CONCRETE COLUMNS & FRAMES

- Concrete construction: columns & frames

lecture twenty six

ARCHITECTURAL STRUCTURES: FORM, BEHAVIOR, AND DESIGN

ARCH 331

DR. ANNE NICHOLS

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http://www.building.co.uk
Concrete in Compression

- crushing
- vertical cracking
  - tension
- diagonal cracking
  - shear
- $f'_c$
Columns Reinforcement

- columns require
  - ties or spiral reinforcement to “confine” concrete (#3 bars minimum)
  - minimum amount of longitudinal steel (#5 bars minimum: 4 with ties, 5 with spiral)
Slenderness

- effective length in monolithic with respect to stiffness of joint: $\Psi$ & $k$
- not slender when

$$\frac{kL_u}{r} < 22$$
Effective Length (revisited)

- **relative rotation**

\[
\Psi = \frac{\sum EI}{\sum EI/l_c}/l_b
\]
Column Behavior

Figure 13.3.2  Spirally reinforced column behavior. (Courtesy of Portland Cement Association.)

Figure 13.3.3  Tied column behavior. (Courtesy of Portland Cement Association.)
Column Design

- $\phi_c = 0.65$ for ties, $\phi_c = 0.75$ for spirals

- $P_o$ – no bending

$$P_o = 0.85 f_c' (A_g - A_{st}) + f_y A_{st}$$

- $P_u \leq \phi_c P_n$
  - ties: $P_n = 0.8P_o$
  - spiral: $P_n = 0.85P_o$

- nominal axial capacity:
  - presumes steel yields
  - concrete at ultimate stress

\[ C_1 = 0.85 f_c' (A_g - A_{st}) \]
\[ C_2 = f_y A_1 \]
\[ C_3 = f_y A_2 \]
Columns with Bending

- eccentric loads can cause moments
- moments can change shape and induce more deflection

\[ (P - \Delta) \]
Columns with Bending

- for ultimate strength behavior, ultimate strains can’t be exceeded
  - concrete 0.003
  - steel \( \frac{f_y}{E_s} \)

- \( P \) reduces with \( M \)

Figure 13.6.1 Typical strength interaction diagram for axial compression and bending moment about one axis. Transition zone is where \( \varepsilon_\theta \leq \varepsilon_t \leq 0.005 \).
Columns with Bending

- need to consider combined stresses
- linear strain
- steel stress at or below $f_y$
- plot interaction diagram

Figure 5-3 Transition Stages on Interaction Diagram
Design Methods

- calculation intensive
  - handbook charts
  - computer programs
Design Considerations

- **bending at both ends**
  - $P-\Delta$ maximum

- **biaxial bending**

- **walls**
  - unit wide columns
  - “deep” beam shear

- **detailing**
  - shorter development lengths
  - dowels to footings