

**ELEMENTS OF ARCHITECTURAL STRUCTURES:
FORM, BEHAVIOR, AND DESIGN**

ARCH 614

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SPRING 2013

lecture
twenty five

**concrete construction:
columns & frames**



Brenton Hardee

Concrete in Compression

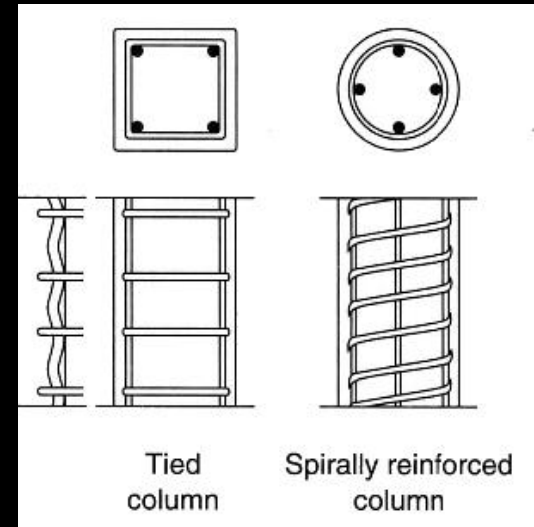
- *crushing*
- *vertical cracking*
 - *tension*
- *diagonal cracking*
 - *shear*
- f'_c



<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

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

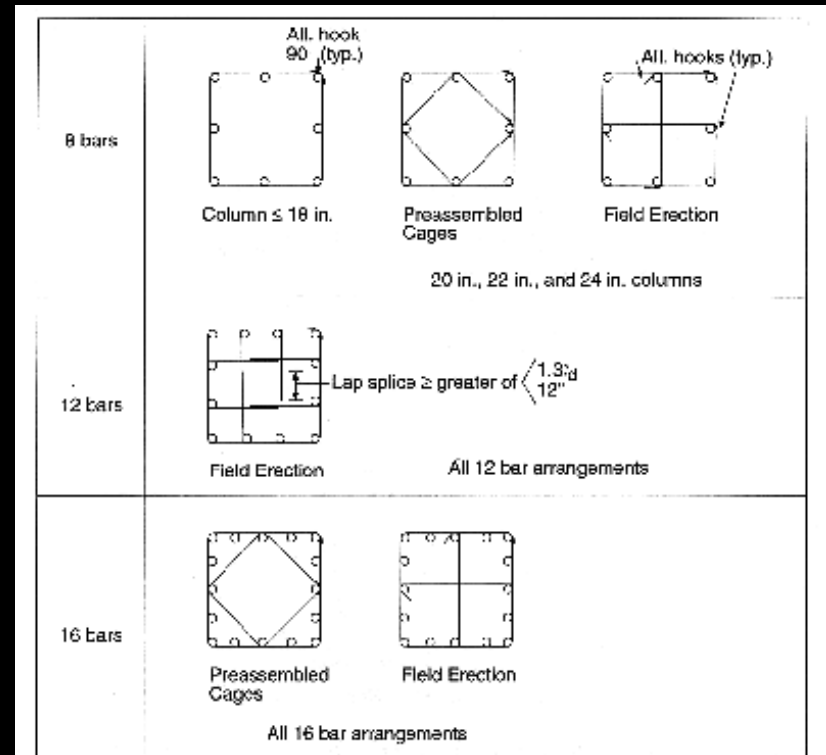
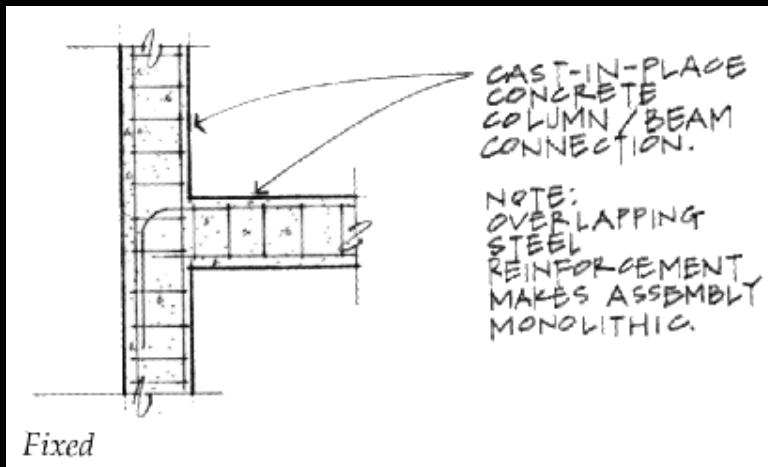
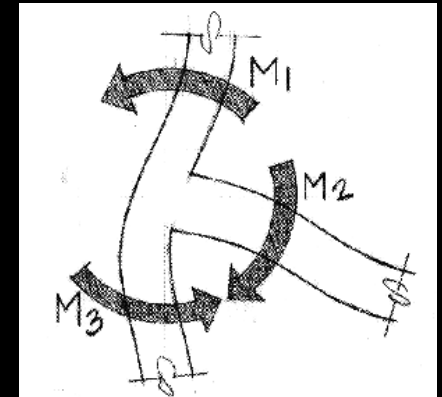
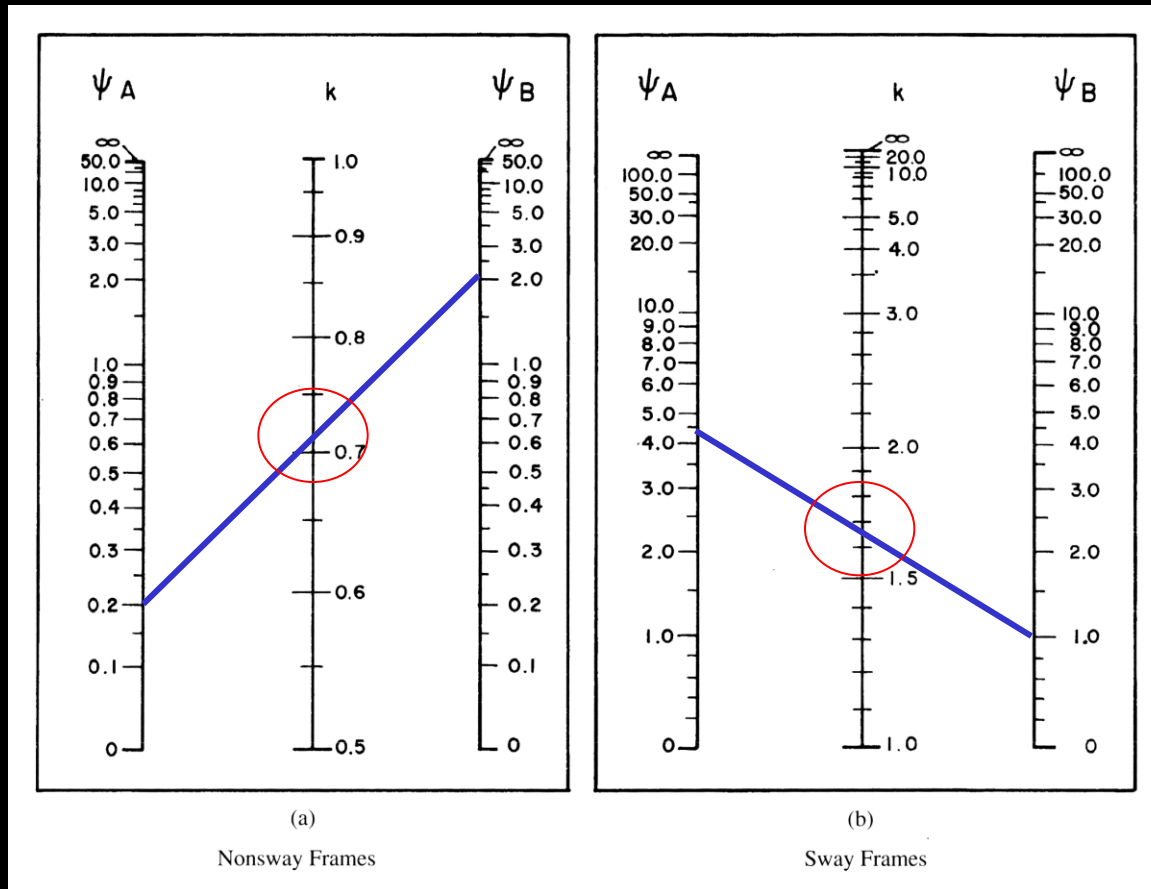


Figure 5-7 Column Tie Details

Effective Length (revisited)

- relative rotation



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

Column Behavior

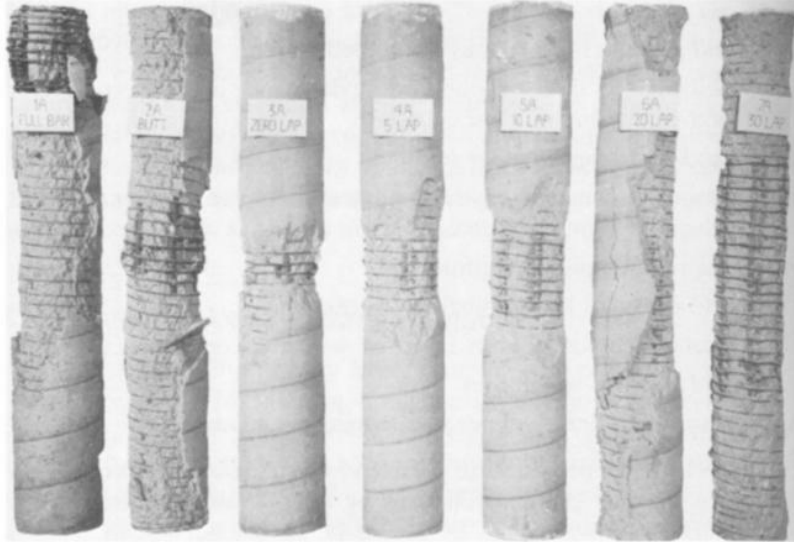


Figure 13.3.2 Spirally reinforced column behavior. (Courtesy of Portland Cement Association.)

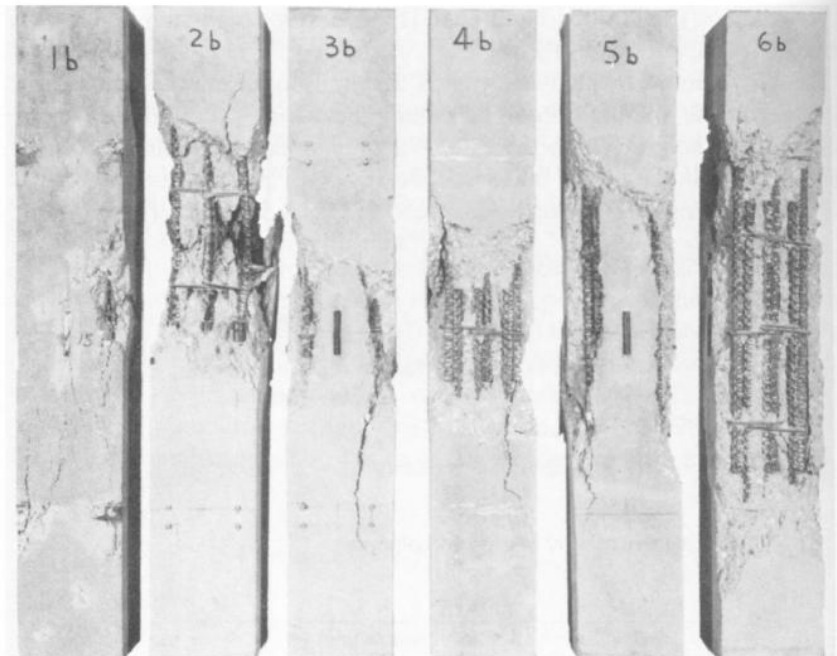


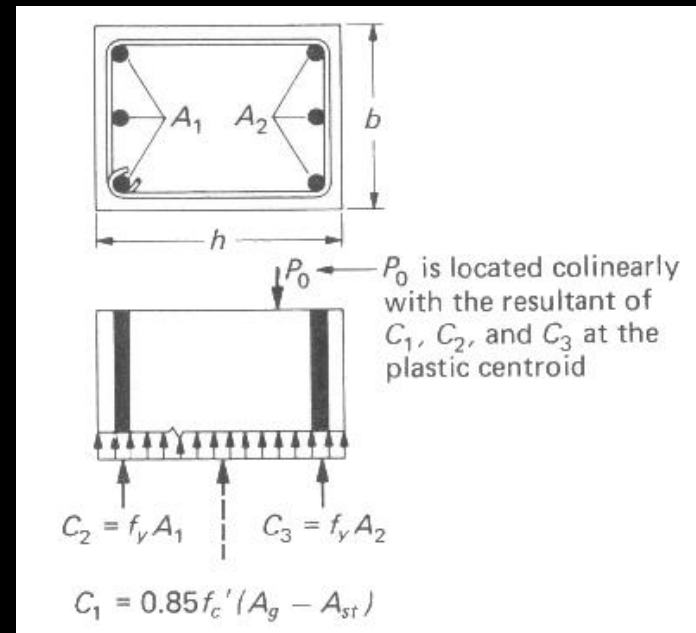
Figure 13.3.3 Tied column behavior. (Courtesy of Portland Cement Association.)

Column Design

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

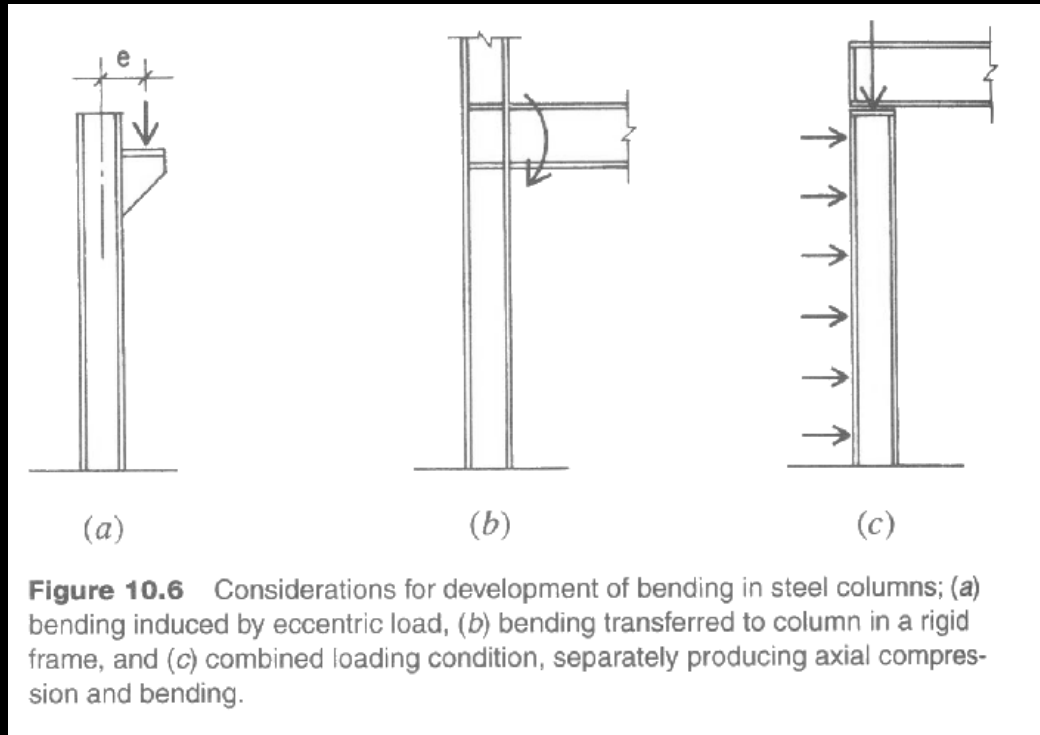
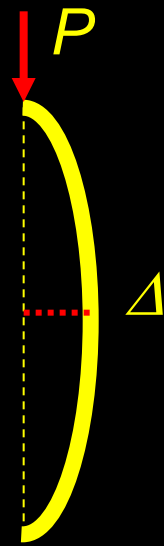
$$P_o = 0.85 f'_c (A_g - A_{st}) + f_y A_{st}$$

- $P_u \leq \phi_c P_n$
 - 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 ($P-\Delta$)*



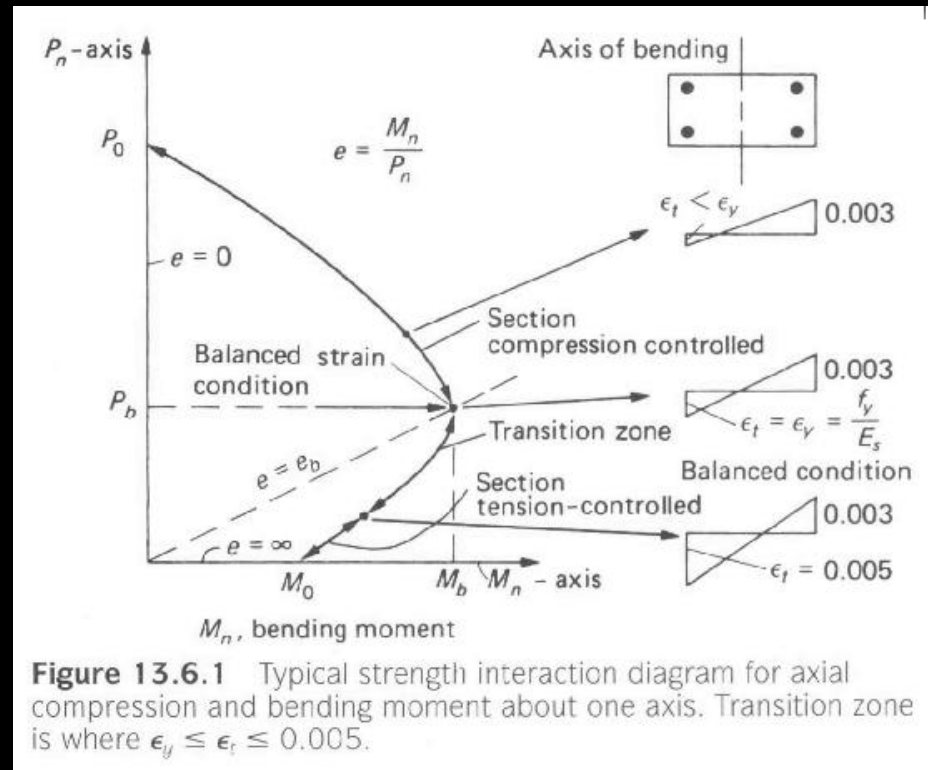
Columns with Bending

- for ultimate strength behavior, ultimate strains can't be exceeded

- concrete 0.003

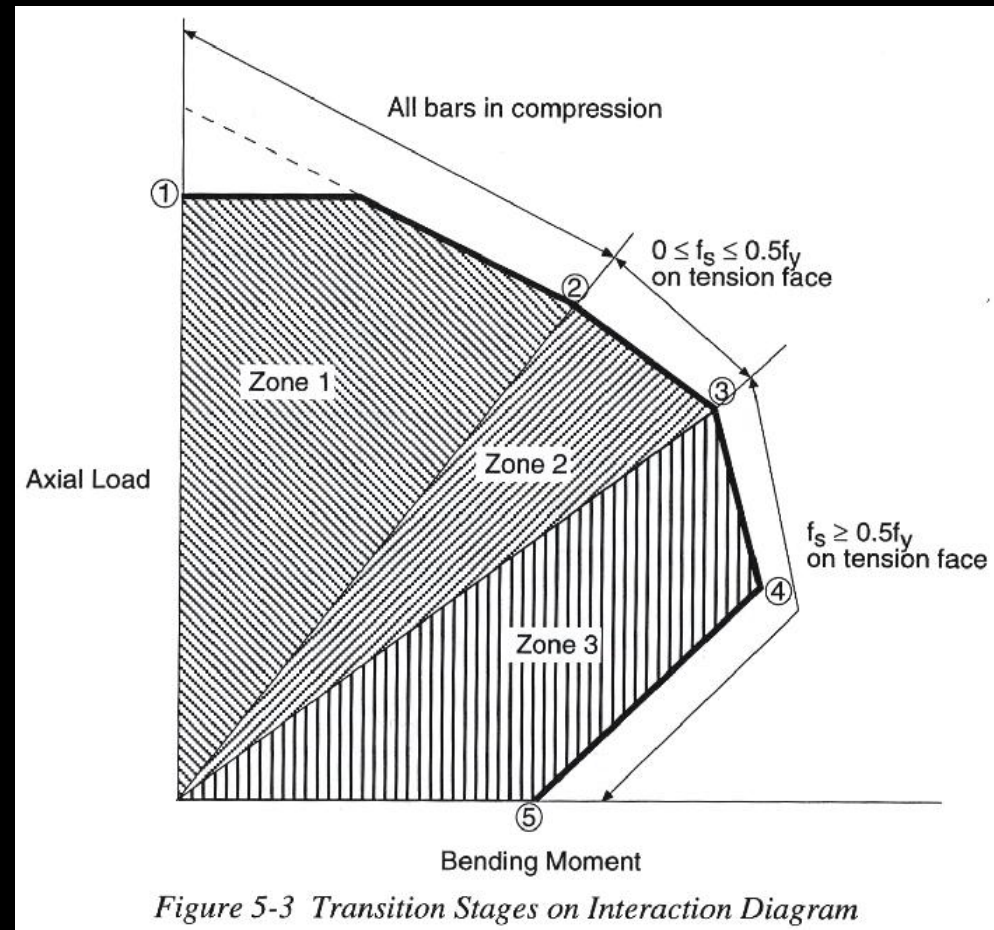
- steel $\frac{f_y}{E_s}$

- P reduces with M



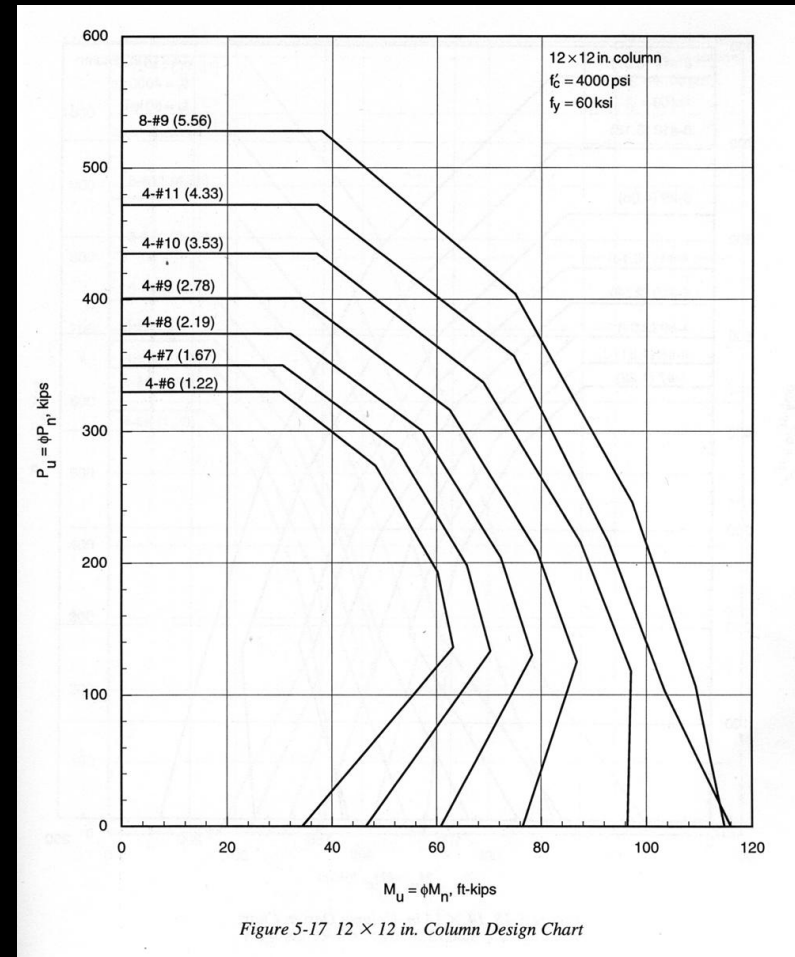
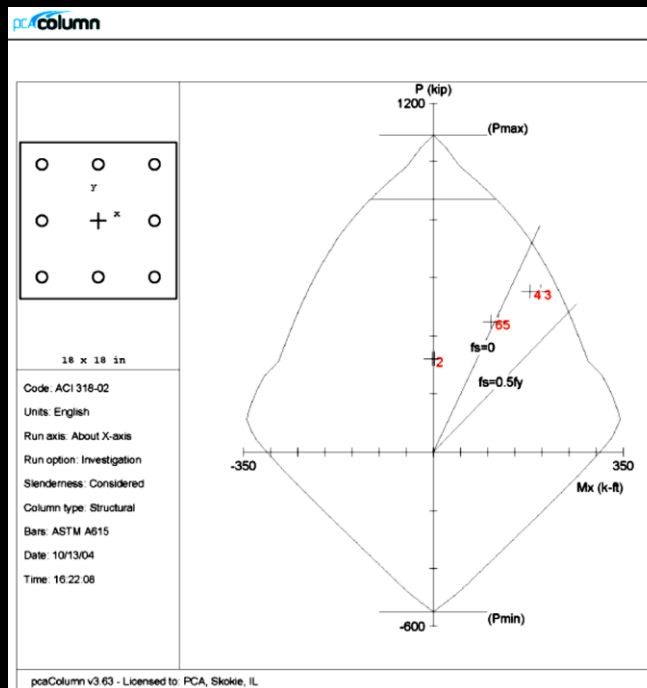
Columns with Bending

- need to consider combined stresses
- linear strain
- steel stress at or below f_y
- plot 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*

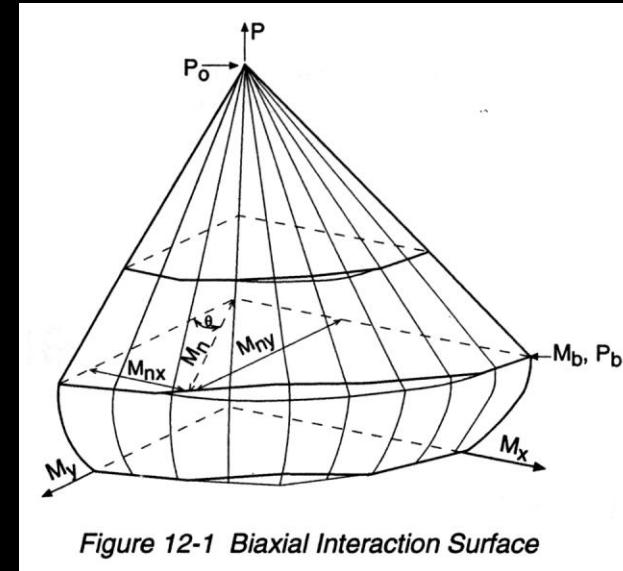
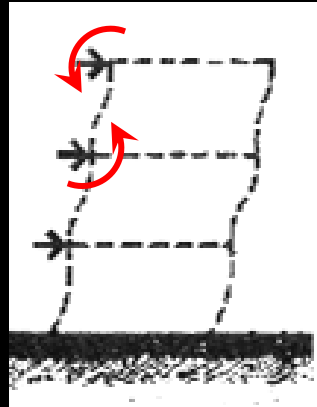


Figure 12-1 Biaxial Interaction Surface

