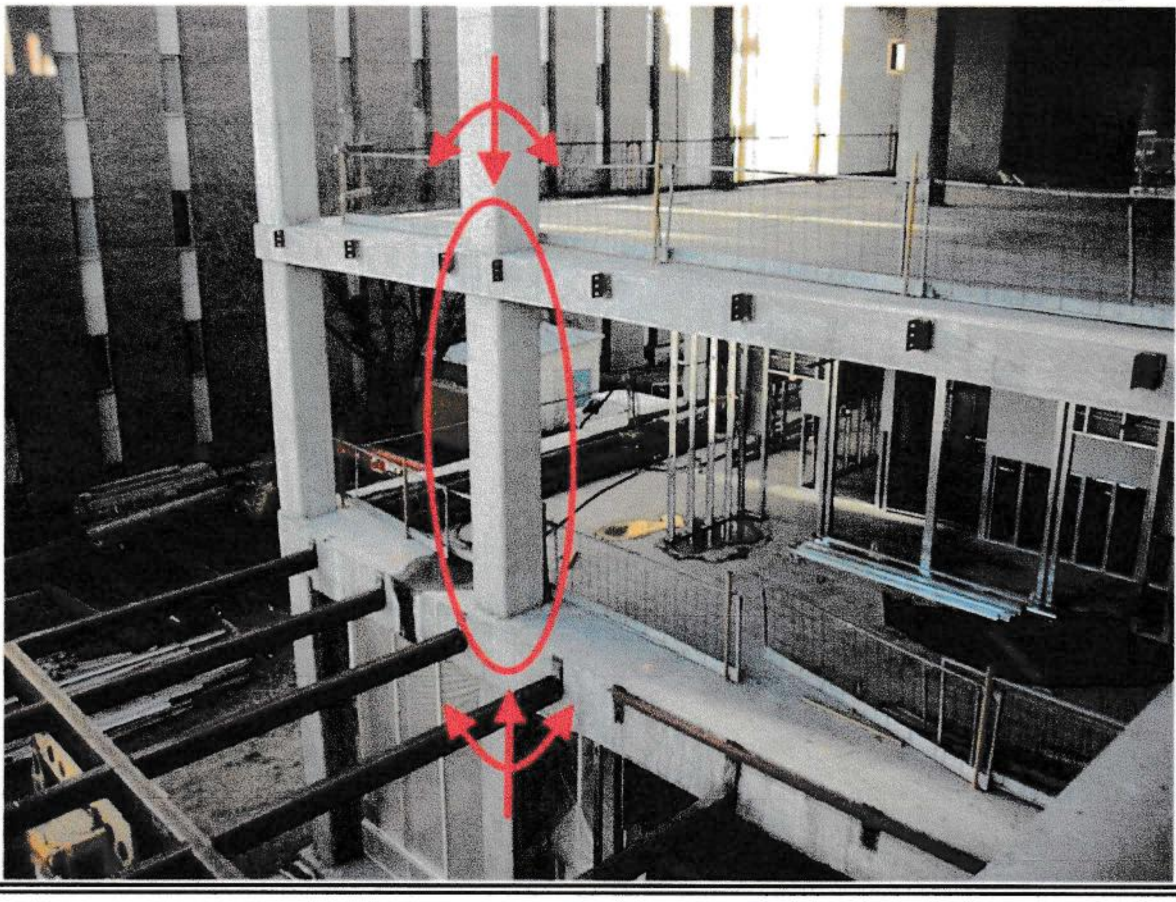
CivE 414
Structural Concrete Design

Topic 6
COLUMNS
Axial Compression and Bending



CONCRETE COLUMNS

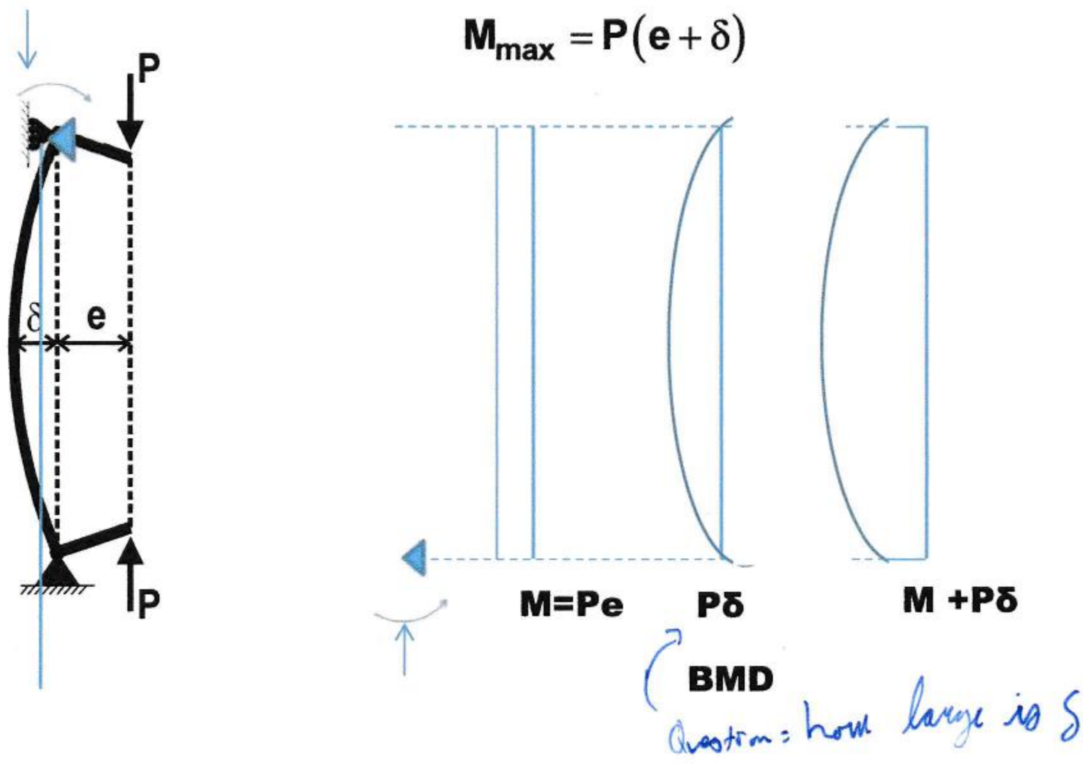
- Primarily compression members
- In general, must design for combined axial load and bending
- Usually vertical, but may be inclined or horizontal in trusses and frames

Because columns are subjected primarily to compression loading, stability effects must be considered. This is done as follows:

- If these effects have little or no impact on the column capacity, we have what we call a "short" column. In this case, stability effects can be safely ignored.
- If stability effects significantly reduce the column capacity, we have a "slender" column. In this case, stability effects must be considered explicitly in the design.

- **Short columns:** no second order effects or buckling
- **Slender columns**: influenced by second order effects (buckling may occur)

$$\mathbf{M_{max}} = \mathbf{P}(\mathbf{e}+\delta)$$

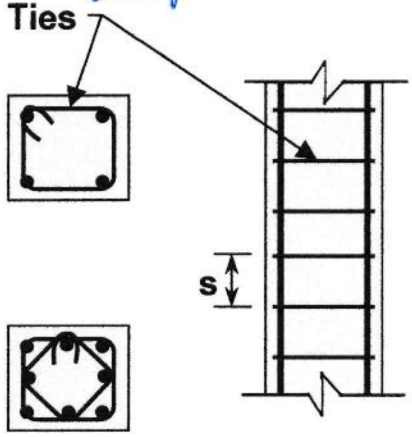


Types of Columns

1. Tied Columns

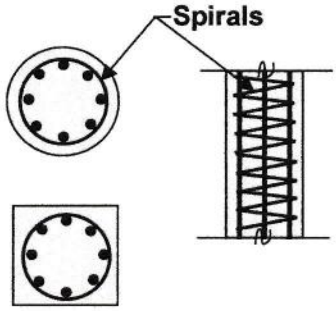
- Ties are used mainly to prevent **buckling** of the longitudinal bars and consequently, to prevent the concrete cover from spalling off.
- For a large number of bars, other tie arrangements may be required.

= always a closed loop, unlike U-bars



2. Spiral Columns

- Spirals are helical ties (continuous) which contain the concrete and prevent local buckling.
- Spirals may be used in square columns.

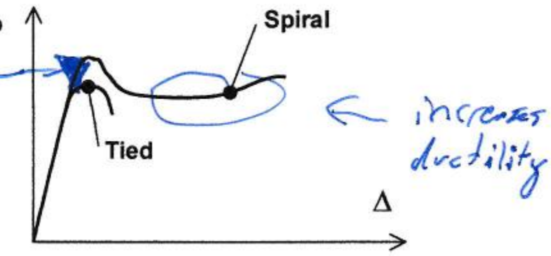


- Ductility and ultimate strength are increased with the use of spirals.

! good for seismic

confinement increases compressive strength

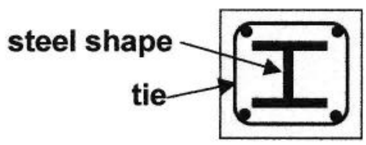
Load vs Deflection for Tied & Spiral Columns



← increases ductility

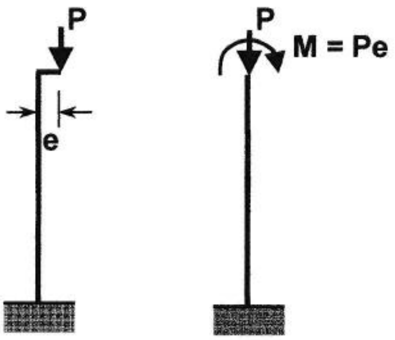
3. Composite Columns

Combination of structural steel shape and reinforced concrete



COLUMNS IN BENDING

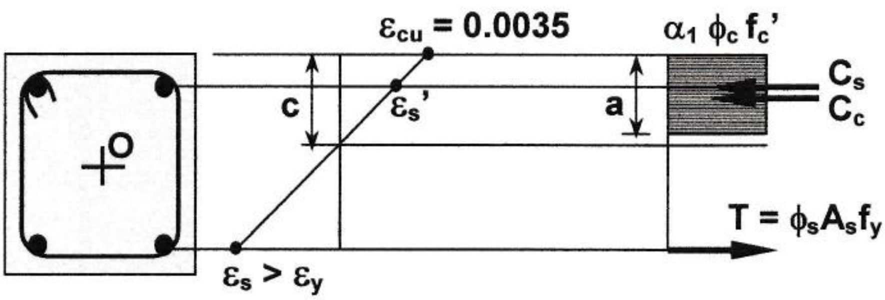
- Very rare for a column to be subjected to pure axial load
- Both vertical loads and lateral loads produce moments in frame columns



For $e = 0$ → pure axial load ($M = 0$)
$e = \infty$ → pure bending ($P = 0$)

PURE BENDING

$M > 0$, $P = 0$ → $e = \infty$



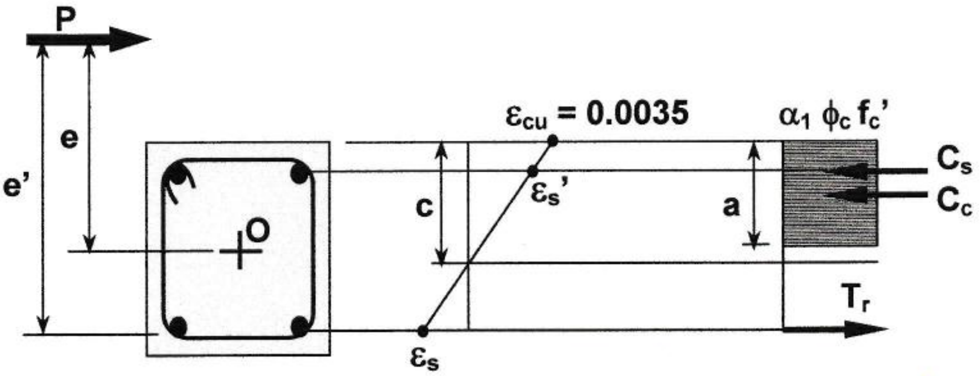
Summation of forces: $$C_c + C_s - T = 0$$

Summation of moments: $$M_r = C_c(d - a/2) + C_s(d - d')$$

(no axial load, any point can be used for summation of moments)

Moment and Axial Load

M > 0, P > 0 → 0 < e < ∞



1. Summation of forces: $\mathbf{P = C_c + C_s - T}$ Axial load

2 Summation of moments:

a) about O *(centroid)*: ← preferred as this corresponds to structural analysis results

M $$\mathbf{Pe = C_c(h/2 - a/2) + C_s(h/2 - d') + T_r(d - h/2)}$$

or

b) about T_r: location of tensile reinforcement $$\mathbf{Pe' = C_c(d - a/2) + C_s(d - d')}$$

where $\mathbf{e' = e + (d - h/2)}$

Two unknowns: **P and a** (for a given e)
e and a (for a given P)

(a is related to strain in tension reinforcement)

Two equations: $\mathbf{\Sigma F = 0}$

$\mathbf{\Sigma M = 0}$

➢ **of P_r & M_r**