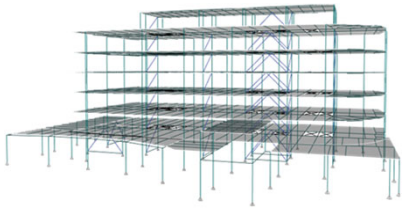
Chapter 17

Structural Modeling and Computer Analysis
Intro to the Design of steel structures



Steel Design of Bean-Columns

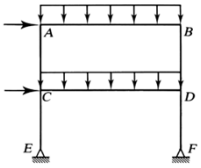
- While many structural members can be treated as axially loaded ***columns*** or as ***beams*** with only flexural loading, most beams and columns are subjected to some degree of both bending and axial load.
- This is especially true of ***statically indeterminate*** structures.
- Even the roller support of a simple beam can experience friction that restrains the beam longitudinally, inducing axial tension when transverse loads are applied.

Steel Design of Bean-Columns

- Many columns can be treated as pure compression members with negligible error.
- If the column is a one-story member and can be treated as pinned at both ends, the only bending will result from minor accidental eccentricity of the load.
- For many structural members, however, there will be a significant amount of both effects, and such members are called ***beam-columns***.

Steel Design of Bean-Columns

- Consider the rigid frame:



- For the given loading condition, the horizontal members *AB* and *CD* must not only support the vertical uniform load but must also assist the vertical members in resisting the concentrated lateral load.
- Therefore, all members of this frame can be considered beam-columns.

Steel Design of Bean-Columns – Interaction Formulas

- The required relationship is expressed as:

$$\frac{\text{Required Strength}}{\text{Available Strength}} \le 1.0$$

- For compression members, the strengths are axial forces

$$\frac{P_r}{P_c} \le 1.0$$

P_r = required axial strength
P_c = available axial strength

Steel Design of Bean-Columns – Interaction Formulas

- The required relationship is expressed as:

$$\frac{\text{Required Strength}}{\text{Available Strength}} \le 1.0$$

- If the member is subjected to bending as well, then:

$$\frac{P_r}{P_c} + \frac{M_r}{M_c} \le 1.0$$

M_r = required bending strength
M_c = available bending strength

Structural Modeling with SAP2000 – Steel Design

Steel Design of Bean-Columns – Interaction Formulas

- The required relationship is expressed as:

$$\frac{\text{Required Strength}}{\text{Available Strength}} \le 1.0$$

- For biaxial bending, there are two moment ratios:

$$\frac{P_r}{P_c} + \left(\frac{M_{rx}}{M_{cx}} + \frac{M_{ry}}{M_{cy}} \right) \le 1.0$$

- Where *x* and *y* subscript refer to the *x* and *y* axes.

Structural Modeling with SAP2000 – Steel Design

Steel Design of Bean-Columns – Interaction Formulas

- For load and resistance factor design (LRFD):

For $\frac{P_u}{\phi_c P_n} \ge 0.2$ $\quad \frac{P_u}{\phi_c P_n} + \frac{8}{9}\left(\frac{M_{ux}}{\phi_b M_{nx}} + \frac{M_{uy}}{\phi_b M_{ny}} \right) \le 1.0$

For $\frac{P_u}{\phi_c P_n} < 0.2$ $\quad \frac{P_u}{2\phi_c P_n} + \left(\frac{M_{ux}}{\phi_b M_{nx}} + \frac{M_{uy}}{\phi_b M_{ny}} \right) \le 1.0$

- Where *x* and *y* subscript refer to the *x* and *y* axes.

Structural Modeling with SAP2000 – Steel Design

Steel Design of Bean-Columns – Interaction Formulas

- For load and resistance factor design (LRFD):

For $\frac{P_u}{\phi_c P_n} \ge 0.2$ $\quad \frac{P_u}{\phi_c P_n} + \frac{8}{9}\left(\frac{M_{ux}}{\phi_b M_{nx}} + \frac{M_{uy}}{\phi_b M_{ny}} \right) \le 1.0$

For $\frac{P_u}{\phi_c P_n} < 0.2$ $\quad \frac{P_u}{2\phi_c P_n} + \left(\frac{M_{ux}}{\phi_b M_{nx}} + \frac{M_{uy}}{\phi_b M_{ny}} \right) \le 1.0$

P_u = required axial strength
P_n = available axial strength
ϕ_c = resistance factor for compression
M_u = required bending strength
M_n = available bending strength
ϕ_b = resistance factor for bending

Structural Modeling with SAP2000 – Steel Design

Steel Design of Bean-Columns – Interaction Formulas

- For allowable stress design (ASD):

For $\frac{P_a}{P_n/\Omega_c} \ge 0.2$ $\quad \frac{P_a}{P_n/\Omega_c} + \frac{8}{9}\left(\frac{M_{ax}}{M_{nx}/\Omega_b} + \frac{M_{ay}}{M_{ny}/\Omega_b} \right) \le 1.0$

For $\frac{P_a}{P_n/\Omega_c} < 0.2$ $\quad \frac{P_a}{2P_n/\Omega_c} + \left(\frac{M_{ax}}{M_{nx}/\Omega_b} + \frac{M_{ay}}{M_{ny}/\Omega_b} \right) \le 1.0$

Structural Modeling with SAP2000 – Steel Design

Any questions?