**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

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**Effect of Length (revisited)**

- long & slender
- short & stubby

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**Critical Stresses (revisited)**

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

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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
  – $\sqrt{\varepsilon/d} \leq 50$ (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

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

• 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)

Strength Factors

• wood properties and load duration, $C_D$
  – short duration
    • higher loads
    – normal duration
    • > 10 years
  – stability, $C_p$
    – combination curve - tables
    $$F'_c = F_c C_p = \left( F_c C_D \right) C_p$$

http://www.swst.org/teach/set2/struct1.html
Procedure for Analysis

1. calculate $L_e/d_{min}$  
   - 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 $P_{allowable} = F'_c A$  
   - or find $f_{actual} = P/A$
7. is $P \leq P_{allowable}$? (or $f_{actual} \leq F'_c$?)  
   - 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 $F_{cE} = \frac{K_{cE}E}{(L_e/d)^2}$
     - $K_{cE} = 0.3$ 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 $F' = F_c C_p$
7. compute $P_{allowable} = F' \cdot A$
   - or find $f_{actual} = P/A$
8. is $P \leq P_{allowable}$? (or $f_{actual} \leq F'$?)
   - 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

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

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