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!

**Wood Columns**

- slenderness ratio $= \frac{L}{d_{\text{min}}}$
  - $d_{\text{min}}$ = smallest dimension
  - $\frac{l}{d} \leq 50$ (max)
  
  $f_c = \frac{P}{A} = F'_c$

  - where $F'_c$ is the allowable compressive strength parallel to the grain
  - bracing common
  - posts, round, built-up

**Allowable Wood Stress**

$$F'_c = F_c \left( C_D \right) \left( C_M \right) \left( C_I \right) \left( C_F \right) \left( C_P \right)$$

- where:
  - $F_c$ = compressive strength parallel to grain
  - $C_D$ = load duration factor
  - $C_M$ = wet service factor (1.0 dry)
  - $C_I$ = 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
    
    $F'_c = F_c C_P = \left( F_c C_D \right) C_P$
Procedure for Analysis

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

2. obtain \( F_c' \)
   - compute \( F_{cE} = \frac{0.822 E'_\text{min}}{C_p E} \left( \frac{l_e}{d} \right)^2 \)
     - \( K_{cE} = 0.3 \) sawn
     - \( K_{cE} = 0.418 \) glu-lam
   - \( E'_\text{min} = E_{\text{min}} (C_M)(C_P)(C_D) \)

3. compute \( F_c = F_c C_D \)

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 \( P_{\text{allowable}} = F_c' A \)
   - 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 $L_e/d_{min}$
   - $KL/d$ each axis, choose largest
3. obtain $F'_c$
   - compute $F_{CE} = \frac{0.822E'_{min}}{\left(\frac{le}{d}\right)^2} = \frac{KcE}{\left(\frac{le}{d}\right)^2}$
     - $KcE = 0.3$ sawn
     - $KcE = 0.418$ glu-lam
     - $E'_{min} = E_{min}(C_M)(C_T)(C_i)$
4. compute $F'_c \approx F_cC_D$
5. calculate $F_{cE}/F'_c$ and get $C_p$ (Table 14)

Procedure for Design (cont’d)

6. compute $F'_c = F^*_cC_p$
7. compute $P_{allowable} = F'_c \cdot A$
   - or find $f_{actual} = P/A$
8. is $P \leq P_{allowable}$? (or $f_{actual} \leq F'_c$?)
   - 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

- Timber frame—column connection, $e = 0.4l = 0.4 \times (6H)$
- Moment connection (rigid frame), $M$ is moment due to beam bending
- Timber frame—column connection, $e = 0.4l = 0.4 \times (6H)$
- Upper chord of a beam—compression plate bending, $M = \frac{(F)x}{A}$
Design
• Wood
\[
\left[ \frac{f_c}{F'_{bx}} \right]^2 + \frac{f_{bw}}{F'_{bx} \left( 1 - \frac{f_c}{F_{cEx}} \right)} \leq 1.0
\]
[] term – magnification factor for P-Δ

\[ F'_{bx} \] – 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
  • \( C_c = 1 - 2000 \left( \frac{t}{r} \right)^2 \)
  • \( F_{b'} = F_b (C_F C_c) \)