Compression Members (revisited)

- designed for strength & stresses
- designed for serviceability & deflection
- need to design for stability
  - ability to support a specified load without sudden or unacceptable deformations

Effect of Length (revisited)

- long & slender
- short & stubby

Critical Stresses (revisited)

- when a column gets stubby, crushing will limit the load
- real world has loads with eccentricity
Bracing (revisited)

- bracing affects shape of buckle in one direction
- both should be checked!

Allowable Wood Stress

$$F'_c = F_c \left( C_D \right) \left( C_M \right) \left( C_t \right) \left( C_F \right) \left( C_p \right)$$

- where:
  - $F_c$ = compressive strength parallel to grain
  - $C_D$ = load duration factor
  - $C_M$ = wet service factor (1.0 dry)
  - $C_t$ = temperature factor
  - $C_F$ = size factor
  - $C_p$ = column stability factor
  (Table 10.3)

Wood Columns

- slenderness ratio = $L/d_{\text{min}}$
  - $d_1$ = smallest dimension
  - $l/e/d \leq 50$ (max)
  - \[ f_c = \frac{P}{A} \leq F'_c \]
  - where $F'_c$ is the allowable compressive strength parallel to the grain
  - bracing common
  - posts, round, built-up

Strength Factors

- wood properties and load duration, $C_D$
  - short duration
    - higher loads
  - normal duration
    - $>10$ years

- stability, $C_p$
  - combination curve - tables
  - \[ F'_c = F_c C_p = (F_c C_D) C_p \]
Procedure for Analysis

1. calculate $L/d_{\text{min}}$
   - KL/d each axis, choose largest
2. obtain $F'_c$
   - compute $F'_{CE} = \frac{0.822E'_{\text{min}}}{l_e/d} \left( \frac{E_c}{E} \right)$
     - $(K_{CE} = 0.3$ sawn$)$
     - $(K_{CE} = 0.418$ glu-lam$)$
     - $E'_{\text{min}} = E_{\text{min}}(C_M)(C_I)(C_P)(C_I)$
3. compute $F'_c \approx F_C D$
4. calculate $F_{CE}/F'_c$ and get $C_p$ (Table 14)
5. calculate $F'_{CE} = F'_c C_p$

Procedure for Analysis (cont’d)

6. compute $P_{\text{allowable}} = F'_{CE} A$
   - or find $f_{\text{actual}} = P/A$
7. is $P \leq P_{\text{allowable}}$? (or $f_{\text{actual}} \leq F'_{CE}$?)
   - yes: OK
   - no: overstressed & no good

Column Charts – Not in Appendix
Procedure for Design

1. guess a size  (pick a section)
2. calculate \( L_e/d_{\text{min}} \)
   - \( \frac{KL}{d} \) each axis, choose largest
3. obtain \( F_c' \)
   - compute \( F_{cE} = \frac{0.822 E'_{\text{min}}}{(\frac{L_e}{d})^2} = \frac{K_c E}{(\frac{L_e}{d})^2} \)
   \( K_c = 0.3 \) sawn
   \( K_c = 0.418 \) glu-lam
   \( E'_{\text{min}} = E_{\text{min}} C_M C_I C_T \)
4. compute \( F_c^* \approx F_c C_D \)
5. calculate \( F_{cE}/F_c^* \) and get \( C_p \) (Table 14)

Procedure for Design (cont’d)

6. compute \( F_c' = F_c^* C_p \)
7. compute \( P_{\text{allowable}} = F_c' A \)
   - or find \( f_{\text{actual}} = P/A \)
8. is \( P \leq P_{\text{allowable}} \)? (or \( f_{\text{actual}} \leq F_c' \)?)
   - yes: OK
   - no: pick a bigger section and go back to step 2.

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Timber Construction by Code

- light-frame
  - light loads
  - 2x’s
  - floor joists – 2x6, 2x8, 2x10, 2x12 typical at spacings of 12”, 16”, 24”
  - normal spans of 20-25 ft or 6-7.5 m
  - plywood spans between joists
  - stud or load-bearing masonry walls
  - limited to around 3 stories – fire safety

Design of Columns with Bending

- satisfy
  - strength
  - stability
- pick
  - section
Design

- Wood

\[
\left[ \frac{f_c}{F'_{cx}} \right]^2 + \frac{f_{bx}}{F'_{bx} \left( 1 - \frac{f_c}{F_{cx}} \right)} \leq 1.0
\]

[ ] term – magnification factor for P-\(\Delta\)

\(F'_{bx}\) – allowable bending strength

Design Steps Knowing Loads

1. assume limiting stress
   - buckling, axial stress, combined stress
2. solve for \(r, A\) or \(S\)
3. pick trial section
4. analyze stresses
5. section ok?
6. stop when section is ok

Laminated Timber Arches

- two & three hinged arches
- bent to wide range of curves
- bending and compression
- residual stress from laminating, \(C_c\)

Laminated Arch Design

- radius of curvature, \(R\), limited by lam thickness, \(t\)
  - \(R = 100t\) – southern pine & hardwoods
  - \(R = 125t\) – softwood
- \(r = \) radius to inside face of laminations
- \(C_C = 1 - 2000 \left( \frac{t}{r} \right)^2\)
- \(F'_b = F_b(C_{F-C_c})\)