3

DESIGN PROVISIONS AND EQUATIONS

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3.1 General

3.1.1 Scope

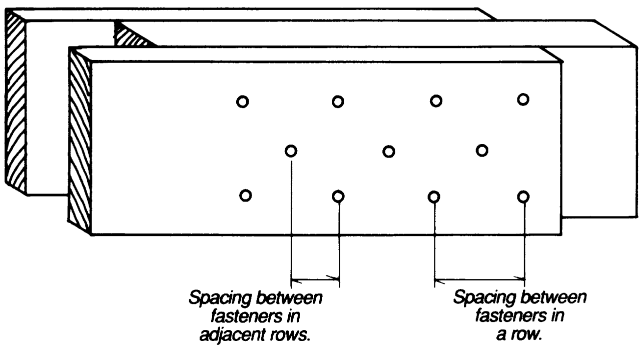
Chapter 3 establishes general design provisions that apply to all wood structural members and connections covered under this Specification. Each wood structural member or connection shall be of sufficient size and capacity to carry the applied loads without exceeding the adjusted design values specified herein. Reference design values and specific design provisions applicable to particular wood products or connections are given in other Chapters of this Specification.

3.1.2 Net Section Area

3.1.2.1 The net section area is obtained by deducting from the gross section area the projected area of all material removed by boring, grooving, dapping, notching, or other means. The net section area shall be used in calculating the load carrying capacity of a member, except as specified in 3.6.3 for columns. The effects of any eccentricity of loads applied to the member at the critical net section shall be taken into account.

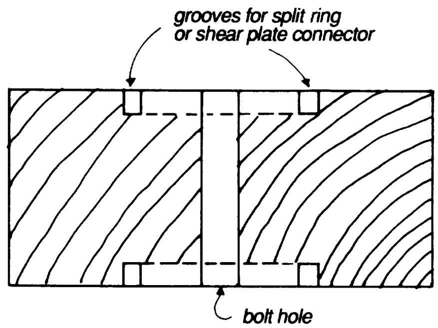
3.1.2.2 For parallel to grain loading with staggered bolts, drift bolts, drift pins, or lag screws, adjacent fasteners shall be considered as occurring at the same critical section if the parallel to grain spacing between fasteners in adjacent rows is less than four fastener diameters (see Figure 3A).

Figure 3A Spacing of Staggered Fasteners



3.1.2.3 The net section area at a split ring or shear plate connection shall be determined by deducting from the gross section area the projected areas of the bolt hole and the split ring or shear plate groove within the member (see Figure 3B and Appendix K). Where split ring or shear plate connectors are staggered, adjacent connectors shall be considered as occurring at the same critical section if the parallel to grain spacing between connectors in adjacent rows is less than or equal to one connector diameter (see Figure 3A).

Figure 3B Net Cross Section at a Split Ring or Shear Plate Connection



3.1.3 Connections

Structural members and fasteners shall be arranged symmetrically at connections, unless the bending moment induced by an unsymmetrical arrangement (such as lapped joints) has been accounted for in the design. Connections shall be designed and fabricated to insure that each individual member carries its proportional stress.

3.1.4 Time Dependent Deformations

Where members of structural frames are composed of two or more layers or sections, the effect of time dependent deformations shall be accounted for in the design (see 3.5.2 and Appendix F).

3.1.5 Composite Construction

Composite constructions, such as wood-concrete, wood-steel, and wood-wood composites, shall be designed in accordance with principles of engineering mechanics using the adjusted design values for structural members and connections specified herein.

3.2 Bending Members – General

3.2.1 Span of Bending Members

For simple, continuous and cantilevered bending members, the span shall be taken as the distance from face to face of supports, plus ½ the required bearing length at each end.

3.2.2 Lateral Distribution of Concentrated Load

Lateral distribution of concentrated loads from a critically loaded bending member to adjacent parallel bending members by flooring or other cross members shall be permitted to be calculated when determining design bending moment and vertical shear force (see 15.1).

3.2.3 Notches

3.2.3.1 Bending members shall not be notched except as permitted by 4.4.3, 5.4.5, 7.4.4, and 8.4.1. A gradual taper cut from the reduced depth of the member to the full depth of the member in lieu of a square-cornered notch reduces stress concentrations.

3.2.3.2 The stiffness of a bending member, as determined from its cross section, is practically unaffected by a notch with the following dimensions:

notch depth ≤ (1/6) (beam depth)

notch length ≤ (1/3) (beam depth)

3.2.3.3 See 3.4.3 for effect of notches on shear strength.

3.3 Bending Members – Flexure

3.3.1 Strength in Bending

The actual bending stress or moment shall not exceed the adjusted bending design value.

3.3.2 Flexural Design Equations

3.3.2.1 The actual bending stress induced by a bending moment, M, is calculated as follows:

$$f_b = \frac{Mc}{I} = \frac{M}{S} \qquad (3.3\text{-}1)$$

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

$$f_b = \frac{M}{S} = \frac{6M}{bd^2} \qquad (3.3\text{-}2)$$

3.3.2.2 For solid rectangular bending members with the neutral axis perpendicular to depth at center:

$$I = \frac{bd^3}{12} = \text{moment of inertia, in.}^4 \qquad (3.3\text{-}3)$$

$$S = \frac{I}{c} = \frac{bd^2}{6} = \text{section modulus, in.}^3 \qquad (3.3\text{-}4)$$

3.3.3 Beam Stability Factor, C_L

3.3.3.1 When the depth of a bending member does not exceed its breadth, $d \le b$, no lateral support is required and $C_L = 1.0$.

3.3.3.2 When rectangular sawn lumber bending members are laterally supported in accordance with 4.4.1, $C_L = 1.0$.

3.3.3.3 When the compression edge of a bending member is supported throughout its length to prevent lateral displacement, and the ends at points of bearing have lateral support to prevent rotation, $C_L = 1.0$.

3.3.3.4 Where the depth of a bending member exceeds its breadth, $d > b$, lateral support shall be provided at points of bearing to prevent rotation. When such lateral support is provided at points of bearing, but no additional lateral support is provided throughout the length of the bending member, the unsupported length, ℓ_u, is the distance between such points of end bearing, or the length of a cantilever. When a bending member is provided with lateral support to prevent rotation at intermediate points as well as at the ends, the unsupported length, ℓ_u, is the distance between such points of intermediate lateral support.

3.3.3.5 The effective span length, ℓ_e, for single span or cantilever bending members shall be determined in accordance with Table 3.3.3.

Table 3.3.3 Effective Length, ℓ_e, for Bending Members

<table>
<tr><th>Cantilever[1]</th><th>where $\ell_u/d < 7$</th><th>where $\ell_u/d \geq 7$</th></tr>
<tr><td>Uniformly distributed load</td><td>ℓ_e=1.33 ℓ_u</td><td>ℓ_e=0.90 ℓ_u + 3d</td></tr>
<tr><td>Concentrated load at unsupported end</td><td>ℓ_e=1.87 ℓ_u</td><td>ℓ_e=1.44 ℓ_u + 3d</td></tr>
<tr><th>Single Span Beam[1,2]</th><th>where $\ell_u/d < 7$</th><th>where $\ell_u/d \geq 7$</th></tr>
<tr><td>Uniformly distributed load</td><td>ℓ_e=2.06 ℓ_u</td><td>ℓ_e=1.63 ℓ_u + 3d</td></tr>
<tr><td>Concentrated load at center with no intermediate lateral support</td><td>ℓ_e=1.80 ℓ_u</td><td>ℓ_e=1.37 ℓ_u + 3d</td></tr>
<tr><td>Concentrated load at center with lateral support at center</td><td colspan="2">ℓ_e=1.11 ℓ_u</td></tr>
<tr><td>Two equal concentrated loads at 1/3 points with lateral support at 1/3 points</td><td colspan="2">ℓ_e=1.68 ℓ_u</td></tr>
<tr><td>Three equal concentrated loads at 1/4 points with lateral support at 1/4 points</td><td colspan="2">ℓ_e=1.54 ℓ_u</td></tr>
<tr><td>Four equal concentrated loads at 1/5 points with lateral support at 1/5 points</td><td colspan="2">ℓ_e=1.68 ℓ_u</td></tr>
<tr><td>Five equal concentrated loads at 1/6 points with lateral support at 1/6 points</td><td colspan="2">ℓ_e=1.73 ℓ_u</td></tr>
<tr><td>Six equal concentrated loads at 1/7 points with lateral support at 1/7 points</td><td colspan="2">ℓ_e=1.78 ℓ_u</td></tr>
<tr><td>Seven or more equal concentrated loads, evenly spaced, with lateral support at points of load application</td><td colspan="2">ℓ_e=1.84 ℓ_u</td></tr>
<tr><td>Equal end moments</td><td colspan="2">ℓ_e=1.84 ℓ_u</td></tr>
</table>

1. For single span or cantilever bending members with loading conditions not specified in Table 3.3.3:
   - $\ell_e = 2.06\ \ell_u$ where $\ell_u/d < 7$
   - $\ell_e = 1.63\ \ell_u + 3d$ where $7 \leq \ell_u/d \leq 14.3$
   - $\ell_e = 1.84\ \ell_u$ where $\ell_u/d > 14.3$
2. Multiple span applications shall be based on table values or engineering analysis.

3.3.3.6 The slenderness ratio, R_B, for bending members shall be calculated as follows:

$$R_B = \sqrt{\frac{\ell_e d}{b^2}} \quad (3.3\text{-}5)$$

3.3.3.7 The slenderness ratio for bending members, R_B, shall not exceed 50.

3.3.3.8 The beam stability factor shall be calculated as follows:

$$C_L = \frac{1+\left(F_{bE}/F_b^*\right)}{1.9} - \sqrt{\left[\frac{1+\left(F_{bE}/F_b^*\right)}{1.9}\right]^2 - \frac{F_{bE}/F_b^*}{0.95}} \quad (3.3\text{-}6)$$

where:

F_b^* = reference bending design value multiplied by all applicable adjustment factors except C_{fu}, C_V (when $C_V \le 1.0$), and C_L (see 2.3), psi

$$F_{bE} = \frac{1.20\, E_{min}'}{R_B^2}$$

3.3.3.9 See Appendix D for background information concerning beam stability calculations and Appendix F for information concerning coefficient of variation in modulus of elasticity (COV_E).

3.3.3.10 Members subjected to flexure about both principal axes (biaxial bending) shall be designed in accordance with 3.9.2.

3.4 Bending Members – Shear

3.4.1 Strength in Shear Parallel to Grain (Horizontal Shear)

3.4.1.1 The actual shear stress parallel to grain or shear force at any cross section of the bending member shall not exceed the adjusted shear design value. A check of the strength of wood bending members in shear perpendicular to grain is not required.

3.4.1.2 The shear design procedures specified herein for calculating f_v at or near points of vertical support are limited to solid flexural members such as sawn lumber, structural glued laminated timber, structural composite lumber, or mechanically laminated timber beams. Shear design at supports for built-up components containing load-bearing connections at or near points of support, such as between the web and chord of a truss, shall be based on test or other techniques.

3.4.2 Shear Design Equations

The actual shear stress parallel to grain induced in a sawn lumber, structural glued laminated timber, structural composite lumber, or timber pole or pile bending member shall be calculated as follows:

$$f_v = \frac{VQ}{Ib} \quad (3.4\text{-}1)$$

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

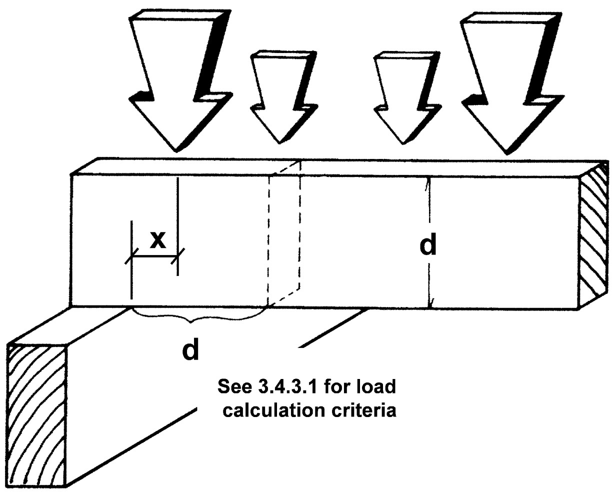
$$f_v = \frac{3V}{2bd} \quad (3.4\text{-}2)$$

3.4.3 Shear Design

3.4.3.1 When calculating the shear force, V, in bending members:

(a) For beams supported by full bearing on one surface and loads applied to the opposite surface, uniformly distributed loads within a distance from supports equal to the depth of the bending member, d, shall be permitted to be ignored. For beams supported by full bearing on one surface and loads applied to the opposite surface, concentrated loads within a distance, d, from supports shall be permitted to be multiplied by x/d where x is the distance from the beam support face to the load (see Figure 3C).

Figure 3C Shear at Supports



(b) The largest single moving load shall be placed at a distance from the support equal to the depth of the bending member, keeping other loads in their normal relation and neglecting any load within a distance from a support equal to the depth of the bending member. This condition shall be checked at each support.

(c) With two or more moving loads of about equal weight and in proximity, loads shall be placed in the position that produces the highest shear force, V, neglecting any load within a distance from a support equal to the depth of the bending member.

3.4.3.2 For notched bending members, shear force, V, shall be determined by principles of engineering mechanics (except those given in 3.4.3.1).

(a) For bending members with rectangular cross section and notched on the tension face (see 3.2.3), the adjusted design shear, V_r', shall be calculated as follows:

$$V_r' = \left[\frac{2}{3} F_v' b d_n\right]\left[\frac{d_n}{d}\right]^2 \qquad (3.4\text{-}3)$$

where:

d = depth of unnotched bending member, in.

d_n = depth of member remaining at a notch measured perpendicular to length of member, in.

F_v' = adjusted shear design value parallel to grain, psi

(b) For bending members with circular cross section and notched on the tension face (see 3.2.3), the adjusted design shear, V_r', shall be calculated as follows:

$$V_r' = \left[\frac{2}{3} F_v' A_n\right]\left[\frac{d_n}{d}\right]^2 \qquad (3.4\text{-}4)$$

where:

A_n = cross-sectional area of notched member, in^2

(c) For bending members with other than rectangular or circular cross section and notched on the tension face (see 3.2.3), the adjusted design shear, V_r', shall be based on conventional engineering analysis of stress concentrations at notches.

(d) A gradual change in cross section compared with a square notch decreases the actual shear stress parallel to grain nearly to that computed for an unnotched bending member with a depth of d_n.

(e) When a bending member is notched on the compression face at the end as shown in Figure 3D, the adjusted design shear, V_r', shall be calculated as follows:

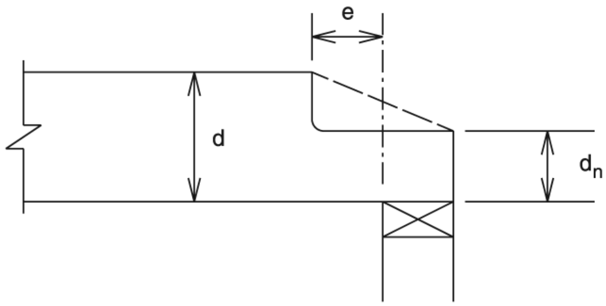
$$V_r' = \frac{2}{3} F_v' b \left[d - \left(\frac{d - d_n}{d_n}\right) e \right] \qquad (3.4\text{-}5)$$

where:

e = the distance the notch extends from the inner edge of the support and must be less than or equal to the depth remaining at the notch, $e \le d_n$. If $e > d_n$, d_n shall be used to calculate f_v using Equation 3.4-2, in.

d_n = depth of member remaining at a notch meeting the provisions of 3.2.3, measured perpendicular to length of member. If the end of the beam is beveled, as shown by the dashed line in Figure 3D, d_n is measured from the inner edge of the support, in.

Figure 3D Bending Member End-Notched on Compression Face



3.4.3.3 When connections in bending members are fastened with split ring connectors, shear plate connectors, bolts, or lag screws (including beams supported by such fasteners or other cases as shown in Figures 3E and 3I) the shear force, V, shall be determined by principles of engineering mechanics (except those given in 3.4.3.1).

(a) Where the connection is less than five times the depth, 5d, of the member from its end, the adjusted design shear, V_r', shall be calculated as follows:

$$V_r' = \left[\frac{2}{3} F_v' b d_e\right]\left[\frac{d_e}{d}\right]^2 \qquad (3.4\text{-}6)$$

where:

for split ring or shear plate connections:

d_e = depth of member, less the distance from the unloaded edge of the member to the nearest edge of the nearest split ring or shear plate connector (see Figure 3E), in.

for bolt or lag screw connections:

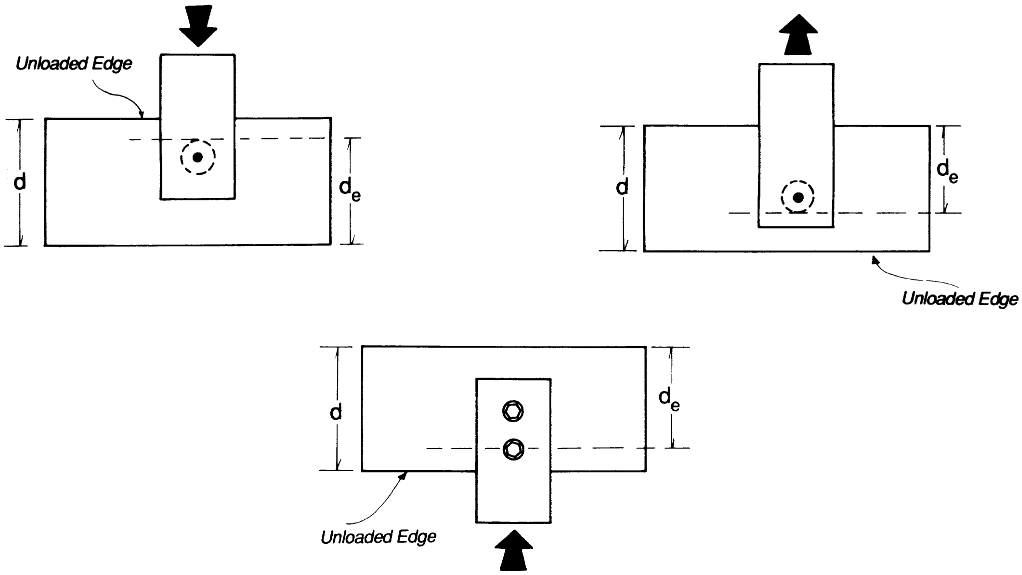
d_e = depth of member, less the distance from the unloaded edge of the member to the center of the nearest bolt or lag screw (see Figure 3E), in.

(b) Where the connection is at least five times the depth, 5d, of the member from its end, the adjusted design shear, V_r', shall be calculated as follows:

$$V_r' = \frac{2}{3} F_v' b d_e \qquad (3.4\text{-}7)$$

(c) Where concealed hangers are used, the adjusted design shear, V_r', shall be calculated based on the provisions in 3.4.3.2 for notched bending members.

Figure 3E Effective Depth, d_e, of Members at Connections



3.5 Bending Members – Deflection

3.5.1 Deflection Calculations

If deflection is a factor in design, it shall be calculated by standard methods of engineering mechanics considering bending deflections and, when applicable, shear deflections. Consideration for shear deflection is required when the reference modulus of elasticity has not been adjusted to include the effects of shear deflection (see Appendix F).

3.5.2 Long-Term Loading

Where total deflection under long-term loading must be limited, increasing member size is one way to provide extra stiffness to allow for this time dependent deformation (see Appendix F). Total deflection, Δ_T, shall be calculated as follows:

$$\Delta_T = K_{cr}\, \Delta_{LT} + \Delta_{ST} \qquad (3.5\text{-}1)$$

where:

K_{cr} = time dependent deformation (creep) factor

= 1.5 for seasoned lumber, structural glued laminated timber, prefabricated wood I-joists, or structural composite lumber used in dry service conditions as defined in 4.1.4, 5.1.4, 7.1.4, and 8.1.4, respectively.

= 2.0 for structural glued laminated timber used in wet service conditions as defined in 5.1.4.

= 2.0 for wood structural panels used in dry service conditions as defined in 9.1.4.

= 2.0 for unseasoned lumber or for seasoned lumber used in wet service conditions as defined in 4.1.4.

= 2.0 for cross-laminated timber used in dry service conditions as defined in 10.1.5.

Δ_{LT} = immediate deflection due to the long-term component of the design load, in.

Δ_{ST} = deflection due to the short-term or normal component of the design load, in.

3.6 Compression Members – General

3.6.1 Terminology

For purposes of this Specification, the term "column" refers to all types of compression members, including members forming part of trusses or other structural components.

3.6.2 Column Classifications

3.6.2.1 Simple Solid Wood Columns. Simple columns consist of a single piece or of pieces properly glued together to form a single member (see Figure 3F).

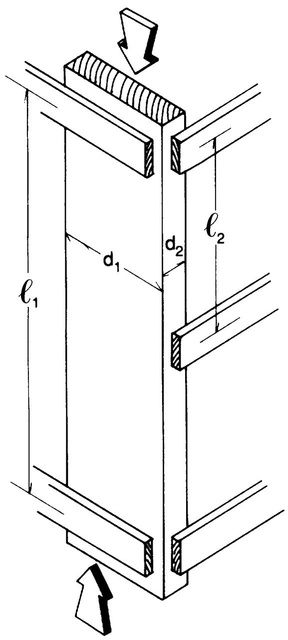
3.6.2.2 Spaced Columns, Connector Joined. Spaced columns are formed of two or more individual members with their longitudinal axes parallel, separated at the ends and middle points of their length by blocking and joined at the ends by split ring or shear plate connectors capable of developing the required shear resistance (see 15.2).

3.6.2.3 Built-Up Columns. Individual laminations of mechanically laminated built-up columns shall be designed in accordance with 3.6.3 and 3.7, except that nailed or bolted built-up columns shall be designed in accordance with 15.3.

3.6.3 Strength in Compression Parallel to Grain

The actual compression stress or force parallel to grain shall not exceed the adjusted compression design value. Calculations of f_c shall be based on the net section area (see 3.1.2) where the reduced section occurs in the critical part of the column length that is most subject to potential buckling. Where the reduced section does not occur in the critical part of the column length that is most subject to potential buckling, calculations of f_c shall be based on gross section area. In addition, f_c based on net section area shall not exceed the reference compression design value parallel to grain multiplied by all applicable adjustment factors except the column stability factor, C_P.

Figure 3F Simple Solid Column



3.6.4 Compression Members Bearing End to End

For end grain bearing of wood on wood, and on metal plates or strips see 3.10.

3.6.5 Eccentric Loading or Combined Stresses

For compression members subject to eccentric loading or combined flexure and axial loading, see 3.9 and 15.4.

3.6.6 Column Bracing

Column bracing shall be installed where necessary to resist wind or other lateral forces (see Appendix A).

3.6.7 Lateral Support of Arches, Studs, and Compression Chords of Trusses

Guidelines for providing lateral support and determining ℓ_e/d in arches, studs, and compression chords of trusses are specified in Appendix A.11.

3.7 Solid Columns

3.7.1 Column Stability Factor, C_P

3.7.1.1 When a compression member is supported throughout its length to prevent lateral displacement in all directions, $C_P = 1.0$.

3.7.1.2 The effective column length, ℓ_e, for a solid column shall be determined in accordance with principles of engineering mechanics. One method for determining effective column length, when end-fixity conditions are known, is to multiply actual column length by the appropriate effective length factor specified in Appendix G, $\ell_e = (K_e)(\ell)$.

3.7.1.3 For solid columns with rectangular cross section, the slenderness ratio, ℓ_e/d, shall be taken as the larger of the ratios ℓ_{e1}/d_1 or ℓ_{e2}/d_2 (see Figure 3F) where each ratio has been adjusted by the appropriate buckling length coefficient, K_e, from Appendix G.

3.7.1.4 The slenderness ratio for solid columns, ℓ_e/d, shall not exceed 50, except that during construction ℓ_e/d shall not exceed 75.

3.7.1.5 The column stability factor shall be calculated as follows:

$$C_P = \frac{1+\left(F_{cE}/F_c^*\right)}{2c} - \sqrt{\left[\frac{1+\left(F_{cE}/F_c^*\right)}{2c}\right]^2 - \frac{F_{cE}/F_c^*}{c}} \quad (3.7\text{-}1)$$

where:

F_c^* = reference compression design value parallel to grain multiplied by all applicable adjustment factors except C_P (see 2.3), psi

$$F_{cE} = \frac{0.822\ E_{min}'}{\left(\ell_e/d\right)^2}$$

c = 0.8 for sawn lumber

c = 0.85 for round timber poles and piles

c = 0.9 for structural glued laminated timber, structural composite lumber, and cross-laminated timber

3.7.1.6 For especially severe service conditions and/or extraordinary hazard, use of lower adjusted design values may be necessary. See Appendix H for background information concerning column stability calculations and Appendix F for information concerning coefficient of variation in modulus of elasticity (COV_E).

3.7.2 Tapered Columns

For design of a column with rectangular cross section, tapered at one or both ends, the representative dimension, d, for each face of the column shall be derived as follows:

$$d = d_{min} + (d_{max} - d_{min})\left[a - 0.15\left(1 - \frac{d_{min}}{d_{max}}\right)\right] \quad (3.7\text{-}2)$$

where:

d = representative dimension for tapered column, in.

d_{min} = the minimum dimension for that face of the column, in.

d_{max} = the maximum dimension for that face of the column, in.

<u>Support Conditions</u>

Large end fixed, small end unsupported or simply supported	a = 0.70
Small end fixed, large end unsupported or simply supported	a = 0.30
Both ends simply supported:	
Tapered toward one end	a = 0.50
Tapered toward both ends	a = 0.70
For all other support conditions:	

$$d = d_{min} + (d_{max} - d_{min})(1/3) \quad (3.7\text{-}3)$$

Calculations of f_c and C_P shall be based on the representative dimension, d. In addition, f_c at any cross section in the tapered column shall not exceed the reference compression design value parallel to grain multiplied by all applicable adjustment factors except the column stability factor, C_P.

3.7.3 Round Columns

The design of a column of round cross section shall be based on the design calculations for a square column of the same cross-sectional area and having the same degree of taper. Reference design values and special design provisions for round timber poles and piles are provided in Chapter 6.

3.8 Tension Members

3.8.1 Tension Parallel to Grain

The actual tension stress or force parallel to grain shall be based on the net section area (see 3.1.2) and shall not exceed the adjusted tension design value.

3.8.2 Tension Perpendicular to Grain

Designs that induce tension stress perpendicular to grain shall be avoided whenever possible (see References 16 and 19). When tension stress perpendicular to grain cannot be avoided, mechanical reinforcement sufficient to resist all such stresses shall be considered (see References 52 and 53 for additional information).

3.9 Combined Bending and Axial Loading

3.9.1 Bending and Axial Tension

Members subjected to a combination of bending and axial tension (see Figure 3G) shall be so proportioned that:

$$\frac{f_t}{F_t'} + \frac{f_b}{F_b^*} \le 1.0 \qquad (3.9\text{-}1)$$

and

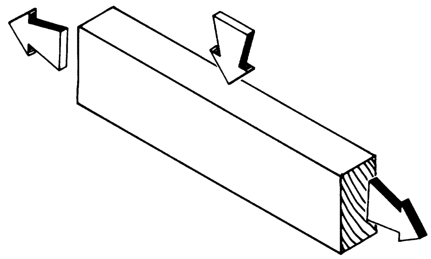
$$\frac{f_b - f_t}{F_b^{**}} \le 1.0 \qquad (3.9\text{-}2)$$

where:

F_b^* = reference bending design value multiplied by all applicable adjustment factors except C_L, psi

F_b^{**} = reference bending design value multiplied by all applicable adjustment factors except C_V, psi

Figure 3G Combined Bending and Axial Tension



3.9.2 Bending and Axial Compression

Members subjected to a combination of bending about one or both principal axes and axial compression (see Figure 3H) shall be so proportioned that:

$$\left[\frac{f_c}{F_c'}\right]^2 + \frac{f_{b1}}{F_{b1}'\left[1-\left(f_c/F_{cE1}\right)\right]} + \frac{f_{b2}}{F_{b2}'\left[1-\left(f_c/F_{cE2}\right)-\left(f_{b1}/F_{bE}\right)^2\right]} \le 1.0 \qquad (3.9\text{-}3)$$

and

$$\frac{f_c}{F_{cE2}} + \left(\frac{f_{b1}}{F_{bE}}\right)^2 < 1.0 \qquad (3.9\text{-}4)$$

where:

$$f_c < F_{cE1} = \frac{0.822\, E_{min}'}{(\ell_{e1} / d_1)^2}$$ for either uniaxial edgewise bending or biaxial bending

and

$$f_c < F_{cE2} = \frac{0.822\, E_{min}'}{(\ell_{e2} / d_2)^2}$$ for uniaxial flatwise bending or biaxial bending

and

$$f_{b1} < F_{bE} = \frac{1.20\, E_{min}'}{(R_B)^2}$$ for biaxial bending

f_{b1} = actual edgewise bending stress (bending load applied to narrow face of member) , psi

f_{b2} = actual flatwise bending stress (bending load applied to wide face of member) , psi

d_1 = wide face dimension (see Figure 3H), in.

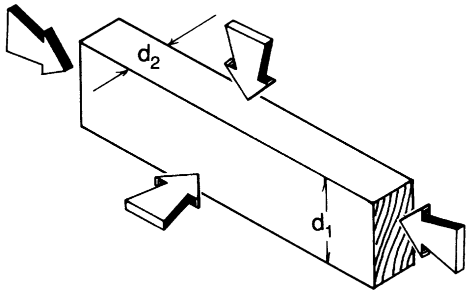
d_2 = narrow face dimension (see Figure 3H), in.

Effective column lengths, ℓ_{e1} and ℓ_{e2}, shall be determined in accordance with 3.7.1.2. F_c', F_{cE1}, and F_{cE2} shall be determined in accordance with 2.3 and 3.7. F_{b1}', F_{b2}', and F_{bE} shall be determined in accordance with 2.3 and 3.3.3.

3.9.3 Eccentric Compression Loading

See 15.4 for members subjected to combined bending and axial compression due to eccentric loading, or eccentric loading in combination with other loads.

Figure 3H Combined Bending and Axial Compression



3.10 Design for Bearing

3.10.1 Bearing Parallel to Grain

3.10.1.1 The actual compressive bearing stress parallel to grain shall be based on the net bearing area and shall not exceed the reference compression design value parallel to grain multiplied by all applicable adjustment factors except the column stability factor, C_P.

3.10.1.2 F_c^*, the reference compression design values parallel to grain multiplied by all applicable adjustment factors except the column stability factor, applies to end-to-end bearing of compression members provided there is adequate lateral support and the end cuts are accurately squared and parallel.

3.10.1.3 When $f_c > (0.75)(F_c^*)$ bearing shall be on a metal plate or strap, or on other equivalently durable, rigid, homogeneous material with sufficient stiffness to distribute the applied load. Where a rigid insert is required for end-to-end bearing of compression members, it shall be equivalent to 20-gage metal plate or better, inserted with a snug fit between abutting ends.

3.10.2 Bearing Perpendicular to Grain

The actual compression stress perpendicular to grain shall be based on the net bearing area and shall not exceed the adjusted compression design value perpendicular to grain, $f_{c\perp} \leq F_{c\perp}'$. When calculating bearing area at the ends of bending members, no allowance shall be made for the fact that as the member bends, pressure upon the inner edge of the bearing is greater than at the member end.

3.10.3 Bearing at an Angle to Grain

The adjusted bearing design value at an angle to grain (see Figure 3I and Appendix J) shall be calculated as follows:

$$F_\theta' = \frac{F_c^* F_{c\perp}'}{F_c^* \sin^2\theta + F_{c\perp}' \cos^2\theta} \quad (3.10\text{-}1)$$

where:

θ = angle between direction of load and direction of grain (longitudinal axis of member), degrees

3.10.4 Bearing Area Factor, C_b

Reference compression design values perpendicular to grain, $F_{c\perp}$, apply to bearings of any length at the ends of a member, and to all bearings 6" or more in length at any other location. For bearings less than 6" in length and not nearer than 3" to the end of a member, the reference compression design value perpendicular to grain, $F_{c\perp}$, shall be permitted to be multiplied by the following bearing area factor, C_b:

$$C_b = \frac{\ell_b + 0.375}{\ell_b} \quad (3.10\text{-}2)$$

where:

ℓ_b = bearing length measured parallel to grain, in.

Equation 3.10-2 gives the following bearing area factors, C_b, for the indicated bearing length on such small areas as plates and washers:

Table 3.10.4 Bearing Area Factors, C_b

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

For round bearing areas such as washers, the bearing length, ℓ_b, shall be equal to the diameter.

Figure 3I Bearing at an Angle to Grain