Centric & Eccentric Loading

- **centric**
  - allowable stress from strength or buckling

- **eccentric**
  - combined stresses

\[
f_{\text{max}} = \frac{P}{A} + \frac{Mc}{I}
\]
\[
M = P \cdot e
\]

- design

\[
f_{\text{max}} \leq F_{cr} = \frac{f_{cr}}{F.S.}
\]

Eccentric Loading

- find \( e \) such that the minimum stress = 0

\[
f_{\text{min}} = \frac{P}{A} - \frac{(Pe)c}{I} = 0
\]

- area defined by \( e \) from centroid is the kern
**Eccentric Loading**

- when there is eccentricity in two directions

\[
\begin{align*}
M_1 &= P \cdot e_1 \\
M_2 &= P \cdot e_2 \\
\end{align*}
\]

\[
\begin{align*}
f_{\text{max}} &= \frac{P}{A} + \frac{M_1 y}{I} + \frac{M_2 z}{I} \\
&= \frac{P}{A} + M_{\text{x,y}} + M_{\text{z,y}} \\
\end{align*}
\]

- biaxial bending

**Stress Limit Conditions**

- ASD interaction formula

\[
\frac{f_a}{F_a} + \frac{f_b}{F_b} \leq 1.0
\]

- with biaxial bending

\[
\frac{f_a}{F_a} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} \leq 1.0
\]

**Stress Limit Conditions**

- in reality, as the column flexes, the moment increases

\[
\frac{f_a}{F_a} + \frac{f_b \times \text{(Magnification factor)}}{F_{bx}} \leq 1.0
\]

**Design**

- satisfy
  - strength
  - stability
- pick
  - section
Design

• ASD Steel

\[
\frac{f_a}{F_a} + \frac{C_{mx}f_{bx}}{F_{bx}} + \frac{C_{my}f_{by}}{F_{by}} \leq 1.0
\]

\(C_m\) – modification factor for end conditions

\(= 0.6 - 0.4(M_1/M_2)\) or 0.85 restrained

\(F'_e\) – allowable buckling strength

() term – magnification factor for \(P-\Delta\)

\(F'_e\), \(F'_b\) – allowable bending strength

\(\phi_c\) - resistance factor for compression = 0.85
\(\phi_b\) - resistance factor for bending = 0.9

Design

• Wood

\[
\frac{f_c}{F'_c} + \frac{f_{bx}}{F'_{bx}} \leq 1.0
\]

() term – magnification factor for \(P-\Delta\)

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