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ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Semester Final Examination — **Summer Semester: 2022–2023**
Course Number: CEE 4611 — **Full Marks: 150**
Course Title: Design of Concrete Structures II — **Time: 3.0 Hours**

There are **6 (six)** questions. Answer **all** of them. The symbols have their usual meanings. Marks of each question and corresponding CO and PO are written in brackets. Assume reasonable value for any missing data.

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1. (a) Name different types of reinforced concrete floor slabs commonly used in Bangladesh with neat sketches. CO1, PO1: [7.5]

(b) For column supported slab, 100 percent of the applied load must be carried in each direction-explain. CO1, PO1: [7.5]

(c) Why is seismic detailing essential for earthquake resistant design of structures? Draw and explain seismic detailing provisions for beam of an intermediate moment resisting frame as per ACI/BNBC code. CO1, PO1: [7.5]

(d) Explain different modes of failure of a high-rise shear wall. CO1, PO1: [7.5]

2. A shear wall of a 16-storey building is subjected to following factored loads: CO2, PO3: [20]

$P_u = 700$ kip
$V_u = 500$ kip
$M_u = 7000$ kip-ft

The wall is 20 ft long, 160 ft high and 12 inches thick. Design the shear wall with $f'_c = 4$ ***ksi*** and $f_y = 60$ ***ksi***.

3. A two-way reinforced concrete building floor system is composed of slab panels measuring 20 ft × 20 ft (c/c) in plan, supported by shallow column line beams cast monolithically with the slab shown in ***Fig. 1***. Using concrete strength of $f'_c = 4$ ***ksi*** and steel with $f_y = 60$ ***ksi***, design a typical interior panel to carry a service live load of 144 psf in addition to the self-weight of the floor. Show reinforcement in neat sketches. CO2, PO3: [25]

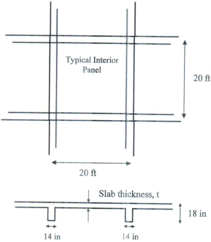


Fig. 1 for Question 3

or

An exterior and interior columns are to be supported by a combined rectangular footing whose outer end cannot protrude beyond the outer face of the exterior column. Column sizes and their respective loads are shown in ***Fig 2***. The bottom of the footing is 6 ft below grade where the net allowable bearing pressure deducting soil load, self-weight of footing and other surcharges is 4000 psf. Determine the size and depth of the footing.

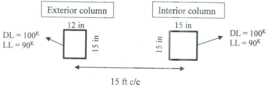


Fig. 2 for Question 3

4. The section of RC cantilever retaining wall supporting granular soil is shown in *Fig. 3*. Assuming that there are adequate factors of safety against overturning, bearing, and sliding, design the thickness and flexural reinforcement for the arm at the bottom. Also, find other reinforcements required in the arm. Show all reinforcement in a sketch. Given: $f'_c = 3$ ***ksi*** and $f_y = 60$ ***ksi***, unit weight of soil = 120 lb/ft^3, $\phi = 30°$, surcharge = 400 psf. (Hint: Calculate the missing dimension using basic proportioning of cantilever retaining wall). CO2, PO3: [25]

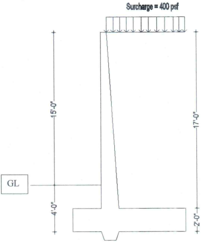


Fig. 3 for Question No. 4

or

18 inch dia cast-in-situ piles shall be provided for a RC column 24 inch × 24 inch in section carrying dead load of 500 kip and live load of 400 kip. The allowable load carrying capacity of each pile is 100 kip. Pile spacing shall be 3 times the pile diameter. Design the pile cap showing all the reinforcements with necessary details. Given, $f'_c = 4$ ***ksi*** and $f_y = 60$ ***ksi.***

5. (a) A flat plate floor has thickness h = 8 inch and is supported by 18 inch × 18 inch columns spaced 20 ft on centers each way. The floor will carry a dead load of 180 psf including its self-weight and a live load of 100 psf. Check the adequacy of the slab in resisting punching shear and provide shear reinforcement, if needed using bent bars. Consider, d = 6.5 inch, $f'_c = 3.5$ *ksi* and steel with $f_y = 60$ *ksi*. CO2, PO3: [7]

(b) Design a square footing for an interior column that carries total working dead load of 600 kip and live load of 400 kip. The column is 25 inch by 25 inch in cross-section. Allowable bearing capacity of soil is 4200 psf. The bottom of the footing is 6 ft below grade. Show the reinforcement in plan and sections with neat sketches. Given: $f'_c = 3.5$ *ksi* and $f_y = 60$ *ksi*. CO2, PO3: [18]

6. (a) A circular column carries working loads $P_{DL} = 900$ kip and $P_{LL} = 500$ kip. Design the spirally reinforced column using reasonable percentage of main reinforcement. Also design the ACI spiral. Given: $f'_c = 3.5$ *ksi* and $f_y = 60$ *ksi*. CO2, PO3: [10]

(b) A ground floor column of a multistoried building is to be designed for the following load combinations: CO2, PO3: [15]

Gravity load combination $P_u = 600$ kip, $M_u = 70$ kip-ft.

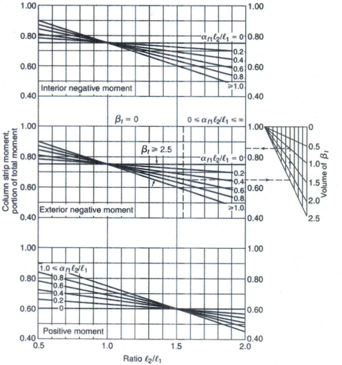
Lateral load combination $P_u = 550$ kip, $M_u = 400$ kip-ft.

Architectural considerations require that a rectangular column with b = 15 in and h = 25 in is to be used. Material strengths are $f'_c = 3$ *ksi* and $f_y = 60$ *ksi*.

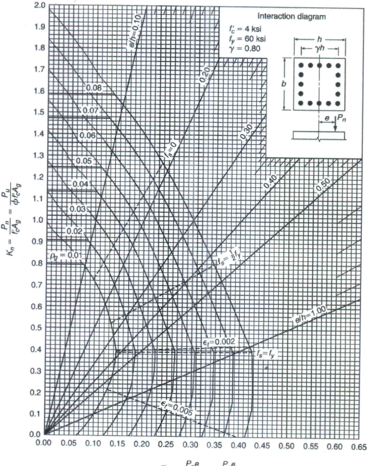
Find the required column reinforcement, tie size and spacing following seismic provisions and show them in neat sketch. Use relevant design chart assuming reinforcement distributed along the perimeter.

Necessary Formulas

1. $V_c = 3.3\lambda\sqrt{f'_c}hd + \frac{N_u d}{4l_w}$
2. $V_c = \left[0.6\lambda\sqrt{f'_c} + \frac{l_w\left(1.25\lambda\sqrt{f'_c}+\frac{0.2N_u}{l_w h}\right)}{\frac{M_u}{V_u}-\frac{l_w}{2}}\right]hd$
3. $M_n = T\left(\frac{l_w}{2}\right) + N_u(\frac{l_w - c}{2})$
4. $c = \left(\frac{\alpha+\omega}{0.85\beta_1+2\omega}\right) l_w \; where, \alpha = \frac{N_u}{hl_w f_c'}, \omega = \frac{\rho_l f_y}{f_c'}$
5. $\frac{P_u}{A_g} + \left(\frac{M_u}{I_g} \times \frac{l_w'}{2}\right) > 0.2f_c'$
6. $V_n = A_{cv}(\alpha_c\lambda\sqrt{f_c'} + \rho_t f_y \leq 8A_{cv}\sqrt{f_c'}$
7. $\phi M_n = \phi\left[T\left(d-\frac{a}{2}\right) + N_u\left(\frac{l_w - a}{2}\right)\right]$
8. $M_u = \phi[0.5A_{st}f_y l_w\left(1-\frac{z}{l_w}\right), where \frac{z}{l_w} = \frac{1}{2+\frac{0.85\beta_1 l_w h f_c'}{A_{st}f_y}}$
9. $\frac{A_{vv}}{s_1} \geq \left[0.0025 + 0.5\left(2.5 - \frac{h_w}{l_w}\right)\left(\frac{A_{ch}}{s_2 h} - 0.0025\right)\right]h$
10. $\rho = 0.85f_c'/f_y\left[1 - \sqrt{1 - \frac{4M_u}{1.7\phi f_c' bd^2}}\right]$
11. $M_u = \phi\rho f_y bd^2\left(1 - \frac{0.59\rho f_y}{f_c'}\right)$
12. $\phi V_c = \phi 4\sqrt{f_c'}b_0 d \leq \phi\left(\frac{\alpha_s d}{b_0} + 2\right)\sqrt{f_c'}\, b_0 d \leq \phi\left(2 + \frac{4}{\beta}\right)\sqrt{f_c'}b_0 d$
13. $y = \frac{h}{3}, P = \frac{1}{2}k_{ah}wh^2$
14. $y = \frac{h}{3}, P = \frac{1}{2}K_a wh^2, K_a = cos\phi$
15. $y = \frac{h^2+3hh'}{3(h+2h')},$
16. $P = \frac{1}{2}K_{ah}wh(h+2h')$



Column strip moment, portion of total moment
Interior negative moment
$\alpha_{f1}\ell_2/\ell_1 = 0$
0.2
0.4
0.6
0.8
≥1.0
$\beta_t = 0$
$0 \leq \alpha_{f1}\ell_2/\ell_1 \leq \infty$
$\beta_t \geq 2.5$
Exterior negative moment
Volume of β_t
0.5
1.0
1.5
2.0
2.5
$1.0 \leq \alpha_{f1}\ell_2/\ell_1$
Positive moment
Ratio ℓ_2/ℓ_1



Interaction diagram
f'_c = 4 ksi
f_y = 60 ksi
γ = 0.80
h
γh
b
e
P_n
e/h=0.10
0.20
0.30
0.40
0.50
e/h=1.00
f_s=0
$f_s=\frac{1}{2}f_y$
$f_s=f_y$
ϵ_t=0.002
ϵ_t=0.005
0.08
0.07
0.06
0.05
0.04
0.03
0.02
ρ_g = 0.01
$K_n = \frac{P_n}{f'_c A_g} = \frac{P_u}{\phi f'_c A_g}$
$R_n = \frac{P_n e}{f'_c A_g h} = \frac{P_u e}{\phi f'_c A_g h}$
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
0.55
0.60
0.65