**Design Methods**

- **know**
  - loads or lengths
- **select**
  - section or load
  - adequate for strength and no buckling

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**Allowable Stress Design (ASD)**

- **AICS 9th ed**
  
  \[ F_a = \frac{f_{\text{critical}}}{F.S.} = \frac{12\pi^2 E}{23(KL/r)^2} \]

- **slenderness ratio** \( \frac{KL}{r} \)
  - for \( kl/r \geq C_c \)
    - \( 126.1 \) with \( F_y = 36 \text{ ksi} \)
    - \( 107.0 \) with \( F_y = 50 \text{ ksi} \)

**\( C_c \) and Euler’s Formula**

- **KL/r < \( C_c \)**
  - short and stubby
  - parabolic transition

- **KL/r > \( C_c \)**
  - Euler’s relationship
  - < 200 preferred

\[
C_c = \sqrt{\frac{2\pi^2 E}{F_y}}
\]
**Cc and Euler’s Formula**

![Euler's Equation Diagram]

**Short / Intermediate**

- \( L_e/r < C_c \)
  
  \[
  F_a = \left[ 1 - \frac{(KL/r)^2}{2C_c^2} \right] \frac{F_y}{F.S.}
  \]

  - where
  
  \[
  F.S. = \frac{5}{3} + \frac{3(KL/r)}{8C_c} - \frac{(KL/r)^3}{8C_c^3}
  \]

**Procedure for Analysis**

1. calculate \( KL/r \)
   - biggest of \( KL/r \) with respect to x axes and y axis
2. find \( F_a \) from Table 10.1 or 10.2
   - pp. 361 - 364
3. compute \( P_{\text{allowable}} = F_a \cdot A \)
   - or find \( f_{\text{actual}} = P/A \)
4. is \( P \leq P_{\text{allowable}} \)? (or is \( f_{\text{actual}} \leq F_a \)?)
   - yes: ok
   - no: overstressed and no good

**Procedure for Design**

1. guess a size (pick a section)
2. calculate \( KL/r \)
   - biggest of \( KL/r \) with respect to x axes and y axis
3. find \( F_a \) from Table 10.1 or 10.2
   - pp. 361 - 364
4. compute \( P_{\text{allowable}} = F_a \cdot A \)
   - or find \( f_{\text{actual}} = P/A \)
Procedure for Design (cont’d)

5. is \( P \leq P_{\text{allowable}} \) (or is \( f_{\text{actual}} \leq F_a \)?)
   - yes: ok
   - no: pick a bigger section and go back to step 2.

6. check design efficiency
   - percentage of stress = \( \frac{P_{\text{actual}}}{P_{\text{allowable}}} \cdot 100\% \)
   - if between 90-100%: good
   - if < 90%: pick a smaller section and go back to step 2.

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Wood Columns

- slenderness ratio = \( \frac{L}{d_{\text{min}}} = \frac{L}{d_1} \)
  - \( d_1 \) = smaller dimension
  - \( L/d_{\text{min}} \leq 50 \) (max)

\[ f_c = \frac{P}{A} \leq F'_c \]

- where \( F'_c \) is the allowable compressive strength parallel to the grain
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

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 \( L_e / d_{\text{min}} \)
2. obtain \( F'_c \)
   - compute \( F_c^E = \frac{K_{ce} E}{\left( \frac{L_e}{d} \right)^2} \)
     - \( K_{ce} \) = 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 $P_{allowable} = F'_c \cdot A$
   - 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 $L_e/d_{min}$
3. obtain $F'_c$
   - compute
     - $K_{cE} = 0.3$ sawn
     - $K_{cE} = 0.418$ glu-lam
4. compute $F'_c \approx F_{cD}$
5. calculate $F_{CE}/F'_c$ and get $C_p$ (table 14)
6. calculate $F'_c = F'_c \cdot C_p$

LRFD design

- limit states for failure
  - yielding
    \[ P_u \leq \phi_c P_n \]
    \[ \phi_c = 0.85 \]
    \[ P_n = F_{cr} A_g \]
  - buckling
    \[ \lambda_c \leq 1.5 \]
    \[ \lambda_c = \frac{Kl}{r \pi \sqrt{\frac{F_y}{E}}} \]
    \[ L_e/r \]

$\lambda_c$ – column slenderness parameter
$A_g$ - gross area

Procedure for Design (cont’d)

6. compute $P_{allowable} = F'_c \cdot A$
   - or find $f_{actual} = P/A$
7. is $P \leq P_{allowable}$? (or $f_{actual} \leq F'_c$?)
   - yes: OK
   - no: pick a bigger section and go back to step 2.
Compact Sections

- flanges continuously connected to the web or webs and width-thickness rations < limiting values
  - no local buckling of flange or web

  - for $\lambda_c \leq 1.5$  
  \[ F_{cr} \left(0.658\lambda_c^2\right)F_y \]

  - for $\lambda_c > 1.5$  
  \[ F_{cr} \left[\frac{0.877}{\lambda_c^2}\right]F_y \]

Column Charts