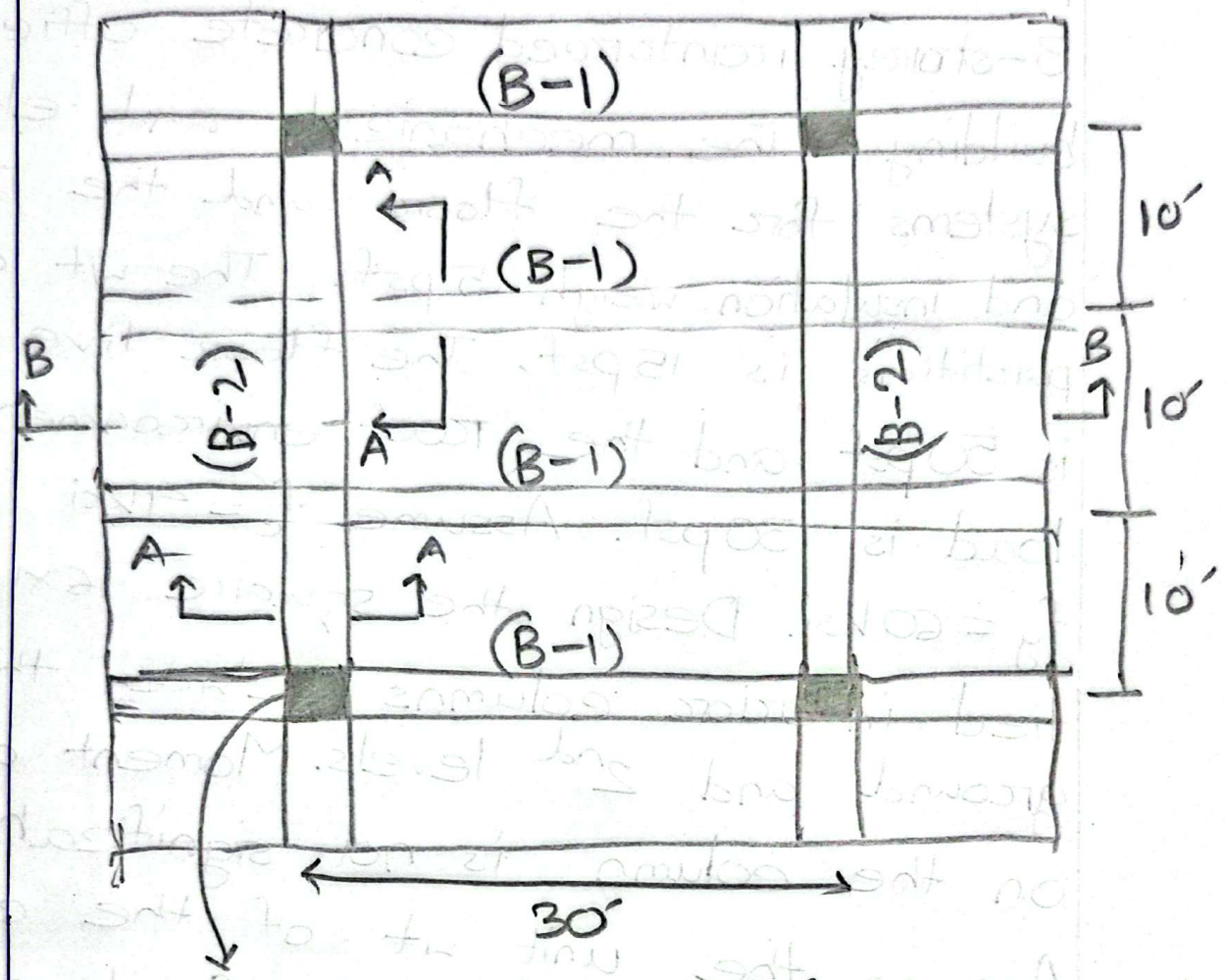
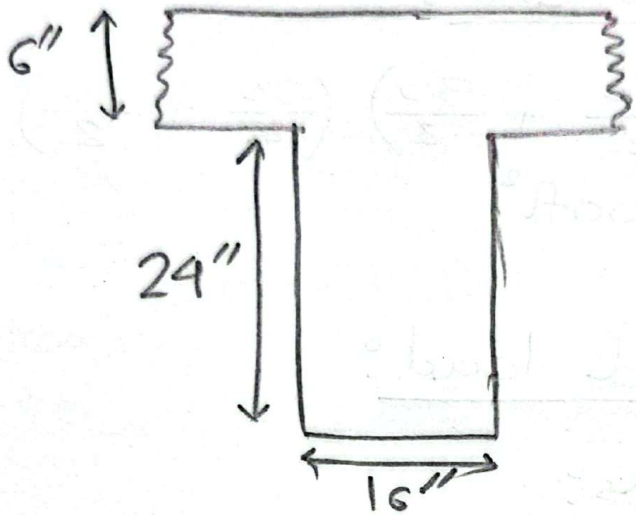
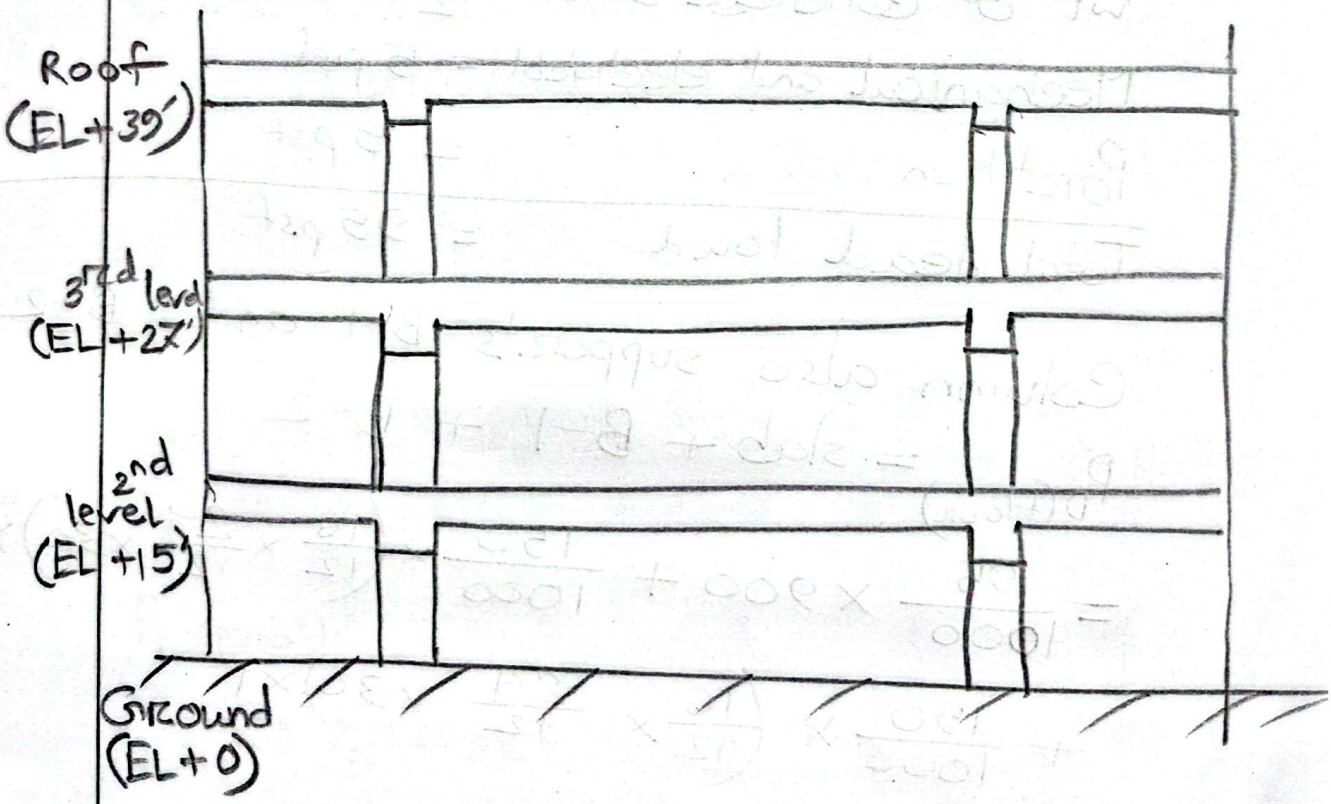
Math: Fig below shows ~~thay~~ the typical partial floor plan and sections of a 3-storey reinforced concrete office building. The mechanical and electrical systems for the floor and the roofing and insulation weigh 5 psf. The wt of the partitions is 15 psf. The floor live load is 50 psf and the roof environmental load is 30 psf. Assume $f'_c = 4$ ksi and $f_y = 60$ ksi. Design the square 16x16 in^2 tied interior columns between the ground and 2nd levels. Moment acting on the column is not significant. Assume the unit wt of the concrete is 150 pcf. Neglect the self wt of the column.



Columns 16 × 16 in²



Section A-A



Soln:

① Tributary area:

$$\text{Area} = \left(\frac{30}{2} + \frac{30}{2}\right)\left(\frac{30}{2} + \frac{30}{2}\right)$$

$$= 900 ft^2$$

② Factored load:

Floor loads:

Dead load,

Wt of concrete slab $= \frac{6}{12} \times 150 = 75$ psf

Mechanical and electrical = 5 psf

Partition = 15 psf

Total dead load = 95 psf

Column also supports B-1 and B-2

$P_{D(floor)}$ = slab + B-1 + B-2

$$= \frac{95}{1000} \times 900 + \frac{150}{1000} \times \left(\frac{16}{12} \times \frac{29}{12} \times 30\right) \times 3$$

$$+ \frac{150}{1000} \times \left(\frac{16}{12} \times \frac{29}{12} \times 30\right) \times 1$$

$= 133.5$ kip.

$$P_{L(floor)} = \frac{50}{1000} \times 900 = 45 \text{ kip}$$

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Roof load:

Wt of concrete slab $= \frac{6}{12} \times 150 = 75$ psf

Roofing and insullation $= 5$ psf

Roof dead load $= 80$ psf

$P_{D(roof)} = \text{slab} + B\text{-}1 + B\text{-}2$

$= \frac{80}{1000} \times 900 + \frac{150}{1000} \times \left(\frac{24}{12} \times \frac{16}{12} \times 30\right) \times 3$

$+ \frac{150}{1000} \times \left(\frac{24}{12} \times \frac{16}{12} \times 30\right) \times 1$

$= 120$ kip.

$P_{L(roof)} = \text{snow load}$

$= \frac{30}{1000} \times 900 = 27$ kip.

Load on GF columns,

$P_D = 2 P_{D(floor)} + P_{D(roof)}$

$= 2 \times 133.5 + 120 = 387$ kip

$P_{L(roof)} = 27$ kip $\quad P_{L(floor)} = 2 \times 45 = 90$ kip

$P_u = 1.2 P_D + 1.6 P_{L(floor)} + 0.5 P_{L(roof)}$

$= 1.2 \times 387 + 1.6 \times 90 + 0.5 \times 27$

$= 621.9$ kip

③ Ast determination:

$$P_R = 0.8 \times 0.65 \left[0.85 f'_c (A_g - A_{st}) + f_y A_{st}\right]$$

$$P_R \geq P_u$$

$$\therefore P_u = 0.8 \times 0.65 \left[0.85 f'_c (A_g - A_{st}) + f_y A_{st}\right]$$

$$\Rightarrow A_{st} = \frac{P_u - 0.8 \times 0.65 \left[0.85 f'_c A_g\right]}{0.8 \times 0.65 \left[f_y - 0.85 f'_c\right]}$$

$$= \frac{621.9 - 0.8 \times 0.65 \left[0.85 \times 4 \times 16 \times 16\right]}{0.8 \times 0.65 \left[60 - 0.85 \times 4\right]}$$

$$= 5.75 \text{ in}^2 \quad \therefore 8\ \#8$$

④ ρ_g check:

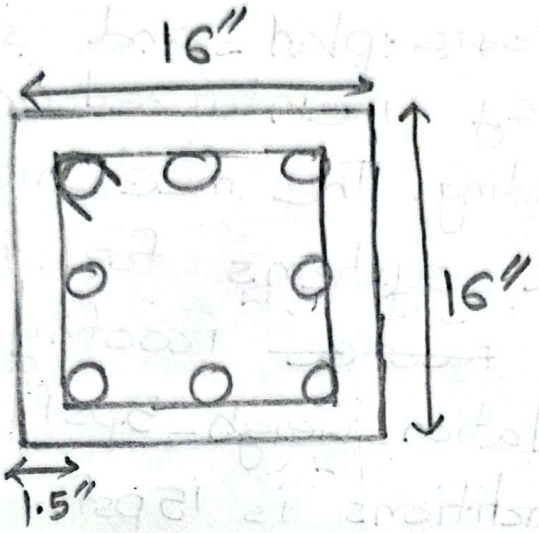
$$\rho_g = \frac{A_{st}}{A_g} = \frac{6.32}{16 \times 16} = 0.0247 = 2.47\%$$

$1\% < 2.47\% < 8\%$

$\therefore$ Ok.

⑤ Design ties: #8 $\therefore$ Tie #3

$$S_{max} = \min\{16 d_b, 48 d_t, b_{min}\}$$
$$= \min\{16 \times 1, 48 \times \tfrac{3}{8}, 16\}$$
$$= \min\{16'', 18'', 16''\}$$
$$= 16''$$



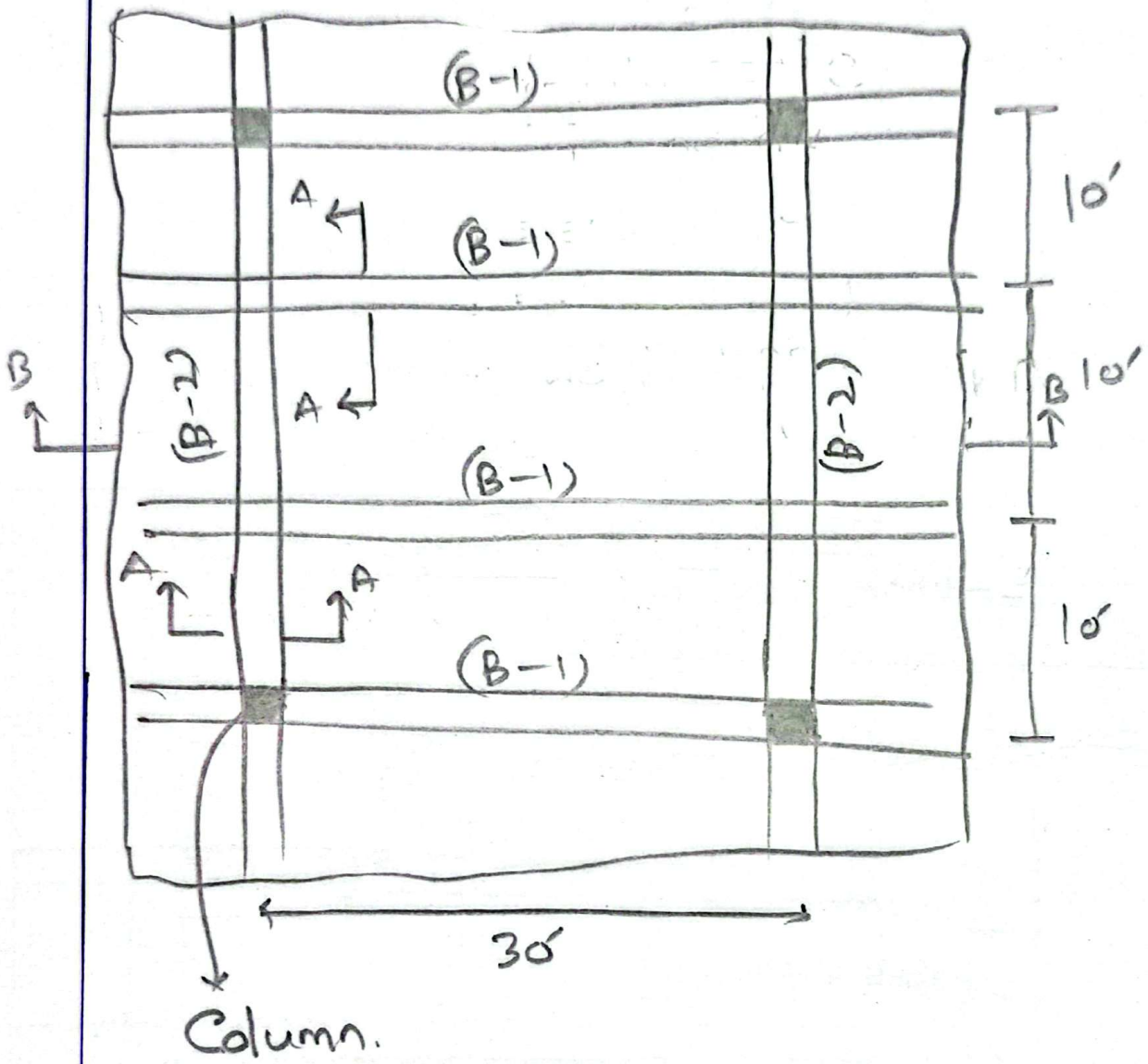
⑥ Clear space:

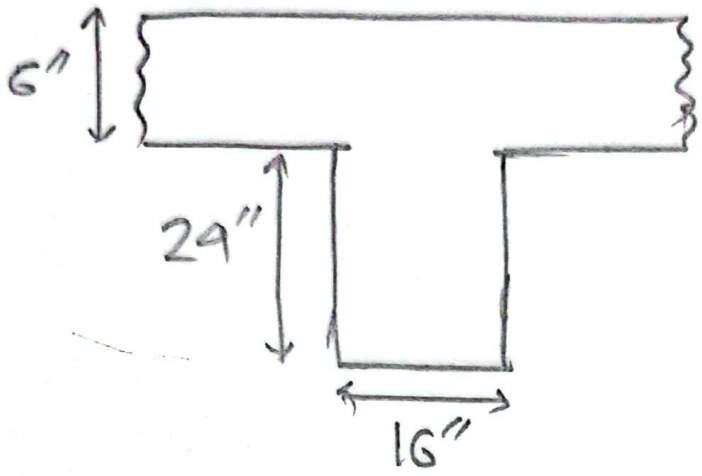
$$\text{Clear space} = \frac{16 - 2\times1.5 - 2\times\frac{3}{8} - 3\times1}{2}$$

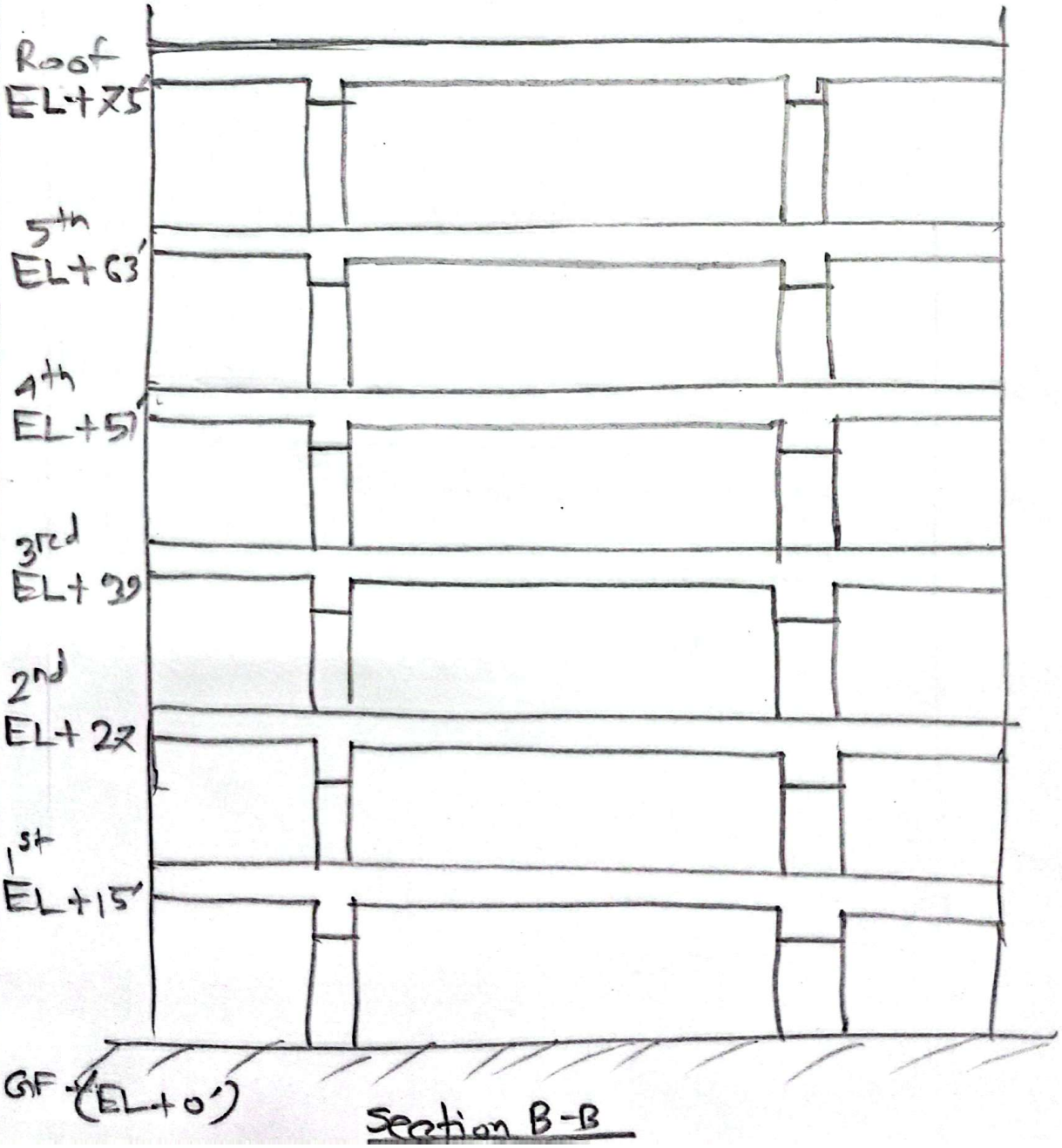
$$= 4.6'' < 6'' \quad \therefore \text{Ok}$$

Math: Fig below shows ~~that~~ the typical partial floor plan and sections of a 5-storey reinforced concrete office building. The mechanical and electrical systems for the floor and the ~~roofiee~~ roofing and ~~insult~~ insulation weigh 5psf. The wt of the partitions is 15psf. The floor live load is 50psf and the roof environmental load is 30psf. Assume $f'_c = 4$ksi and $f_y = 60$ksi. Design the tied interior columns ~~between the~~ for the GF and level 1. Assume the unit wt of the concrete is 150 pcf. Neglect the self wt of the concrete. Assume Ag.

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(B-1)
(B-1)
(B-1)
(B-1)
(B-2)
(B-2)
A
A
A
A
B
B
10'
10'
10'
30'
Column.


6"
24"
16"


Roof
EL+75'
5th
EL+63'
4th
EL+51'
3rd
EL+39'
2nd
EL+27'
1st
EL+15'
GF (EL+0')

Section B-B

① Tributary area:

$$\text{Area} = \left(\frac{30}{2} + \frac{30}{2}\right)\left(\frac{30}{2} + \frac{30}{2}\right)$$
$$= 900 ft^2$$

② Factored load:

Floor loads:

Dead load,

Wt of concrete slab $= \frac{6}{12} \times 150 = 75$ psf

Mechanical and electrical = 5 psf

Partition = 15 psf

Floor DL = 95 psf

$$P_{D(floor)} = \frac{95}{1000} \times 900 + \frac{150}{1000}\left(\frac{16}{12} \times \frac{29}{12} \times 30\right) \times 3$$
$$+ \frac{150}{1000} \times \left(\frac{16}{12} \times \frac{29}{12} \times 30\right) \times 1$$

$= 133.5$ kip.

$$P_{L(floor)} = \frac{50}{1000} \times 900 = 95 \text{ kip}$$

Roof loads:

Wt of concrete slab = 75 psf

Roofing and installation = 5 "

Roof dead load = 80 "

$$P_{D(roof)} = \frac{80}{1000} \times 900 + \frac{150}{1000}\left(\frac{29}{12} \times \frac{16}{12} \times 30\right) \times 3$$

$$+ \frac{150}{1000} \times \left(\frac{29}{12} \times \frac{16}{12} \times 30\right) \times 1$$

$$= 120 \text{ kip}$$

$$P_{L(roof)} = \text{snow load} = \frac{30}{1000} \times 900 = 27 \text{ kip}$$

For GF columns:

$$P_D = 5P_{D(floor)} + P_{D(roof)}$$

$$= 5 \times 133.5 + 120 = 787.5 \text{ kip}$$

$$P_{L(floor)} = 5 \times 45 = 225 \text{ kip}$$

$$P_{L(roof)} = 27 \text{ kip}$$

$$P_u = 1.2P_D + 1.6P_{L(floor)} + 0.5P_{L(roof)}$$

$$= 1.2 \times 787.5 + 1.6 \times 225 + 0.5 \times 27$$

$$= 1318.5 \text{ kip}$$

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③ A_{st} & A_g:

Lets 10 #19

$$A_{st} = \frac{P_u - 0.8 \times 0.65 (0.85 f'_c A_g)}{0.8 \times 0.65 (f_y - 0.85 f'_c)}$$

$$\Rightarrow 10 \times 2.25 = \frac{1318.5 - 0.8 \times 0.65 (0.85 \times 4 \times A_g)}{0.8 \times 0.65 (60 - 0.85 \times 4)}$$

$$\Rightarrow A_g = 371.19 \text{ in}^2$$

$\therefore$ 16" × 24" column

④ Check ρ_g:

$$\rho_g = \frac{A_{st}}{A_g} = \frac{10 \times 2.25}{16 \times 24} = 0.05 = 5\%$$

$\therefore 1\% < 5\% < 8\%$ $\therefore$ ok

⑤ Ties: #14 $\therefore$ Tie #4

$$S_{max} = \min \{16 d_b, 48 d_t, b_{min}\}$$

$$= \min \left\{16 \times \frac{14}{8}, 48 \times \frac{9}{8}, 16\right\}$$

$$= \min \{28", 24", 16"\}$$

$$= 16"$$

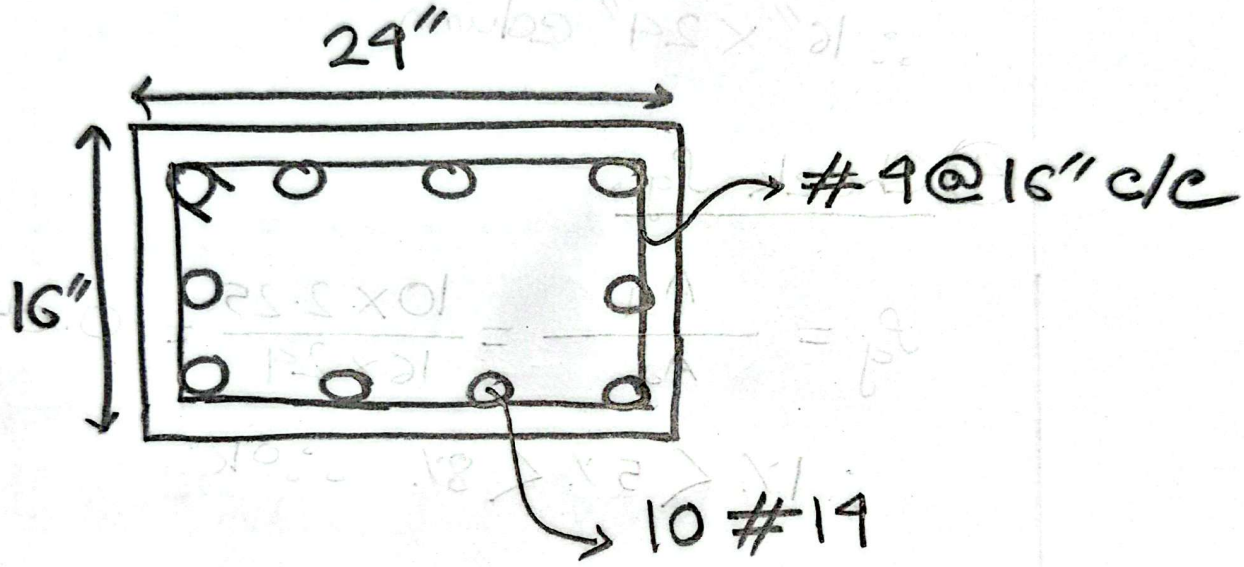
⑥ Clear spacing:

$$\text{Clear spacing}_1 = \frac{29 - 2\times1.5 - 2\times\frac{9}{8} - 4\times\frac{19}{8}}{3}$$

$$= 4.33'' < 6''$$

$$\text{Clear spacing}_2 = \frac{16 - 2\times1.5 - 2\times\frac{9}{8} - 3\times\frac{19}{8}}{2}$$

$$= 3.375'' < 6''$$



For 1st floor column:

~~(2) A_g & A_{st}:~~

$$P_D = 4P_{D(floor)} + P_{D(roof)}$$

$$= 4 \times 133.5 + 120 = 654 \text{ kip}$$

$$P_{L(floor)} = 4 \times 45 = 180 \text{ kip}$$

$$P_{L(roof)} = 27 \text{ kip}$$

$$P_u = 1.2 \times 654 + 1.6 \times 180 + 0.5 \times 27$$

$$= 1086.3 \text{ kip}$$

$$A_g = \frac{1086.3 - 0.8 \times 0.65 (0.85 \times 4 \times 384)}{0.8 \times 0.65 (60 - 0.85 \times 4)}$$

$$= 13.89 \text{ in}^2$$

(3) A_g & A_{st}:

$$A_g = 16 \times 24 = 384 \text{ in}^2$$

$$A_{st} = \frac{P_u - 0.8 \times 0.65 (0.85 f'_c A_g)}{0.8 \times 0.65 (f_y - 0.85 f'_c)}$$

$$= \frac{1086.3 - 0.8 \times 0.65 \times (0.85 \times 4 \times 16 \times 24)}{0.8 \times 0.65 (60 - 0.85 \times 4)}$$

$$= 13.89 \text{ in}^2$$

$\therefore$ 10 #12

④ Check ρ_g:

$$\rho_g = \frac{10 \times 1.56}{16 \times 29} = 0.09 = 9\%$$

$1\% < 4\% < 8\%$ ∴ Ok

⑤ Ties: #12 ∴ Tie #4

$$S_{max} = \min\left\{16 \times \frac{12}{8}, 48 \times \frac{4}{8}, 16\right\}$$

$$= \min\{24'', 24'', 16''\}$$

$$= 16''$$

⑥ Clear spacing:

$$\text{Clear space}_1 = \frac{29 - 2\times1.5 - 2\times\frac{4}{8} - 4\times\frac{12}{8}}{3}$$

$$= 4.67'' < 6''$$

$$\text{Clear space}_2 = \frac{16 - 2\times1.5 - 2\times\frac{4}{8} - 3\times\frac{12}{8}}{2}$$

$$= 3.75'' < 6''$$

