ARCHITECTURAL STRUCTURES:
FORM, BEHAVIOR, AND DESIGN

ARCH 331

DR. ANNE NICHOLS

FALL 2013

lecture
twenty six

concrete construction: columns & frames

http://www.building.co.uk

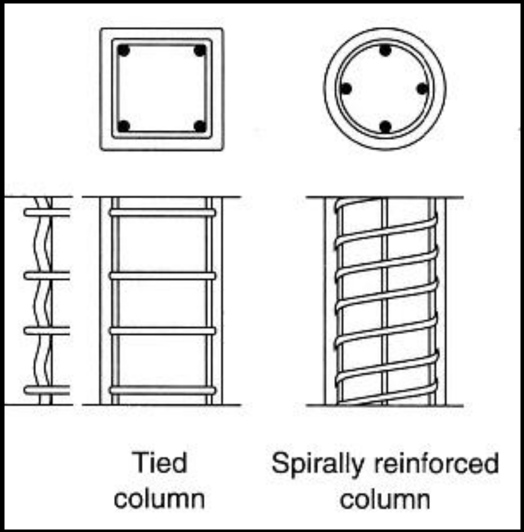
Concrete in Compression

- *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)*

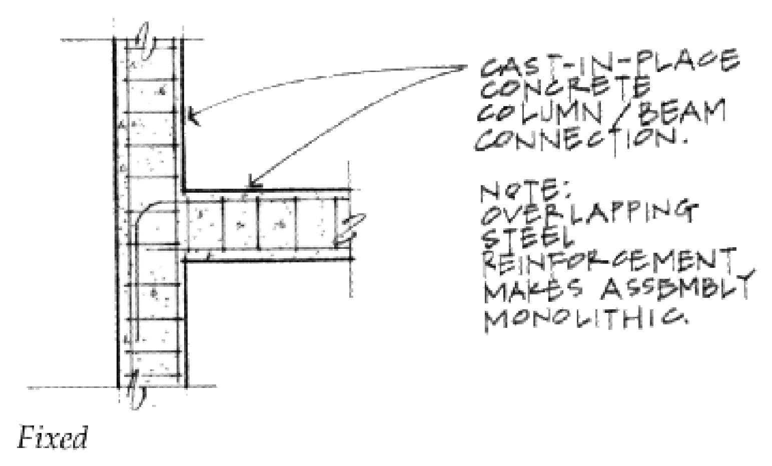


  - *minimum amount of longitudinal steel (#5 bars minimum: 4 with ties, 5 with spiral)*

Slenderness

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

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



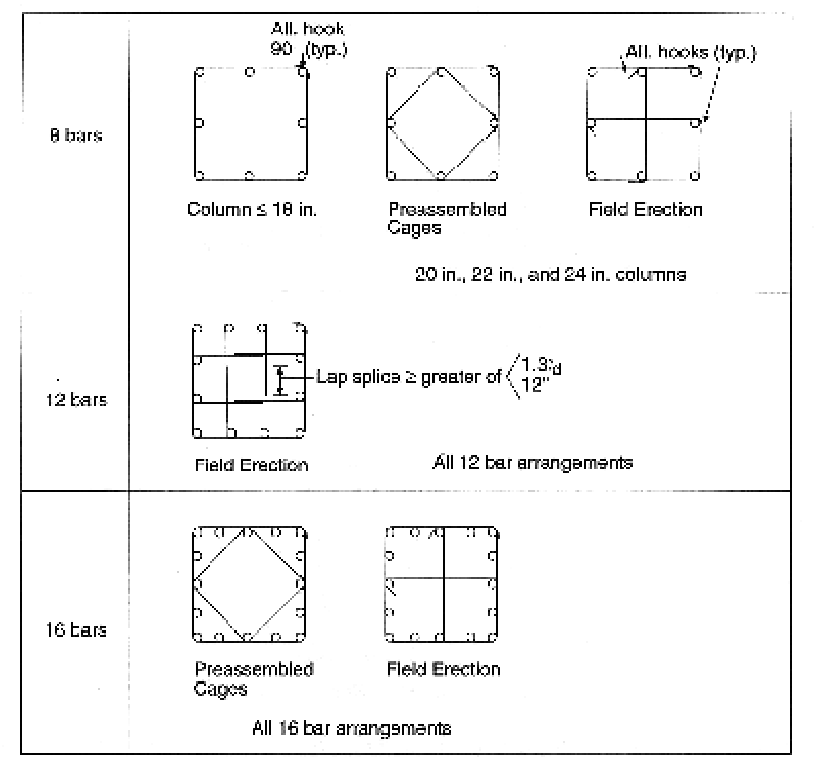
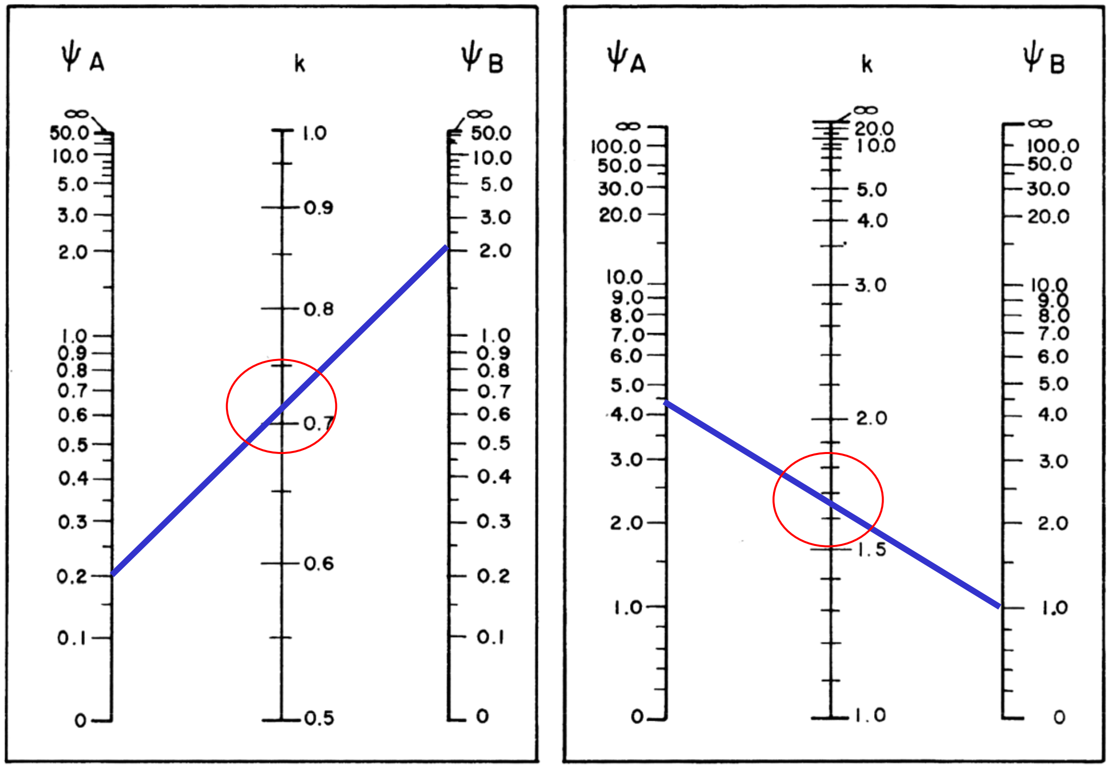


Figure 5-7 Column Tie Details

Effective Length (revisited)

- *relative rotation*

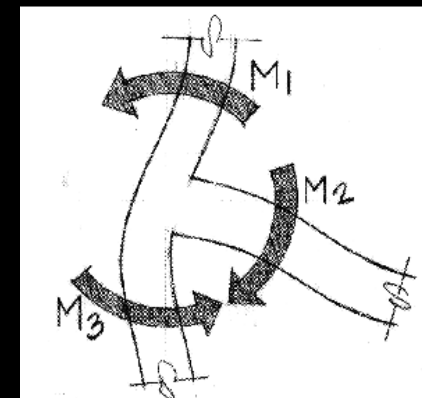


(a)

Nonsway Frames

(b)

Sway Frames



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

Column Behavior

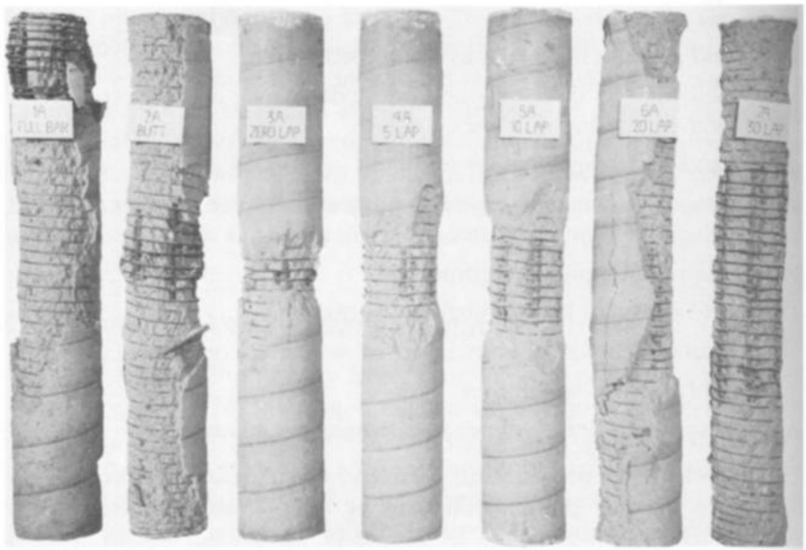


Figure 13.3.2 Spirally reinforced column behavior. (Courtesy of Portland Cement Association.)

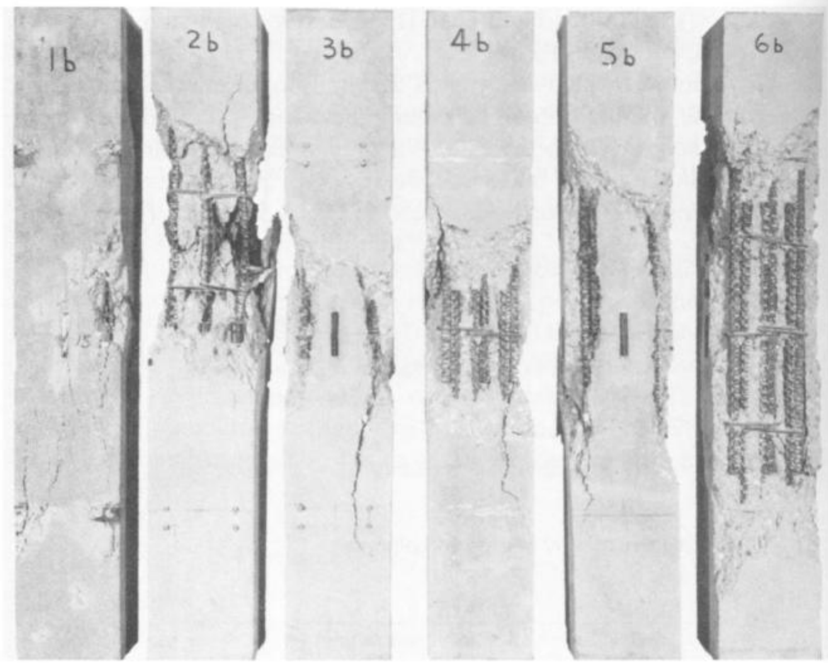


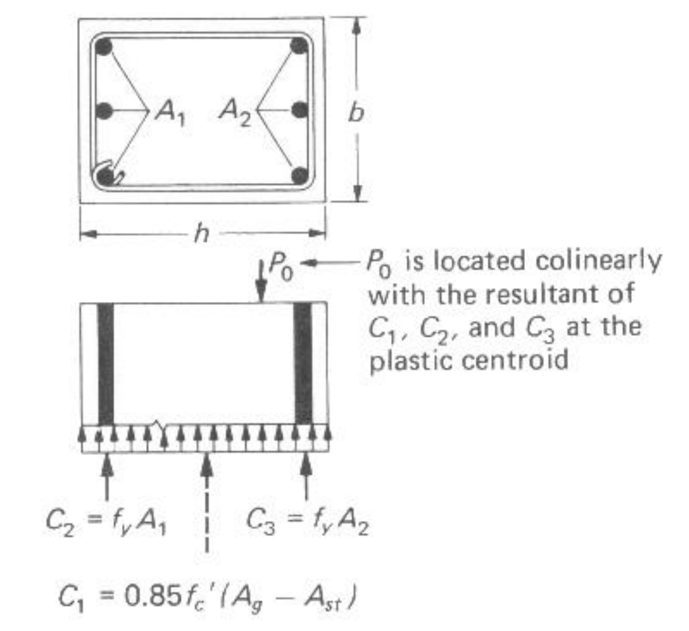
Figure 13.3.3 Tied column behavior. (Courtesy of Portland Cement Association.)

Column Design

- $\phi_c = 0.65$ for ties, $\phi_c = 0.75$ for spirals
- P_o – no bending

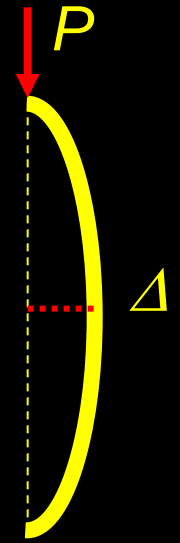
$$P_o = 0.85 f_c'(A_g - A_{st}) + f_y A_{st}$$

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



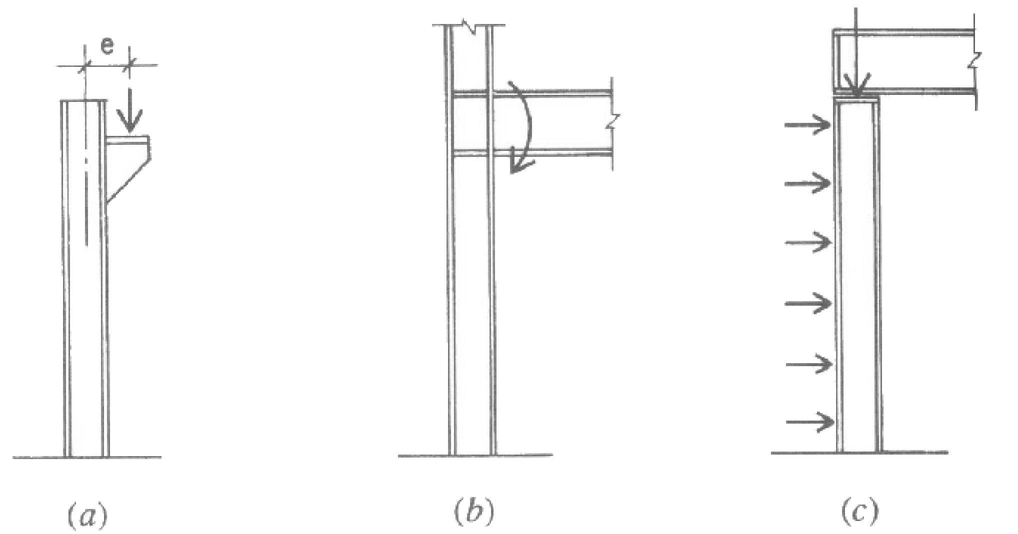


Figure 10.6 Considerations for development of bending in steel columns; (*a*) bending induced by eccentric load, (*b*) bending transferred to column in a rigid frame, and (*c*) combined loading condition, separately producing axial compression and bending.

Columns with Bending

- *for ultimate strength behavior, ultimate strains can't be exceeded*
  - *concrete 0.003*
  - *steel* $\dfrac{f_y}{E_s}$
- *P reduces with M*

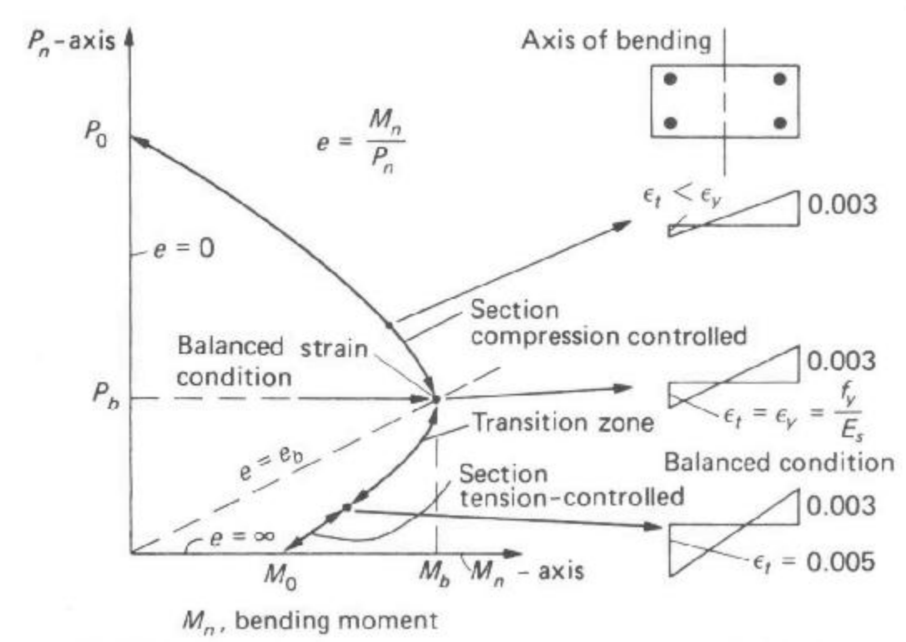


Figure 13.6.1 Typical strength interaction diagram for axial compression and bending moment about one axis. Transition zone is where $\epsilon_y \leq \epsilon_t \leq 0.005$.

Columns with Bending

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

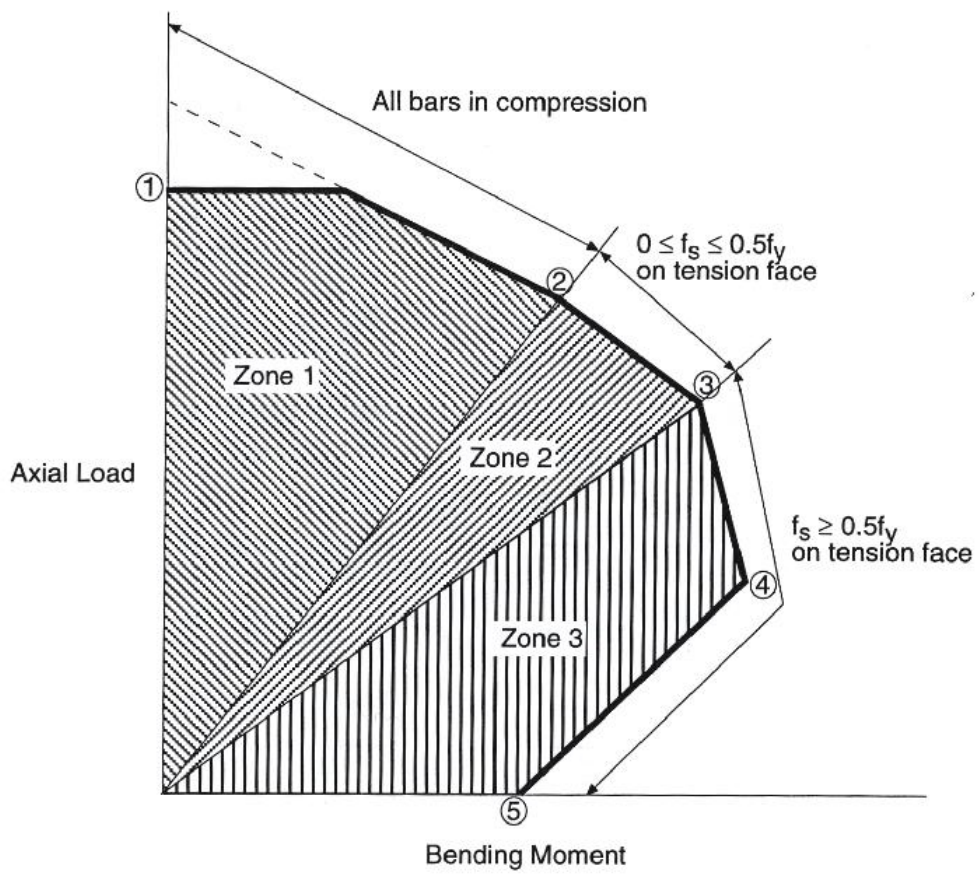
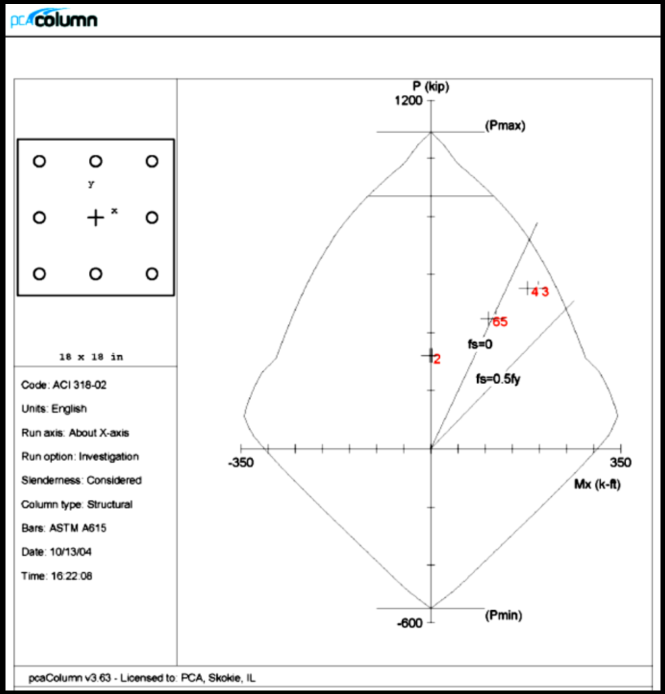


Figure 5-3 Transition Stages on Interaction Diagram

Design Methods

- calculation intensive
  - handbook charts
  - computer programs



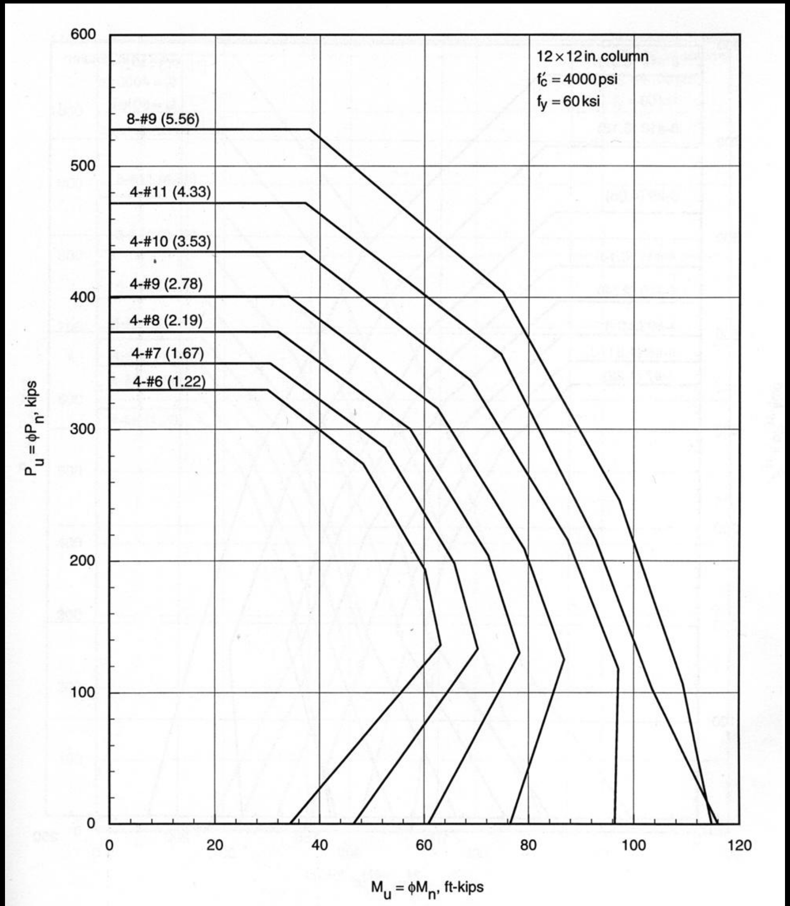
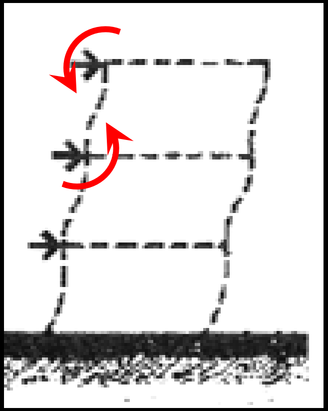


Figure 5-17 12 × 12 in. Column Design Chart

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*



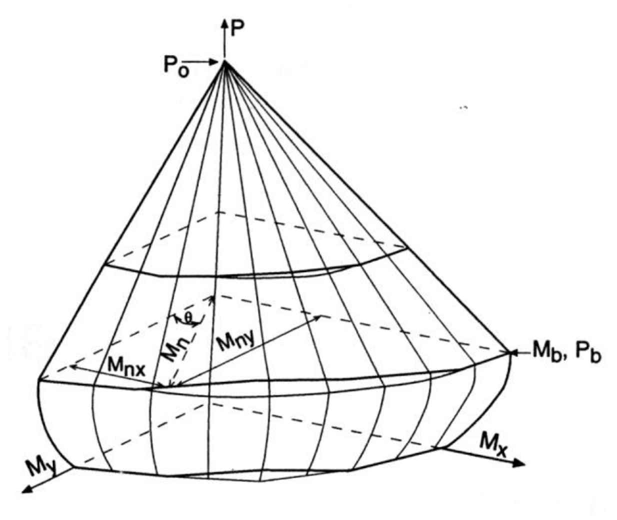
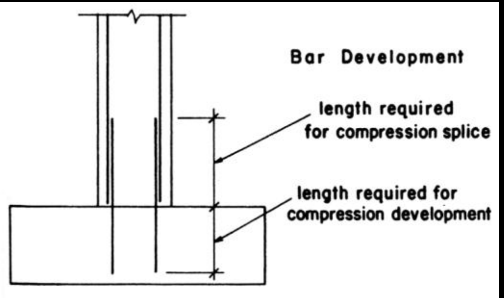


Figure 12-1 Biaxial Interaction Surface



(c) Footing without Pedestal