ELEMENTS OF ARCHITECTURAL STRUCTURES: FORM, BEHAVIOR, AND DESIGN

ARCH 614

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SPRING 2014

lecture
twenty five


http://www.building.co.uk

concrete construction: columns & frames

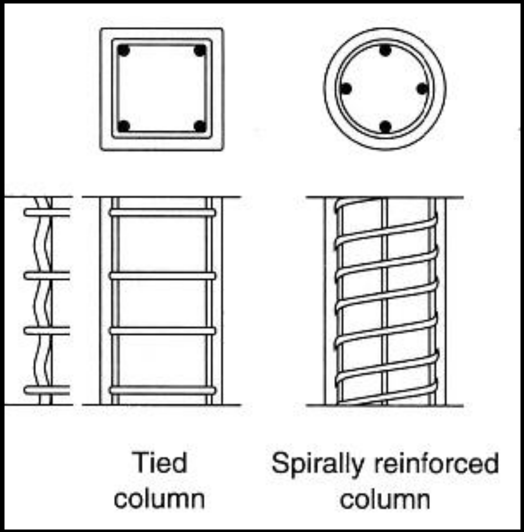
Concrete in Compression

- crushing
- vertical cracking
  - tension
- diagonal cracking
  - shear
- f_c'

http://www.bam.de

Columns Reinforcement

- columns require
  - ties or spiral reinforcement to "confine" concrete (#3 bars minimum)

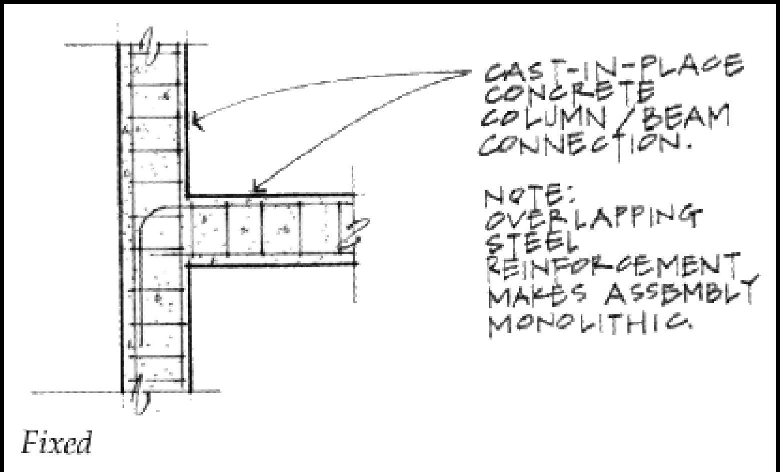


  - minimum amount of longitudinal steel (#5 bars minimum: 4 with ties, 5 with spiral)

Slenderness

- *effective length in monolithic with respect to stiffness of joint: Ψ & k*
- *not slender when*

$$\frac{kL_u}{r} < 22$$



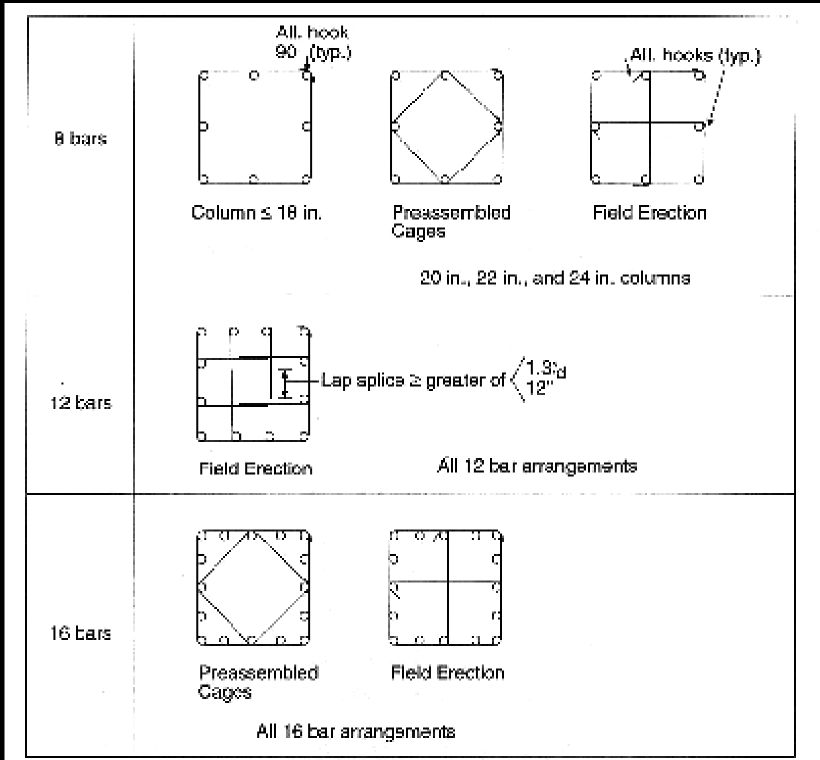
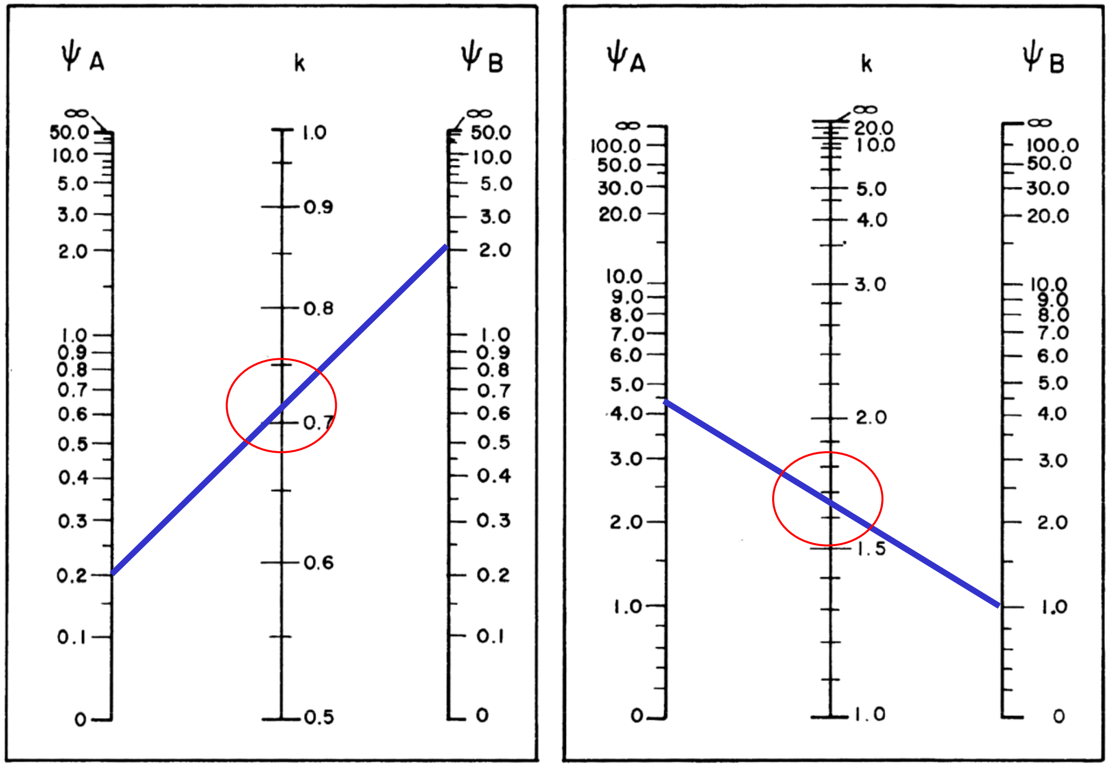


Figure 5-7 Column Tie Details

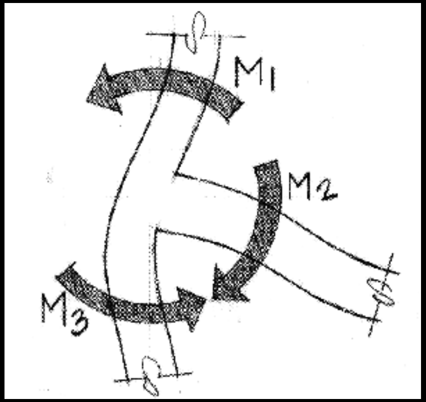
Effective Length (revisited)

- *relative rotation*



(a) Nonsway Frames

(b) Sway Frames



$$\Psi = \frac{\sum EI/l_c}{\sum EI/l_b}$$

Column Behavior

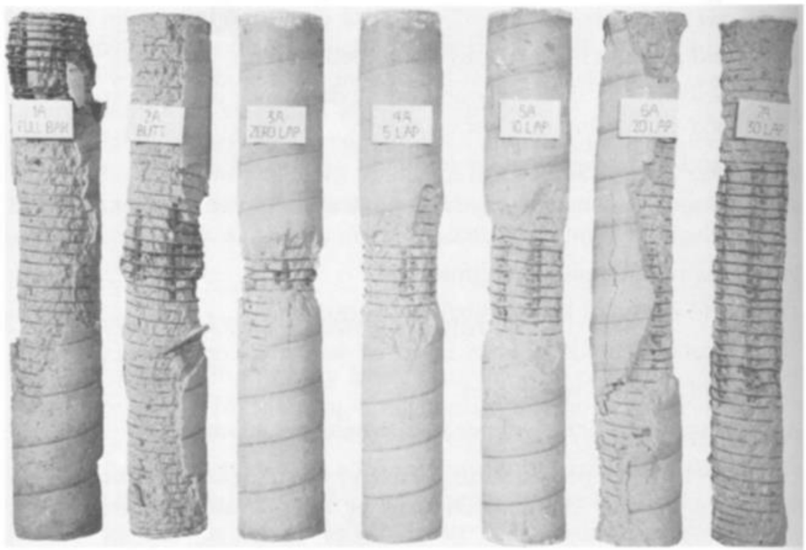


Figure 13.3.2 Spirally reinforced column behavior. (Courtesy of Portland Cement Association.)

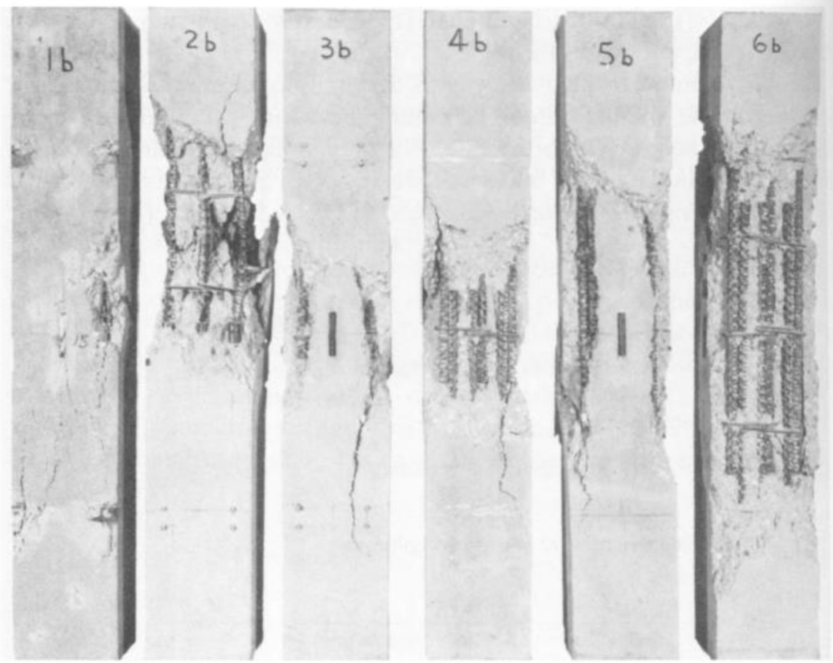


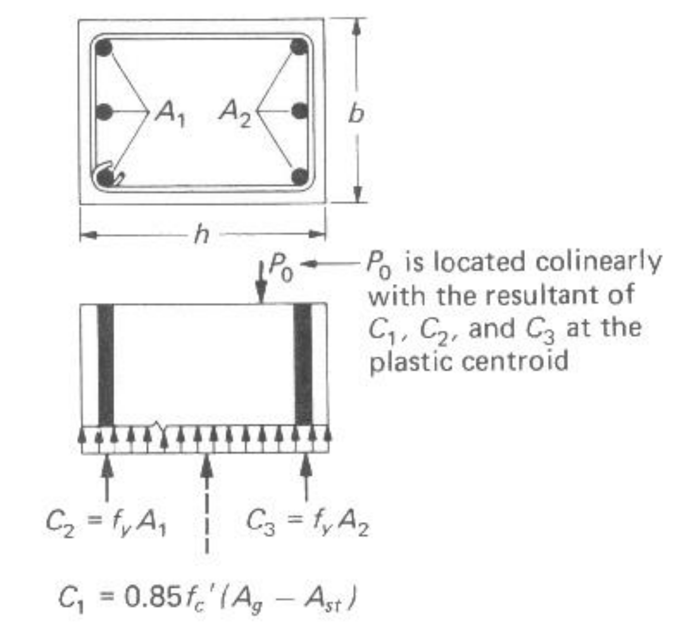
Figure 13.3.3 Tied column behavior. (Courtesy of Portland Cement Association.)

Column Design

- ϕ_c = 0.65 for ties, ϕ_c = 0.75 for spirals
- P_o – no bending

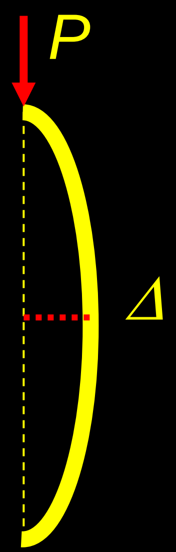
$$P_o = 0.85 f_c'(A_g - A_{st}) + f_y A_{st}$$

- $P_u \leq \phi_c P_n$
  - 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-Δ)*



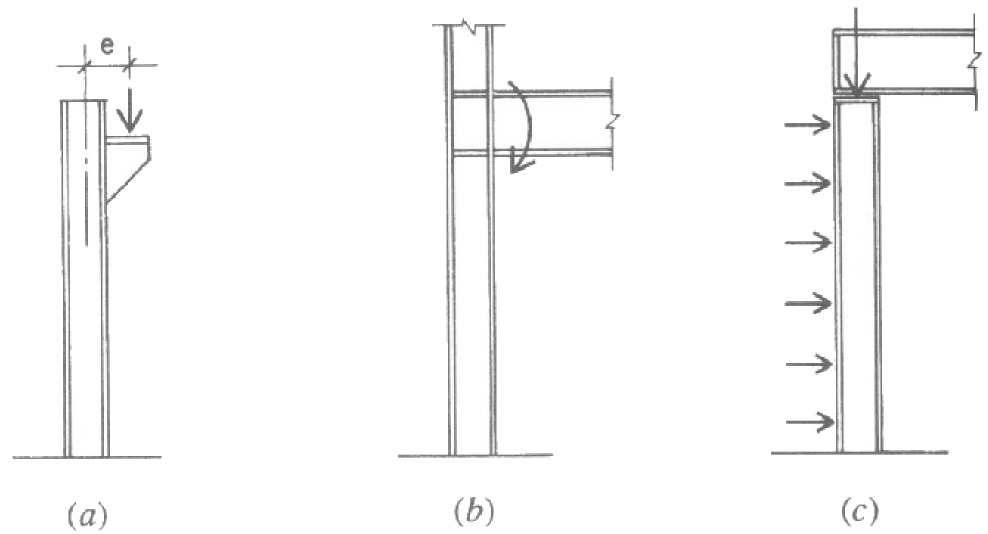


Figure 10.6 Considerations for development of bending in steel columns; (*a*) bending induced by eccentric load, (*b*) bending transferred to column in a rigid frame, and (*c*) combined loading condition, separately producing axial compression and bending.

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*

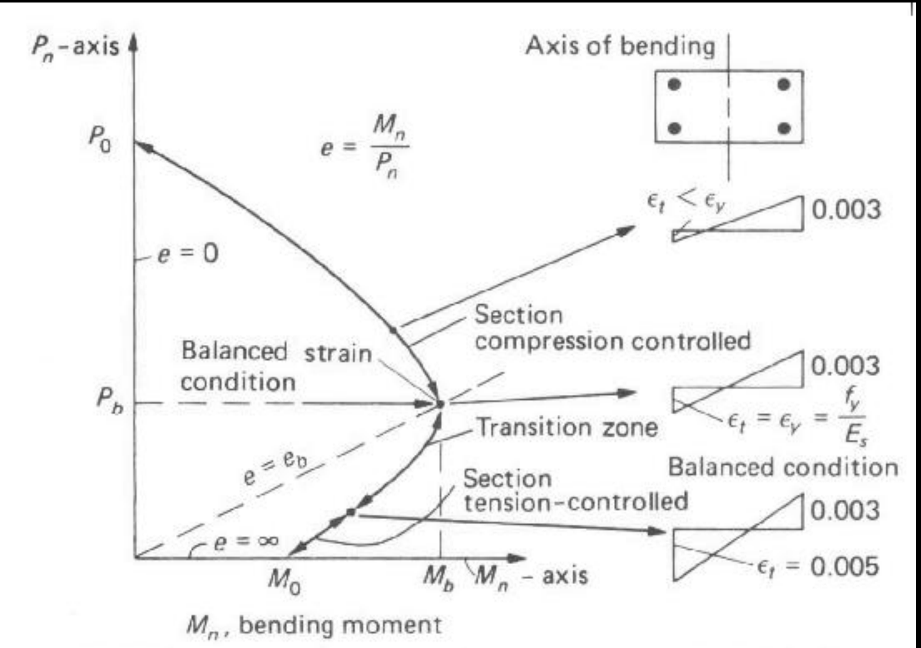


Figure 13.6.1 Typical strength interaction diagram for axial compression and bending moment about one axis. Transition zone is where $\epsilon_y \le \epsilon_t \le 0.005$.

Columns with Bending

- *need to consider combined stresses*
- *linear strain*
- *steel stress at or below f_y*
- *plot <u>interaction</u> diagram*

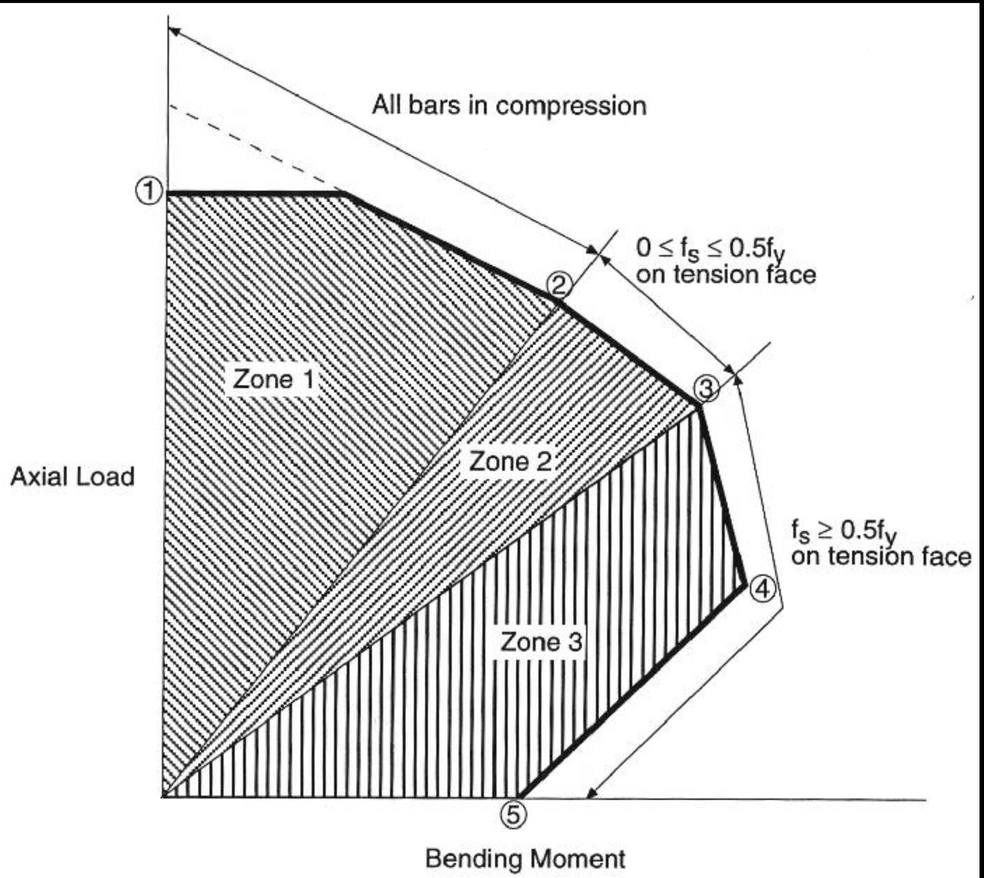
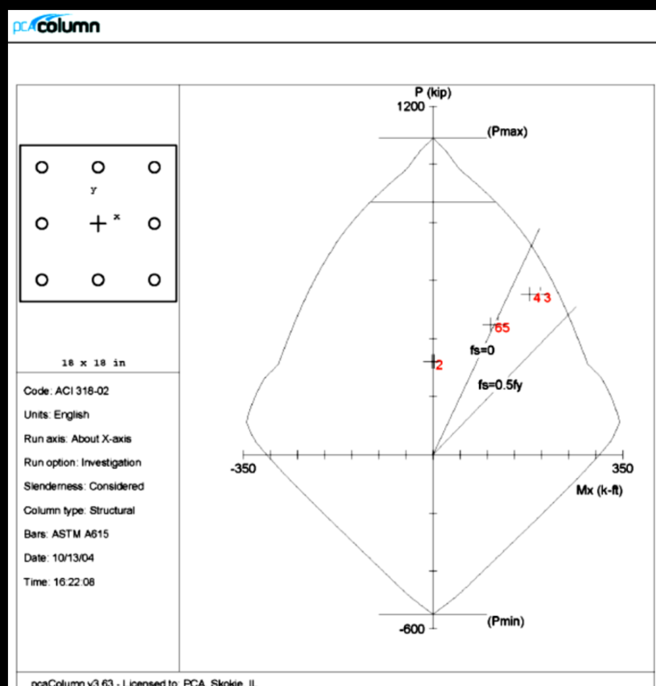


Figure 5-3 Transition Stages on Interaction Diagram

Design Methods

- calculation intensive
  - handbook charts
  - computer programs



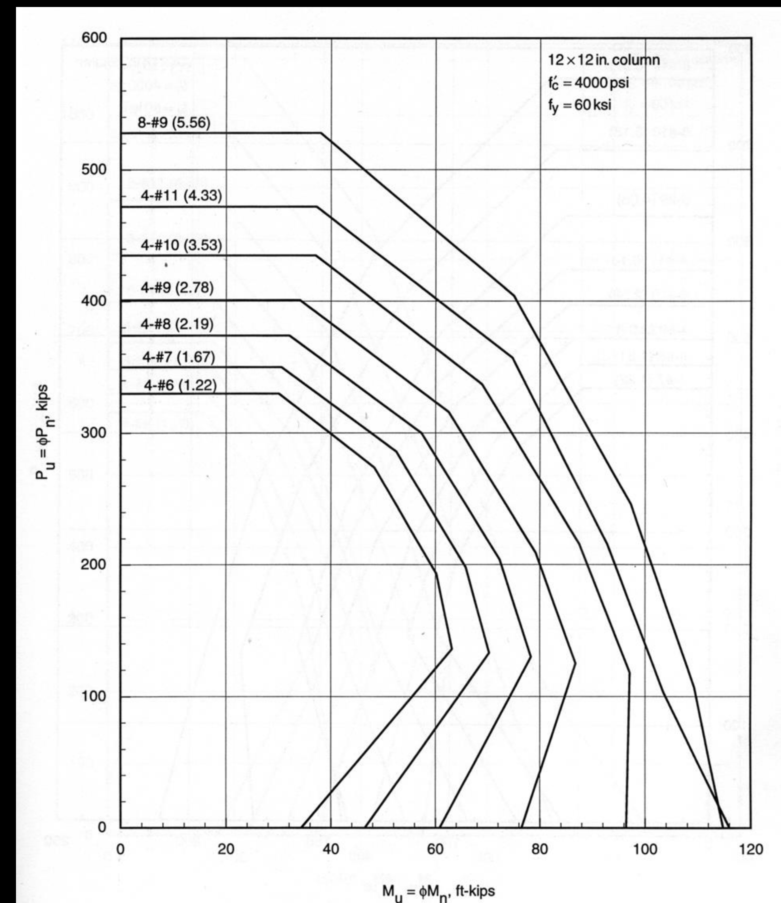
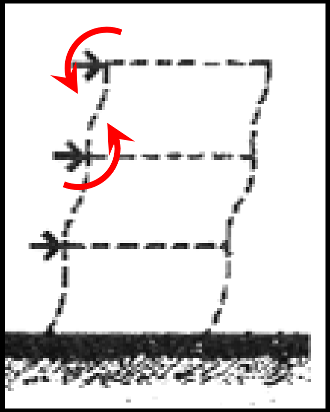


Figure 5-17 12 × 12 in. Column Design Chart

Design Considerations

- bending at both ends
  - P- Δ maximum
- biaxial bending
- walls
  - unit wide columns
  - "deep" beam shear
- detailing
  - shorter development lengths
  - dowels to footings



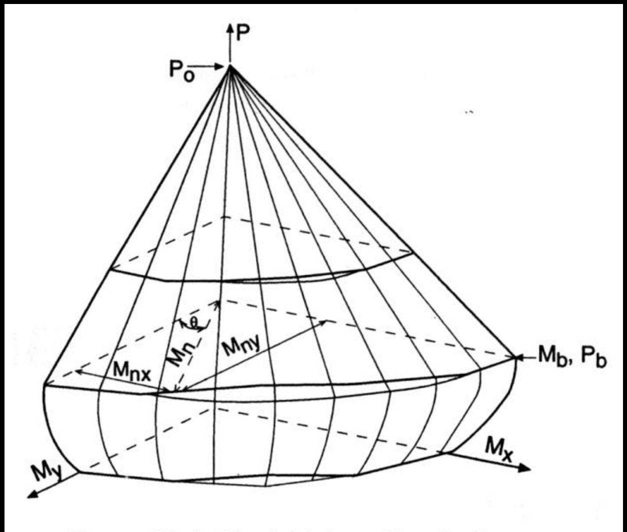
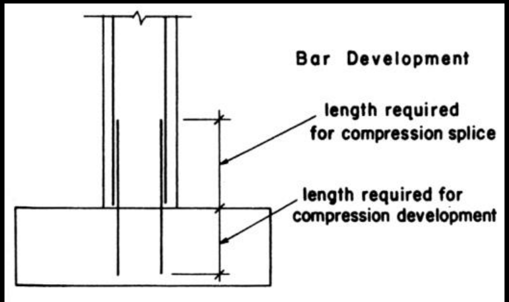


Figure 12-1 Biaxial Interaction Surface



(c) Footing without Pedestal