing, Light Framing, Studs, and Joists and Planks (see References 42, 43, 45, 46, 47, and 49 for additional information).

4.1.3.3 “Beams and Stringers” refers to lumber of rectangular cross section, 5" (nominal) or more thick, with width more than 2" greater than thickness, graded with respect to its strength in bending when loaded on the narrow face.

4.1.3.4 “Posts and Timbers” refers to lumber of square or approximately square cross section, 5" x 5" (nominal) and larger, with width not more than 2" greater than thickness, graded primarily for use as posts or columns carrying longitudinal load.

4.1.3.5 “Decking” refers to lumber from 2" to 4" (nominal) thick, tongued and grooved, or grooved for spline on the narrow face, and intended for use as a roof, floor, or wall membrane. Decking is graded for

application in the flatwise direction, with the wide face of the decking in contact with the supporting members, as normally installed.

4.1.4 Moisture Service Condition of Lumber

The reference design values for lumber specified herein are applicable to lumber that will be used under dry service conditions such as in most covered structures, where the moisture content in use will be a maximum of 19%, regardless of the moisture content at the time of manufacture. For lumber used under conditions where the moisture content of the wood in service will exceed 19% for an extended period of time, the design values shall be multiplied by the wet service factors, C_M , specified in Tables 4A, 4B, 4C, 4D, 4E, and 4F.

4.1.5 Lumber Sizes

4.1.5.1 Lumber sizes referred to in this Specification are nominal sizes. Computations to determine the required sizes of members shall be based on the net dimensions (actual sizes) and not the nominal sizes. The dressed sizes specified in Reference 31 shall be accepted as the minimum net sizes associated with nominal dimensions (see Table 1A in the Supplement to this Specification).

4.1.5.2 For 4" (nominal) or thinner lumber, the net DRY dressed sizes shall be used in all computations of structural capacity regardless of the moisture content at the time of manufacture or use.

4.1.5.3 For 5" (nominal) and thicker lumber, the net GREEN dressed sizes shall be used in computations of structural capacity regardless of the moisture content at the time of manufacture or use.

4.1.5.4 Where a design is based on rough sizes or special sizes, the applicable moisture content and size used in design shall be clearly indicated in plans or specifications.

4.1.6 End-Jointed or Edge-Glued Lumber

Reference design values for sawn lumber are applicable to structural end-jointed or edge-glued lumber of the same species and grade. Such use shall include, but not be limited to light framing, studs, joists, planks, and decking. When finger jointed lumber is marked “STUD USE ONLY” or “VERTICAL USE ONLY” such lumber shall be limited to use where any bending or tension stresses are of short duration.

4.1.7 Resawn or Remanufactured Lumber

4.1.7.1 When structural lumber is resawn or remanufactured, it shall be regraded, and reference design values for the regraded material shall apply (see References 16, 42, 43, 45, 46, 47, and 49).

4.1.7.2 When sawn lumber is cross cut to shorter lengths, the requirements of 4.1.7.1 shall not apply, except for reference bending design values for those Beam and Stringer grades where grading provisions for the middle 1/3 of the length of the piece differ from grading provisions for the outer thirds.

4.2 Reference Design Values

4.2.1 Reference Design Values

Reference design values for visually graded lumber and for mechanically graded dimension lumber are specified in Tables 4A, 4B, 4C, 4D, 4E, and 4F (published in the Supplement to this Specification). The reference design values in Tables 4A, 4B, 4C, 4D, 4E, and 4F are taken from the published grading rules of the agencies cited in References 42, 43, 45, 46, 47, and 49.

4.2.2 Other Species and Grades

Reference design values for species and grades of lumber not otherwise provided herein shall be established in accordance with appropriate ASTM standards and other technically sound criteria (see References 16, 18, 19, and 31).

4.2.3 Basis for Reference Design Values

4.2.3.1 The reference design values in Tables 4A, 4B, 4C, 4D, 4E, and 4F are for the design of structures where an individual member, such as a beam, girder, post or other member, carries or is responsible for carrying its full design load. For repetitive member uses see 4.3.9.

4.2.3.2 Visually Graded Lumber. Reference design values for visually graded lumber in Tables 4A, 4B, 4C, 4D, 4E, and 4F are based on the provisions of ASTM Standards D 245 and D 1990.

4.2.3.3 Machine Stress Rated (MSR) Lumber and Machine Evaluated Lumber (MEL). Reference design values for machine stress rated lumber and machine evaluated lumber in Table 4C are determined by visual grading and nondestructive pretesting of individual pieces.

4.2.4 Modulus of Elasticity, E

4.2.4.1 Average Values. Reference design values for modulus of elasticity assigned to the visually graded

species and grades of lumber listed in Tables 4A, 4B, 4C, 4D, 4E, and 4F are average values which conform to ASTM Standards D 245 and D 1990. Adjustments in modulus of elasticity have been taken to reflect increases for seasoning, increases for density where applicable, and, where required, reductions have been made to account for the effect of grade upon stiffness. Reference modulus of elasticity design values are based upon the species or species group average in accordance with ASTM Standards D 1990 and D 2555.

4.2.4.2 Special Uses. Average reference modulus of elasticity design values listed in Tables 4A, 4B, 4C, 4D, 4E, and 4F are to be used in design of repetitive member systems and in calculating the immediate deflection of single members which carry their full design load. In special applications where deflection is a critical factor, or where amount of deformation under long-term loading must be limited, the need for use of a reduced modulus of elasticity design value shall be determined. See Appendix F for provisions on design value adjustments for special end use requirements.

4.2.5 Bending, F_b

4.2.5.1 Dimension Grades. Adjusted bending design values for Dimension grades apply to members with the load applied to either the narrow or wide face.

4.2.5.2 Decking Grades. Adjusted bending design values for Decking grades apply only when the load is applied to the wide face.

4.2.5.3 Post and Timber Grades. Adjusted bending design values for Post and Timber grades apply to members with the load applied to either the narrow or wide face.

4.2.5.4 Beam and Stringer Grades. Adjusted bending design values for Beam and Stringer grades apply to members with the load applied to the narrow face. When Post and Timber sizes of lumber are graded to Beam and Stringer grade requirements, design values for the applicable Beam and Stringer grades shall be used. Such lumber shall be identified in accordance

with 4.1.2.1 as conforming to Beam and Stringer grades.

4.2.5.5 Continuous or Cantilevered Beams. When Beams and Stringers are used as continuous or cantilevered beams, the design shall include a requirement that the grading provisions applicable to the middle 1/3 of the length (see References 42, 43, 45, 46, 47, and 49) shall be applied to at least the middle 2/3 of the length of pieces to be used as two span continuous beams, and to the entire length of pieces to be used over three or more spans or as cantilevered beams.

4.2.6 Compression Perpendicular to Grain, $F_{c\perp}$

For sawn lumber, the reference compression design values perpendicular to grain are based on a deformation limit that has been shown by experience to provide for adequate service in typical wood frame construction. The reference compression design values

perpendicular to grain specified in Tables 4A, 4B, 4C, 4D, 4E, and 4F are species group average values associated with a deformation level of 0.04" for a steel plate on wood member loading condition. One method for limiting deformation in special applications where it is critical, is use of a reduced compression design value perpendicular to grain. The following equation shall be used to calculate the compression design value perpendicular to grain for a reduced deformation level of 0.02":

$$F_{c\perp 0.02} = 0.73 F_{c\perp} \quad (4.2-1)$$

where:

$F_{c\perp 0.02}$ = compression perpendicular to grain design value at 0.02" deformation limit, psi

$F_{c\perp}$ = reference compression perpendicular to grain design value at 0.04" deformation limit (as published in Tables 4A, 4B, 4C, 4D, 4E, and 4F), psi

4.3 Adjustment of Reference Design Values

4.3.1 General

Reference design values (F_b , F_t , F_v , $F_{c\perp}$, F_c , E , E_{min}) from Tables 4A, 4B, 4C, 4D, 4E, and 4F shall be multiplied by the adjustment factors specified in Table 4.3.1 to determine adjusted design values (F_b' , F_t' , F_v' , $F_{c\perp}'$, F_c' , E' , E_{min}').

4.3.2 Load Duration Factor, C_D (ASD Only)

All reference design values except modulus of elasticity, E , modulus of elasticity for beam and column stability, E_{min} , and compression perpendicular to grain, $F_{c\perp}$, shall be multiplied by load duration factors, C_D , as specified in 2.3.2.

4.3.3 Wet Service Factor, C_M

Reference design values for structural sawn lumber are based on the moisture service conditions specified in 4.1.4. When the moisture content of structural members in use differs from these moisture service conditions, reference design values shall be multiplied by the wet service factors, C_M , specified in Tables 4A, 4B, 4C, 4D, 4E, and 4F.

4.3.4 Temperature Factor, C_t

When structural members will experience sustained exposure to elevated temperatures up to 150°F (see Appendix C), reference design values shall be multiplied by the temperature factors, C_t , specified in 2.3.3.

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
													K_F	ϕ	
$F_b' = F_b$	x	C_D	C_M	C_t	C_L	C_F	C_{fu}	C_i	C_r	-	-	-	2.54	0.85	λ
$F_t' = F_t$	x	C_D	C_M	C_t	-	C_F	-	C_i	-	-	-	-	2.70	0.80	λ
$F_v' = F_v$	x	C_D	C_M	C_t	-	-	-	C_i	-	-	-	-	2.88	0.75	λ
$F_c' = F_c$	x	C_D	C_M	C_t	-	C_F	-	C_i	-	C_P	-	-	2.40	0.90	λ
$F_{c\perp}' = F_{c\perp}$	x	-	C_M	C_t	-	-	-	C_i	-	-	-	C_b	1.67	0.90	-
$E' = E$	x	-	C_M	C_t	-	-	-	C_i	-	-	-	-	-	-	-
$E_{min}' = E_{min}$	x	-	C_M	C_t	-	-	-	C_i	-	-	C_T	-	1.76	0.85	-

4.3.5 Beam Stability Factor, C_L

Reference bending design values, F_b , shall be multiplied by the beam stability factor, C_L , specified in 3.3.3.

4.3.6 Size Factor, C_F

4.3.6.1 Reference bending, tension, and compression parallel to grain design values for visually graded dimension lumber 2" to 4" thick shall be multiplied by the size factors specified in Tables 4A and 4B.

4.3.6.2 Where the depth of a rectangular sawn lumber bending member 5" or thicker exceeds 12", the reference bending design values, F_b , in Table 4D shall be multiplied by the following size factor:

$$C_F = (12 / d)^{1/9} \leq 1.0 \quad (4.3-1)$$

4.3.6.3 For beams of circular cross section with a diameter greater than 13.5", or for 12" or larger square beams loaded in the plane of the diagonal, the size fac-

tor shall be determined in accordance with 4.3.6.2 on the basis of an equivalent conventionally loaded square beam of the same cross-sectional area.

4.3.6.4 Reference bending design values for all species of 2" thick or 3" thick Decking, except Redwood, shall be multiplied by the size factors specified in Table 4E.

4.3.7 Flat Use Factor, C_{fu}

4.3.7.1 When sawn lumber 2" to 4" thick is loaded on the wide face, multiplying the reference bending design value, F_b , by the flat use factors, C_{fu} , specified in Tables 4A, 4B, 4C, and 4F, shall be permitted.

4.3.7.2 When members classified as Beams and Stringers are loaded on the wide face, the reference bending design value, F_b , and the reference modulus of elasticity, (E or E_{min}), shall be multiplied by the flat use factors, C_{fu} , specified in Table 4D.

4.3.8 Incising Factor, C_i

Reference design values for dimension lumber shall be multiplied by the incising factor, C_i , in Table 4.3.8 when dimension lumber is incised parallel to grain a maximum depth of 0.4", a maximum length of 3/8", and a density of incisions up to 1100/ft². As an alternative, incising factors for specific incising patterns and lumber sizes shall be obtained from the company providing the incising.

Table 4.3.8 Incising Factors, C_i

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

4.3.9 Repetitive Member Factor, C_r

Reference bending design values, F_b , in Tables 4A, 4B, 4C, and 4F for dimension lumber 2" to 4" thick shall be multiplied by the repetitive member factor, $C_r = 1.15$, where 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 three in number and are joined by floor, roof or other load distributing elements adequate to support the design load. (A load distributing element is any adequate system that is designed or has been proven by experience to transmit the design load to adjacent members, spaced as described above, without displaying structural weakness or unacceptable deflection. Subflooring, flooring, sheathing, or other covering elements and nail gluing or tongue-and-groove joints, and through nailing generally meet these criteria.) Reference bending design values in Table 4E for visually graded Decking have already been multiplied by $C_r = 1.15$.

4.3.10 Column Stability Factor, C_p

Reference compression design values parallel to grain, F_c , shall be multiplied by the column stability factor, C_p , specified in 3.7.

4.3.11 Buckling Stiffness Factor, C_T

Reference modulus of elasticity for beam and column stability, E_{min} , shall be permitted to be multiplied by the buckling stiffness factor, C_T , as specified in 4.4.2.

4.3.12 Bearing Area Factor, C_b

Reference compression design values perpendicular to grain, $F_{c\perp}$, shall be permitted to be multiplied by the bearing area factor, C_b , as specified in 3.10.4.

4.3.13 Pressure-Preservative Treatment

Reference design values apply to sawn lumber pressure-treated by an approved process and preservative (see Reference 30). Load duration factors greater than 1.6 shall not apply to structural members pressure-treated with water-borne preservatives.

4.3.14 Format Conversion Factor, K_F (LRFD Only)

For LRFD, reference design values shall be multiplied by the format conversion factor, K_F , specified in Table 4.3.1.

4.3.15 Resistance Factor, ϕ (LRFD Only)

For LRFD, reference design values shall be multiplied by the resistance factor, ϕ , specified in Table 4.3.1.

4.3.16 Time Effect Factor, λ (LRFD Only)

For LRFD, reference design values shall be multiplied by the time effect factor, λ , specified in Appendix N.3.3.

4.4 Special Design Considerations

4.4.1 Stability of Bending Members

4.4.1.1 Sawn lumber bending members shall be designed in accordance with the lateral stability calculations in 3.3.3 or shall meet the lateral support requirements in 4.4.1.2 and 4.4.1.3.

4.4.1.2 As an alternative to 4.4.1.1, rectangular sawn lumber beams, rafters, joists, or other bending members, shall be designed in accordance with the following provisions to provide restraint against rotation or lateral displacement. If the depth to breadth, d/b , based on nominal dimensions is:

- (a) $d/b \leq 2$; no lateral support shall be required.
- (b) $2 < d/b \leq 4$; the ends shall be held in position, as by full depth solid blocking, bridging, hangers, nailing, or bolting to other framing members, or other acceptable means.
- (c) $4 < d/b \leq 5$; the compression edge of the member shall be held in line for its entire length to prevent lateral displacement, as by adequate sheathing or subflooring, and ends at point of bearing shall be held in position to prevent rotation and/or lateral displacement.
- (d) $5 < d/b \leq 6$; bridging, full depth solid blocking or diagonal cross bracing shall be installed at intervals not exceeding 8 feet, the compression edge of the member shall be held in line as by adequate sheathing or subflooring, and the ends at points of bearing shall be held in position to prevent rotation and/or lateral displacement.
- (e) $6 < d/b \leq 7$; both edges of the member shall be held in line for their entire length and ends at points of bearing shall be held in position to prevent rotation and/or lateral displacement.

4.4.1.3 If a bending member is subjected to both flexure and axial compression, the depth to breadth ratio shall be no more than 5 to 1 if one edge is firmly held in line. If under all combinations of load, the unbraced edge of the member is in tension, the depth to breadth ratio shall be no more than 6 to 1.

4.4.2 Wood Trusses

4.4.2.1 Increased chord stiffness relative to axial loads where a 2" x 4" or smaller sawn lumber truss compression chord is subjected to combined flexure and axial compression under dry service condition and has 3/8" or thicker wood structural panel sheathing nailed to the narrow face of the chord in accordance with code required roof sheathing fastener schedules (see References 32, 33, and 34), shall be permitted to be accounted for by multiplying the reference modulus of elasticity design value for beam and column stability, E_{min} , by the buckling stiffness factor, C_T , in column stability calculations (see 3.7 and Appendix H). When $\ell_e < 96"$, C_T shall be calculated as follows:

$$C_T = 1 + \frac{K_M \ell_e}{K_T E} \quad (4.4-1)$$

where:

ℓ_e = effective column length of truss compression chord (see 3.7), in.

K_M = 2300 for wood seasoned to 19% moisture content or less at the time of wood structural panel sheathing attachment.

= 1200 for unseasoned or partially seasoned wood at the time of wood structural panel sheathing attachment.

$K_T = 1 - 1.645(COV_E)$

= 0.59 for visually graded lumber

= 0.75 for machine evaluated lumber (MEL)

= 0.82 for products with $COV_E \leq 0.11$ (see Appendix F.2)

When $\ell_e > 96"$, C_T shall be calculated based on $\ell_e = 96"$.

4.4.2.2 For additional information concerning metal plate connected wood trusses see Reference 9.

4.4.3 Notches

4.4.3.1 End notches, located at the ends of sawn lumber bending members for bearing over a support, shall be permitted, and shall not exceed 1/4 the beam depth (see Figure 4A).

4.4.3.2 Interior notches, located in the outer thirds of the span of a single span sawn lumber bending member, shall be permitted, and shall not exceed 1/6 the depth of the member. Interior notches on the tension side of 3-1/2" or greater thickness (4" nominal thickness) sawn lumber bending members are not permitted (see Figure 4A).

4.4.3.3 See 3.1.2 and 3.4.3 for effect of notches on strength.

Figure 4A Notch Limitations for Sawn Lumber Beams

