ARCHITECTURAL STRUCTURES:
FORM, BEHAVIOR, AND DESIGN
ARCH 331
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FALL 2018

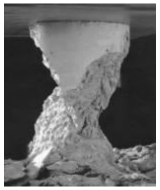
lecture
twenty six


http://www.building.co.uk

concrete construction: columns & frames

Concrete in Compression

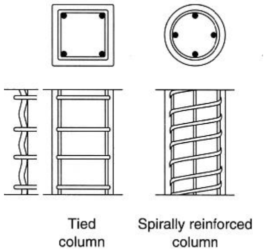
- crushing
- vertical cracking
  – tension
- diagonal cracking
  – shear
- f'_c



http://www.bam.de

Columns Reinforcement

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

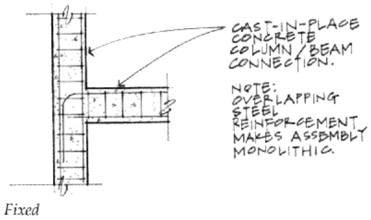


Slenderness

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

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

*not braced



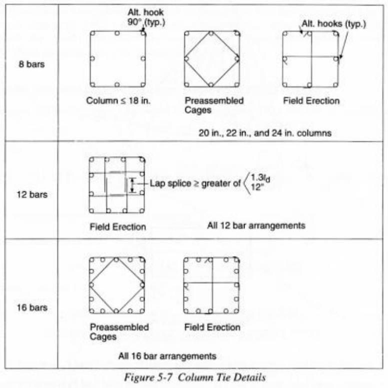
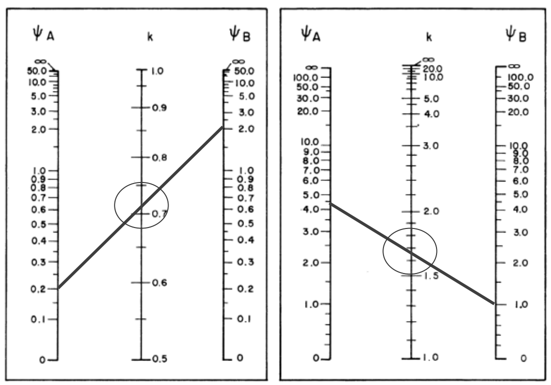
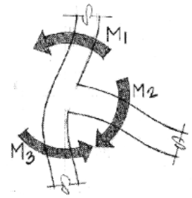


Figure 5-7 Column Tie Details

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.)

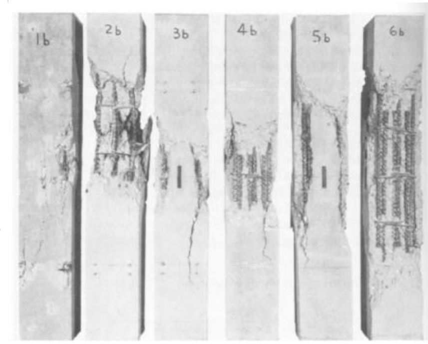


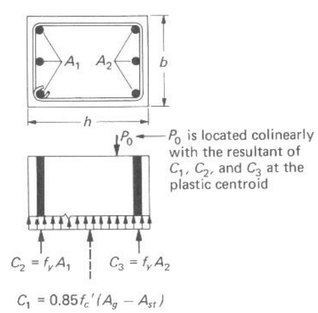
Figure 13.3.3 Tied column behavior. (Courtesy of Portland Cement Association.)

Column Design

- ϕ_c *= 0.65 for ties,* ϕ_c *= 0.70 for spirals*
- P_o *– no bending*

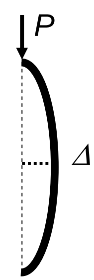
$$P_o = 0.85 f_c'(A_g - A_{st}) + f_y A_{st}$$

- $P_u \le \phi_c P_n$
  - *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)*



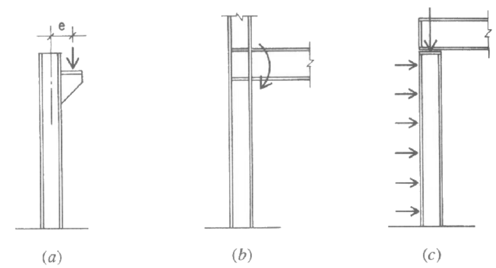


Figure 10.6 Considerations for development of bending in steel columns; (*a*) bending induced by eccentric load, (*b*) bending transferred to column in a rigid frame, and (*c*) combined loading condition, separately producing axial compression and bending.

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*

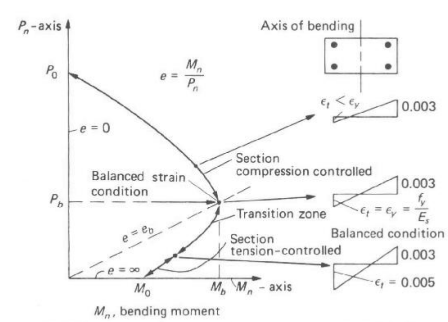


Figure 13.6.1 Typical strength interaction diagram for axial compression and bending moment about one axis. Transition zone is where $\epsilon_y \le \epsilon_t \le 0.005$.

Columns with Bending

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

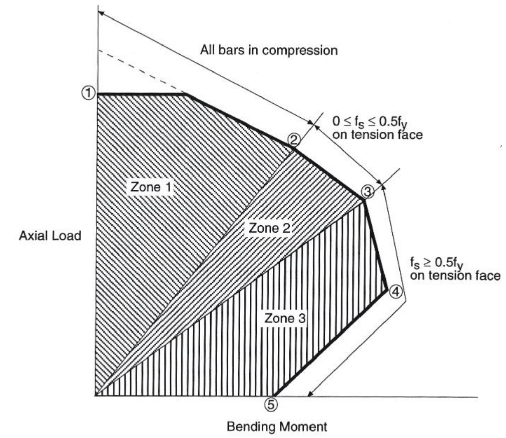
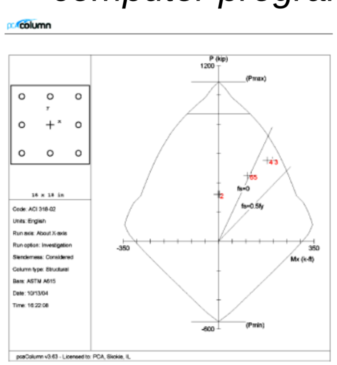


Figure 5-3 Transition Stages on Interaction Diagram

Design Methods

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



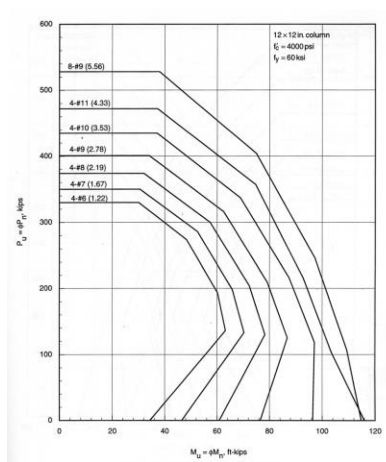
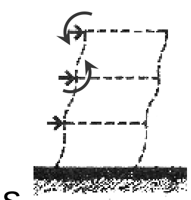


Figure 5-17 12 × 12 in. Column Design Chart

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*



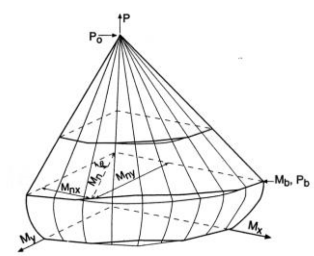
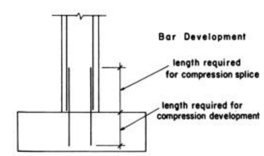


Figure 12-1 Biaxial Interaction Surface



(c) Footing without Pedestal