Elements of Architectural Structures: Form, Behavior, and Design

ARCH 614

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Lecture twenty five

Concrete construction: columns & frames
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 (4 bars minimum)
**Slenderness**

- **effective length in monolithic with respect to stiffness of joint:** $\Psi$ & $k$

- **not slender when**

\[
\frac{kL_{u}}{r} < 22\] *not braced*

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**Cast-in-place Concrete Column/Beam Connection.**

**Note:** Overlapping steel reinforcement makes assembly monolithic.

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**Figure 5-7: Column Tie Details**
Effective Length (revisited)

- relative rotation

\[ \Psi = \frac{\sum EI/l_c}{\sum EI/l_b} \]
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
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 $\varepsilon_d \leq \varepsilon_t \leq 0.005$. 
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**
  - $P - \Delta_{\text{maximum}}$

- **biaxial bending**

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

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