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 = \( L/d_{\text{min}} \)
  - \( d_{\text{1}} \) = 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

---

**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*

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**Strength Factors**

- wood properties and load duration, \( C_D \)
  - short duration
    - higher loads
  - normal duration
    - > 10 years
- stability, \( C_p \)
  - combination curve - tables

\[
F'_c = F_c C_p = \left( F_c C_D \right) C_p
\]

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*http://www.swst.org/teach/aset/struct1.html*
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 \( F_c^* \approx F_cC_D \)
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 \( P_{\text{allowable}} = F'_cA \)
   - 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 $F_{cE} = \frac{K_{cE}E}{(L_e/d)^2}$
     - $K_{cE} = 0.3$ 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 $F'_c = F_{c}^* C_p$
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.

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
- \( r = \text{radius to inside face of laminations} \)
  - \( C_c = 1 - 2000 \left( \frac{t}{r} \right)^2 \)
  - \( F'_b = F_b(C_FC_d) \)