http://www.building.co.uk

lecture
twenty five

# concrete construction:
columns & frames
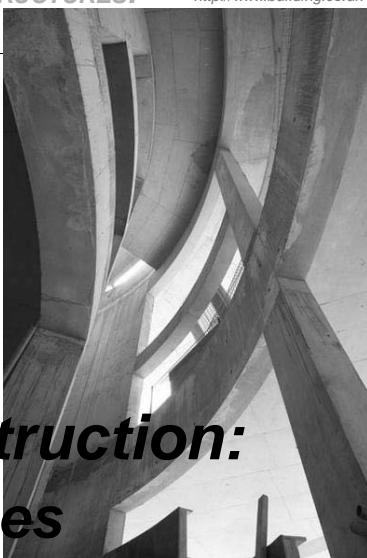
Concrete in Compression

- *crushing*
- *vertical cracking*
  - *tension*
- *diagonal cracking*
  - *shear*
- f'_c
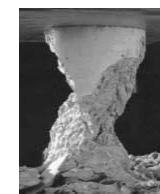
http://www.bam.de

Columns Reinforcement

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

  Tied column   Spirally reinforced column

  - *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*

$$\frac{kL_u}{r} < 22$$
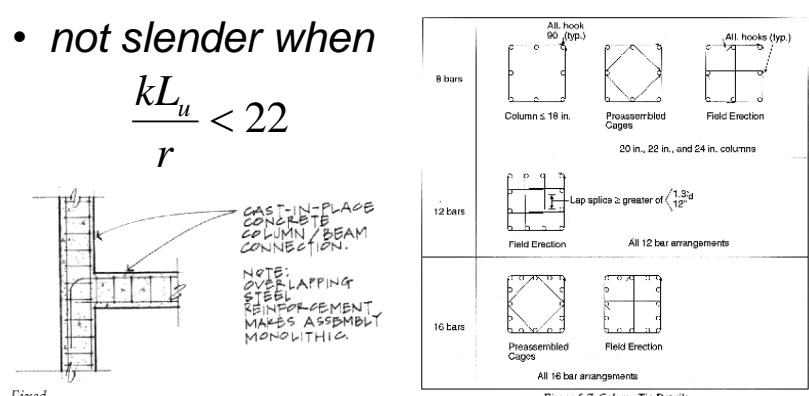
Figure 5-7 Column Tie Details

1

Effective Length (revisited)

- *relative rotation*
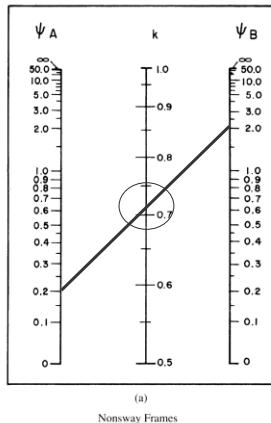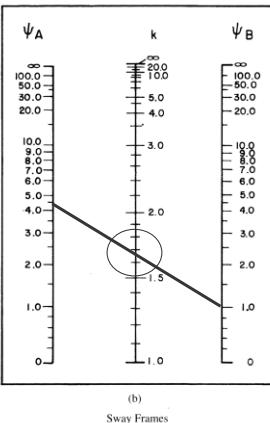
$$\Psi = \frac{\sum EI/l_c}{\sum EI/l_b}$$

(a) Nonsway Frames

(b) Sway Frames
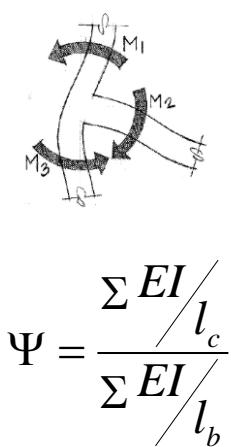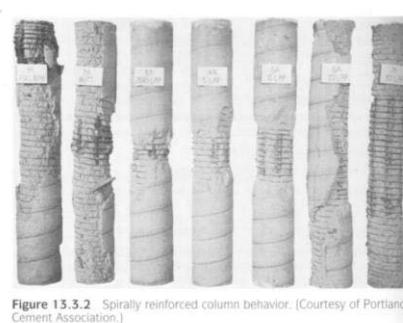
Column Behavior

Figure 13.3.2 Spirally reinforced column behavior. (Courtesy of Portland Cement Association.)
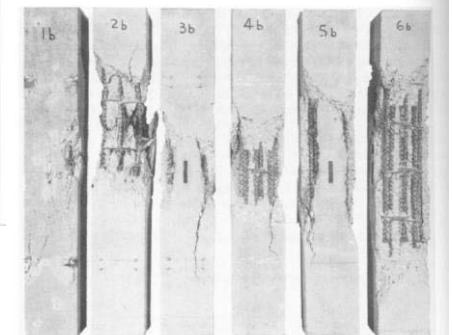
Figure 13.3.3 Tied column behavior. (Courtesy of Portland Cement Association.)

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*
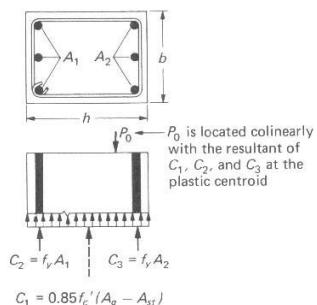
P_o is located colinearly with the resultant of C_1, C_2, and C_3 at the plastic centroid

$C_2 = f_y A_1$ $C_3 = f_y A_2$

$C_1 = 0.85 f_c'(A_g - A_{st})$

Columns with Bending

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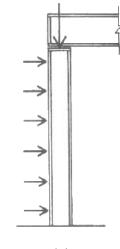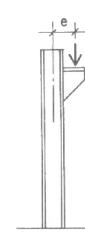

Figure 10.6 Considerations for development of bending in steel columns; (a) bending induced by eccentric load, (b) bending transferred to column in a rigid frame, and (c) combined loading condition, separately producing axial compression and bending.

2

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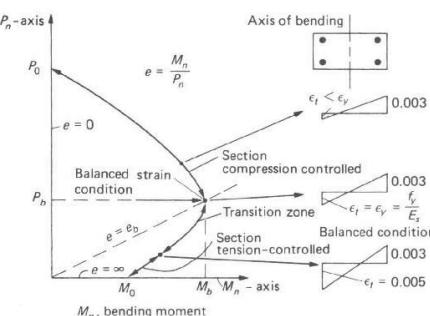
Figure 13.6.1 Typical strength interaction diagram for axial compression and bending moment about one axis. Transition zone is where $\epsilon_{ij} \le \epsilon_t \le 0.005$.

Columns with Bending

- *need to consider combined stresses*
- *linear strain*
- *steel stress at or below f_y*
- *plot interaction diagram*
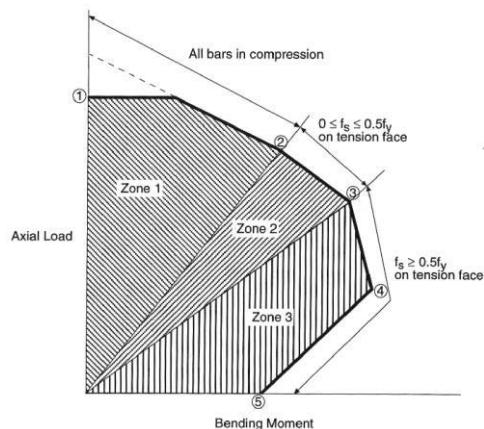
Figure 5-3 Transition Stages on Interaction Diagram

Design Methods

- *calculation intensive*
  - *handbook charts*
  - *computer programs*
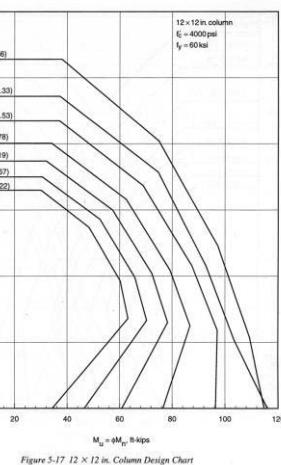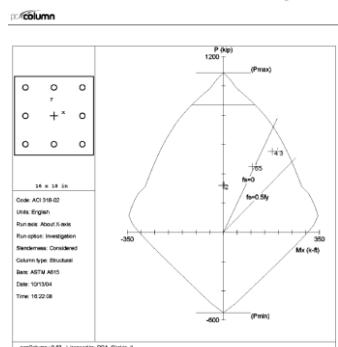
Figure 5-17 12 × 12 in. Column Design Chart

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*
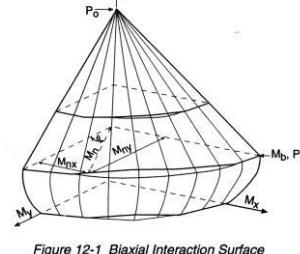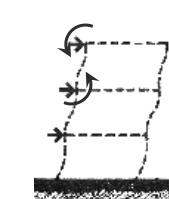
Figure 12-1 Biaxial Interaction Surface