Design Methods

- **know**
  - loads or lengths

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

### 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 \( F_y = 36 \) ksi
  - 107.0 with \( F_y = 50 \) 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 Graph]

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

- 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

**Short / Intermediate**

- \( L_e/r < C_c \)

**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.

Column Charts

Wood Columns

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

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

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

\[ F'_c = F_c (C_D)(C_M)(C_t)(C_F)(C_p) \]

- 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

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

\( C_p \) Charts

<table>
<thead>
<tr>
<th>Column Stability Factor ( C_p )</th>
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<tr>
<td>( \text{Values} )</td>
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</tbody>
</table>
...
Procedure for Analysis

1. calculate $\frac{L_e}{d_{min}}$
2. obtain $F'_{c}$
   - compute $F_{cE} = \frac{K_{cE} E}{\left(\frac{L_e}{d}\right)^2}$
     - $K_{cE} = 0.3$ sawn
     - $K_{cE} = 0.418$ glu-lam
3. compute $F_c^* \approx F_c C_D$
4. calculate $\frac{F_{cE}}{F_c^*}$ 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 $\frac{L_e}{d_{min}}$
3. obtain $F'_{c}$
   - compute $F_{cE} = \frac{K_{cE} E}{\left(\frac{L_e}{d}\right)^2}$
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   - yes: OK
   - no: pick a bigger section and go back to step 2.
LRFD design

- limit states for failure \[ P_u \leq \phi_c P_n \]

\[ \phi_c = 0.85 \quad P_n = F_{cr} A_g \]

1. yielding \[ \frac{\lambda_c}{\sqrt{r/E}} \leq \phi \]

\[ \lambda_c = \frac{K_l}{r} \sqrt{\frac{F_y}{E}} \frac{L_e}{r} \]

2. buckling \[ \lambda_c > 1.5 \]

\[ \lambda_c - \text{column slenderness parameter} \]

\[ A_g - \text{gross area} \]

Compact Sections

- flanges continuously connected to the web or webs and width-thickness ratios < limiting values

  - no local buckling of flange or web

  - for \[ \frac{\lambda_c}{\sqrt{r/E}} \leq 1.5 \]

\[ F_{cr} = 0.658 \frac{x^2}{\lambda_c^2} F_y \]

  - for \[ \frac{\lambda_c}{\sqrt{r/E}} > 1.5 \]

\[ F_{cr} = \frac{0.877}{\lambda_c^2} F_y \]

Column Charts