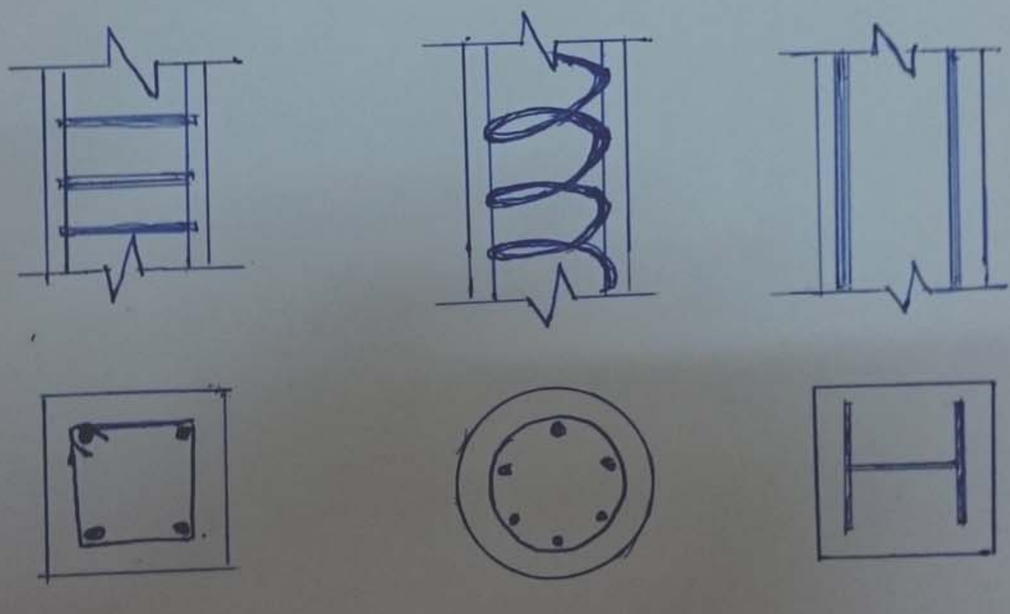
- Types of reinforced concrete columns ;

1. Tied columns are reinforced with longitudinal bars enclosed by lateral ties provided throughout the column length.

2. Spiral columns are reinforced with longitudinal bars enclosed by closely spaced and continuously wound spiral reinforcement.

3. Composite columns are reinforced longitudinally with a structural steel shap, either encased in or encasing the concrete, and with or without longitudinal bars.



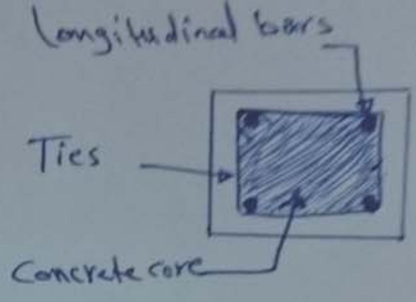
Tied columns — Spiral columns — Composite Columns

- Main components of a' R.C. Column

(1) longitudinal reinforcement.

(2) transverse reinforcement (ties or spirals)

(3) Concrete core.



- Longitudinal reinforcement with adequate transverse reinforcement contributes to the load-carrying capacity of a column in the following two ways;

a- by increasing the column compression capacity.

b- by providing flexural capacity.

- Transverse reinforcement (ties or spirals) functioned as;

a- Provide lateral restraint for longitudinal bars under compression and prevent their buckling.

b- to increase compressive strength and prevent the sudden bursting of the concrete core.

c- to hold the longitudinal reinforcement in place during construction.

d- to resist shear and/or torsion when reinforcing for these effects is required.

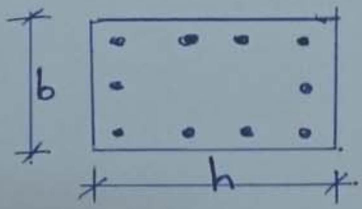
Design of Short Columns

- The ACI code 318 specify that the ultimate load on a column must be;

$$P_{u,max} = 0.8\phi\left[0.85 f'_c (A_g - A_{st}) + f_y \cdot A_{st}\right]$$

---- for tied columns

A_g = Gross area ($b * h$)
A_{st} = Area of steel reinf.
$\phi = 0.7$ (tie)



- Estimating the column size;

The initial stage in column design involves estimating the required size of the column. The column size is governed by the maximum axial-load capacity, the approximate relationship is used for estimating the column size as follows,

$$A_{g(trial)} \geq \frac{P_u}{0.4(f'_c + f_y \cdot \rho_g)}$$

ρ_g = Gross steel ratio.

Example : Design a tied short column to support $P_u = 900$ kN , $f'_c = 25$ MPa , $f_y = 420$ MPa ?

Solution :

① Selection material properties if it's not specified

② Trial size

$$A_{g\,(trial)} \geq \frac{P_u}{0.4\,(f'_c + f_y \cdot \rho_g)}$$

$$\therefore A_g \geq \frac{900 * 10^3}{0.4\,(25 + 420 * 0.01)}$$; Assume $\rho_{g\,min} = 0.01$

$A_g \geq 77055\ mm^2$; used square cross-section column.

$\Rightarrow b = 278$ mm $= h$

try 300 * 300 mm column

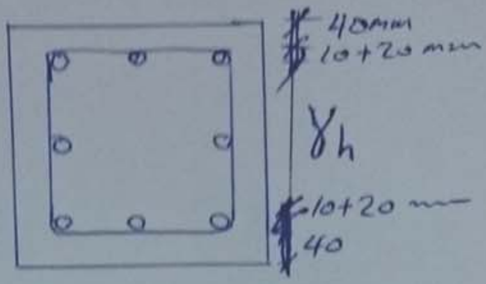
$$e = \frac{M_u}{P_u} = 0$$

$\frac{e}{h} = 0$; but minimum eccentricity $\frac{e}{h} = 0.10$

$\frac{kl}{r} \leq 40$ (short column)

$\frac{kl}{r} \leq 34 - 12\frac{M_1}{M_2}$

$$\gamma = \frac{h - 140}{h}$$



$$= \frac{300 - 140}{300}$$

$$= 0.53 < 0.6$$

Maximum value of $\gamma = 0.6$ in charts, use $\gamma = 0.6$ for this case and increase area of steel.

$$\frac{P_u}{A_g} = \frac{P_u}{b*h} = \frac{900 \times 10^3}{300*300} = 10 \text{ MPa} = 1.45 \text{ ksi}$$

$1 \text{ MPa} = 0.145 \text{ ksi} \Rightarrow$ $f'_c = 25 \text{ MPa} = 3.6 \text{ ksi}$
$f_y = 420 \text{ MPa} = 60 \text{ ksi}$

$$\frac{M_u}{A_g * h} = \frac{M_u}{b*h*h} = 0$$; zero moment

use charts ;

From Fig. A-9a (interaction diagram for $\gamma = 0.6$)

$\rho_g = 0.01$ (Minimum)

$A_{st} = \rho_g \cdot A_g = 0.01 * 300 * 300 = 900 \text{ mm}^2$

If we use $\phi 12 \Rightarrow A_b = 113\ mm^2$

$\therefore$ No. of bars $= \frac{A_{st}}{A_b} = \frac{900}{113} = 7.96$

use $8\phi 12$ bars

$\therefore A_{st} = 8 * 113 = 904\ mm^2 > A_s$ req.

or from fig. A-6a (interaction diagram) $\gamma = 0.6$

$\Rightarrow \rho = 0.01$

$A_{st} = 0.01 * 300 * 300 = 900\ mm^2$

If we use $\phi 16 \Rightarrow A_b = 201\ mm^2$

$\therefore$ No. of bars $= \frac{A_{st}}{A_b} = \frac{900}{201} = 4.47$

use $6\phi 16$ bars

$\Rightarrow A_{st} = 6 * 201 = 1206\ mm^2 > 900\ mm^2$ ok.

- check Maximum Load capacity

$P_n = 0.8\phi\ [0.85 f'_c (A_g - A_{st}) + f_y \cdot A_{st}]$

$= 0.8 * 0.7\ [0.85 * 25 (300 * 300 - 904) + (420 * 904)] * 10^{-3}$

$= 1273\ kN > 900\ kN$ applied

o.k. Safe.

- Select the ties ; from ACI code 318, section 7.10.5.1

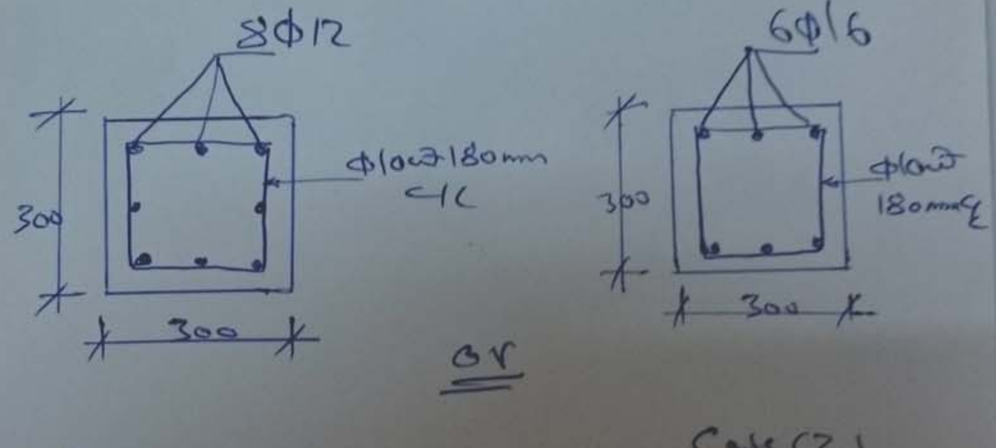
The require spacing of ties is ; smallest one

① 16 * longitudinal bar diameters = 16 * 12 = 192 mm

② 48 * tie diameter = 48 * 10 = 480 mm

③ Least dimension of column = 300 mm

∴ use Φ10 @ 180 mm c/c



or

Case (1)

Case (2)