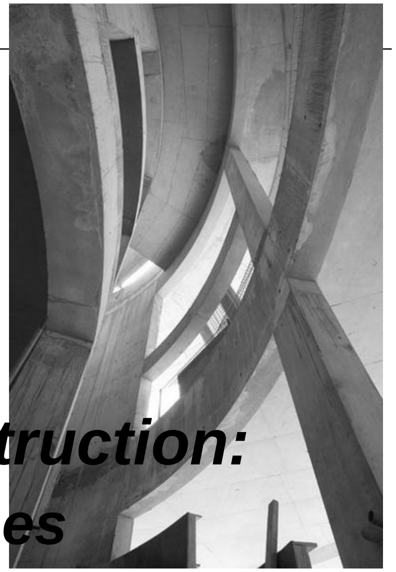
DR. ANNE NICHOLS
SPRING 2019

lecture
twenty five

http://www.building.co.uk

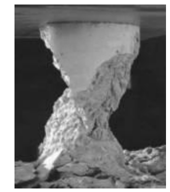


# concrete construction: columns & frames



## Concrete in Compression

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



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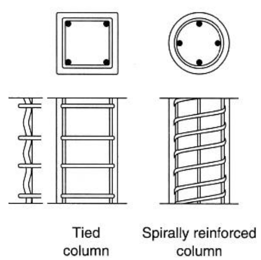
## Columns Reinforcement

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



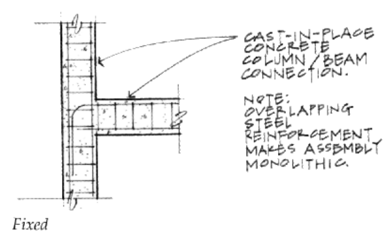



## Slenderness

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

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

*not braced



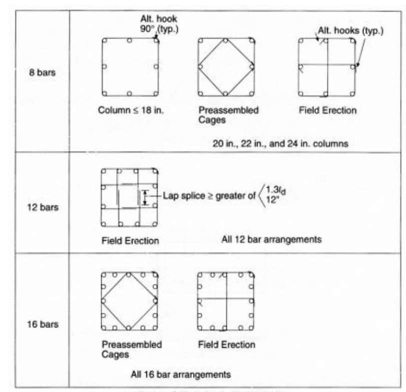
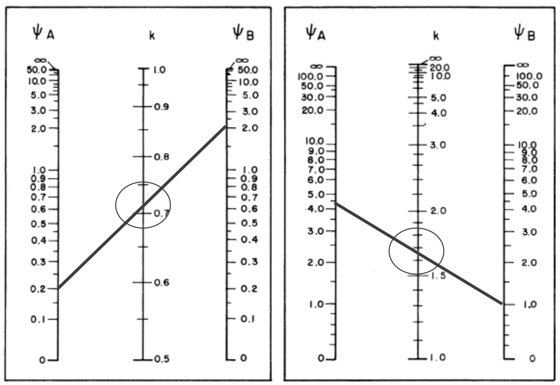




Figure 5-7 Column Tie Details

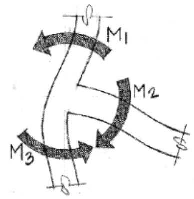
# Effective Length (revisited)

- *relative rotation*




(a) Nonsway Frames

(b) Sway Frames




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



# Column Behavior

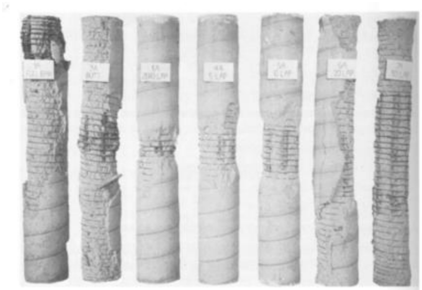


Figure 13.3.2 Spirally reinforced column behavior. (Courtesy of Portland Cement Association.)

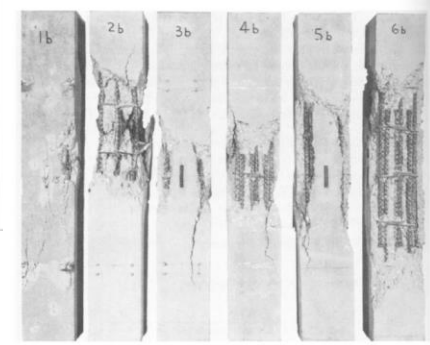


Figure 13.3.3 Tied column behavior. (Courtesy of Portland Cement Association.)

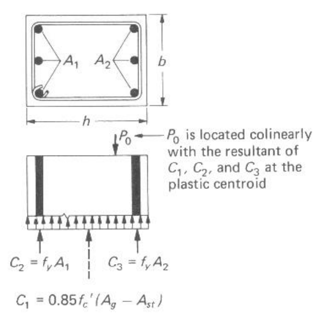


# Column Design

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

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

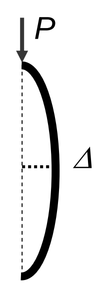
- $P_u \le \phi_c P_n$
  - ties: $P_n = 0.8P_o$
  - spiral: $P_n = 0.85P_o$
- *nominal axial capacity:*
  - presumes steel yields
  - concrete at ultimate stress






# Columns with Bending

- *eccentric loads can cause moments*
- *moments can change shape and induce more deflection (P-Δ)*



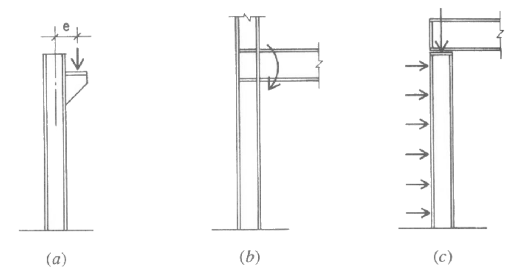




Figure 10.6 Considerations for development of bending in steel columns; (a) bending induced by eccentric load, (b) bending transferred to column in a rigid frame, and (c) combined loading condition, separately producing axial compression and bending.

# 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*

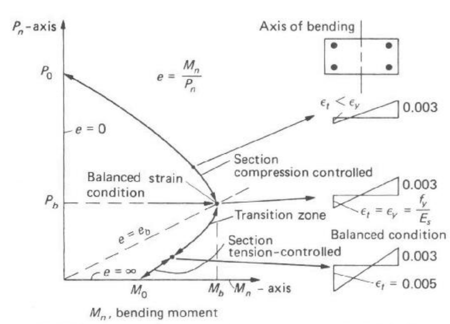



**Figure 13.6.1** Typical strength interaction diagram for axial compression and bending moment about one axis. Transition zone is where $\epsilon_y \leq \epsilon_t \leq 0.005$.



# Columns with Bending

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

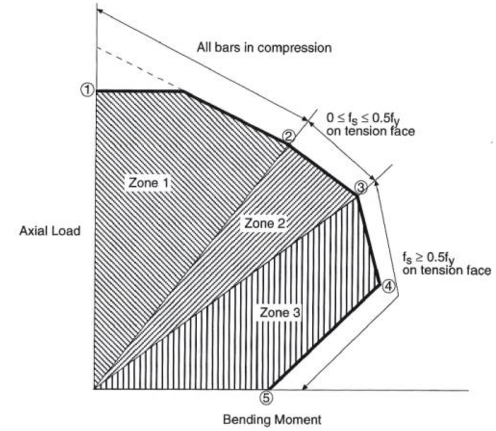
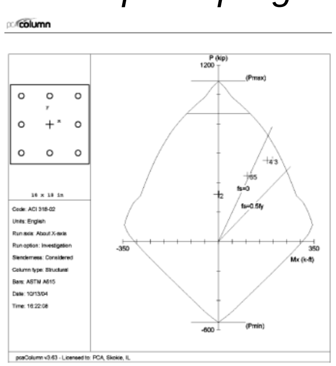



*Figure 5-3 Transition Stages on Interaction Diagram*



# Design Methods

- *calculation intensive*
  - *handbook charts*
  - *computer programs*



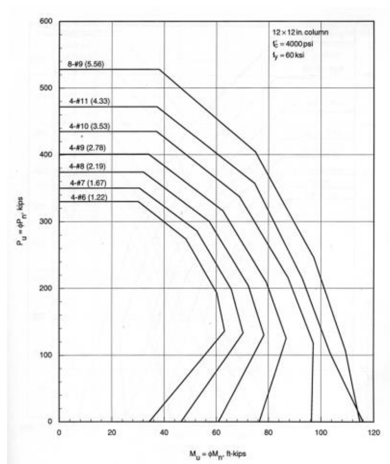
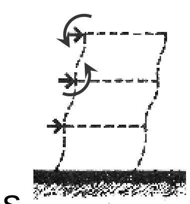



*Figure 5-17 12 × 12 in. Column Design Chart*



# 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*



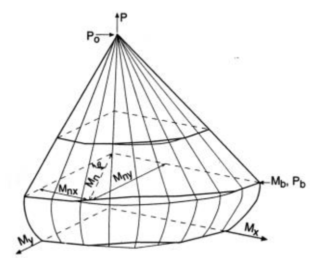



*Figure 12-1 Biaxial Interaction Surface*