wood construction: column design
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

![Graph showing critical stresses and equations](graph.png)
Bracing (revisited)

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

- slenderness ratio = \( L/d_{\text{min}} \)
  - \( d_1 = \) smallest dimension
  - \( \ell_e/d \leq 50 \) (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
Allowable Wood Stress

\[ F' = F_c (C_D)(C_M)(C_t)(C_F)(C_p) \]

- 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)
**Strength Factors**

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

- **stability,** $C_p$
  - combination curve - tables

\[ F'_c = F_c^* C_p = (F_c C_D) C_p \]
### C_p Charts – Appendix A

**Table 14** Column Stability Factor C_p

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### Table 12  Allowable Column Loads—Selected Species/Sizes. (Continued)

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Procedure for Analysis

1. calculate \( L_e/d_{\text{min}} \)
   - \( KL/d \) each axis, choose largest

2. obtain \( F'_c \)
   - compute
     \[
     F_{cE} = \frac{K_{cE} E}{(L_e/d)^2}
     \]
     - \( K_{cE} = 0.3 \) sawn
     - \( K_{cE} = 0.418 \) glu-lam

3. compute \( F_c^* \approx F_c C_D \)

4. calculate \( F_{cE} / F_c^* \) and get \( C_p \) (Table 14)

5. calculate \( F'_c = F_c^* C_p \)
Procedure for Analysis (cont’d)

6. compute $P_{\text{allowable}} = F'_c \cdot A$
   - or find $f_{\text{actual}} = P/A$

7. is $P \leq P_{\text{allowable}}$? (or $f_{\text{actual}} \leq F'_c$?)
   - yes: OK
   - no: overstressed & no good
Procedure for Design

1. guess a size (pick a section)
2. calculate \( L_e / d_{\text{min}} \)
   - \( KL/d \) each axis, choose largest
3. obtain \( F'_c \)
   - compute \( F_{cE} = \frac{K_{cE}E}{\left(L_e/d\right)^2} \)
     - \( K_{cE} = 0.3 \) sawn
     - \( K_{cE} = 0.418 \) glu-lam
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 \( P_{\text{allowable}} = F'_c \cdot A \)
   - 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.
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

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

[] 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
- \( C_c = 1 - 2000\left(\frac{t}{r}\right)^2 \)
- \( F_b' = F_b(C_F C_c) \)

Fig. 24.6  Circular arch moment analysis