**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

**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
  – \( \ell/e/d \leq 50 \) (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

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 $L_c/d_{min}$
   - $KL/d$ each axis, choose largest

2. obtain $F'_c$
   - compute $F_E = \frac{K_{CE}E}{(L_c/d)^2}$
   - $K_{CE} = 0.3$ 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 $P_{allowable} = F'_cA$
   - 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 $F'_c = F_c^* C_p$
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-Δ

\[F_{bx}'\] – allowable bending strength

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**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

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**Laminated Timber Arches**

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

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**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
  - \(C_C = 1 - 2000 \left( \frac{t}{r} \right)^2\)
  - \(F_{b'} = F_b(C_F C_d)\)