L-4/T-1/WRE Date : 03/10/2023

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2021-2022

Sub : **CE 325** (Design of Concrete Structure II)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) A 18 × 28 inch column is reinforced with 10 # 9 bars as shown in Fig. 1. Construct the nominal strength interaction diagram for the column with three points corresponding to pure axial load, pure bending, balanced condition. Also find corresponding φ for the above points. Assume bending about Y-Y axis. Given : $f_c' = 4.0$ ksi and $f_y = 60$ ksi. **(20)**

   (b) Why spiral columns are more ductile than tie columns. **(7)**

   (c) Show seismic detailing of a tied column which is a part of IMRF system according to BNBC. **(8)**

2. (a) Design a column which has to carry unfactored working loads: DL = 600 kip and LL = 450 kip. Also design the transverse reinforcement of the column. Given: $f_c' = 4.0$ ksi and $f_y = 60$ ksi. **(18)**

   (b) Show seismic detailing of a beam which is a part of IMRF system according to BNBC. **(8)**

   (c) Explain the Seismic Design Philosophy with allowed damage levels under different levels of earthquakes. **(9)**

3. (a) Discuss about the different types of loss of prestress concrete members. **(12)**

   (b) A posttensioned simple beam as shown in Fig. 2 has an initial prestress of 140 ksi, reducing to 118 ksi after deducting all losses. The parabolic cable has an area of 2.75 sq in., $n = 6$. The beam carries superimposed live load of 800 lb/ft in addition to its own weight of 375 lb/ft. Compute the extreme fiber stresses at midspan; (i) under the initial condition with full prestress and no live load, (ii) at final condition with live loads and considering losses. (iii) Compute also the live load that can be carried by the beam for zero tensile stress in the bottom fiber. **(23)**

4. (a) A 54″ × 54″ square pier of a bridge is reinforced with sixty No-9 bars arranged uniformly around the perimeter: Material strengths are $f_c' = 4.0$ ksi and $f_y = 60$ ksi. Check adequacy of the short column using Reciprocal Load Method for: **(20)**

   $P_u = 3000$ kip, $M_{ux} = 4050$ kip-ft, $M_{uy} = 2700$ kip-ft

   Use supplied column strength interaction diagram chart assuming $\gamma = 0.9$.

   (b) Calculate the ultimate resisting moment for the prestressed beam section given in question 3(b) (Fig. 2) considering bonded beam and following ACI code. Material properties are: $f_{pu} = 270$ ksi, $f_c' = 7$ ksi. **(15)**

Contd P/2

CE 325/WRE

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

Assume reasonable values for any missing data.

5. A commercial building is to be designed using a flat plate floor system. The interior columns are 24″ × 24″ and they are spaced 25 ft c/c in both direction. Specified live load 100 psf and superimposed dead load 150 psf including self weight of slab. Material strengths are $f_c' = 4000$ psi and $f_y = 60{,}000$ psi.

   (a) Find the slab thickness for adequacy against punching shear failure, when no shear reinforced is used. **(15)**

   (b) Design a typical interior panel of the above building and show the reinforcements with neat sketches. **(20)**

6. (a) Design a square footing for an interior column that carries total working DL = 600 kip and LL = 400 kip. The column is 24″ × 24″ in cross section. Allowable bearing capacity of soil is 4500 psf. The bottom of the footing is 6 ft below the grade. Show the reinforcement in plan and section with neat sketch. Given: $f_c' = 3500$ psi and $f_y = 60{,}000$ psi. **(18)**

   (b) If flat plate floor of the building stated in Q. 5 has thickness h = 7.5″, design the shear reinforcement for the slab. Loads and material strengths are same as in Q. 5. **(17)**

7. (a) Two interior columns for a structure are spaced 14 ft apart and each column carries service DL = 300 kip and LL = 250 kip. Column sizes are 21″ × 21″. They are supported on a rectangular combined footing with a long-side dimension twice that of the short side. The allowable soil bearing pressure is 4000 psf. The bottom of the footing will be 5 ft below grade. Design the footing for these columns and show the reinforcements in plan and section. Material strength for footing: $f_c' = 3500$ psi and $f_y = 60{,}000$ psi. **(20)**

   (b) A 12″ concrete wall supports DL = 16 kip/ft and LL = 10 kip/ft. The allowable bearing capacity of soil is 4000 psf at the bottom level of footing which is 5 ft below grade. Design the footing of the concrete wall with $f_c' = 3000$ psi and $f_y = 40{,}000$ psi. Check development length. **(15)**

8. (a) Name different types of reinforced concrete floor/roof slabs commonly used in Bangladesh with proper sketches. **(12)**

   (b) A three storied reinforced concrete wall is subjected to factored lateral loads as shown in Fig. 3. The wall is 15 ft long and 10″ thick. Design reinforcements for the wall at the first level between the base and the first floor. Given: $f_c' = 4000$ psi and $f_y = 60{,}000$ psi. **(23)**

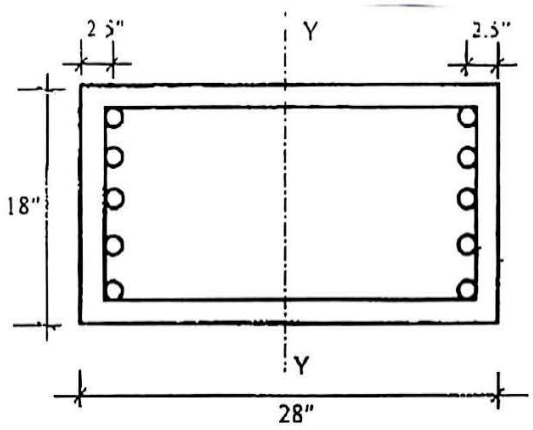


Figure: 1

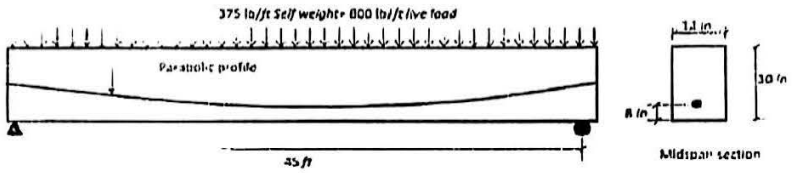
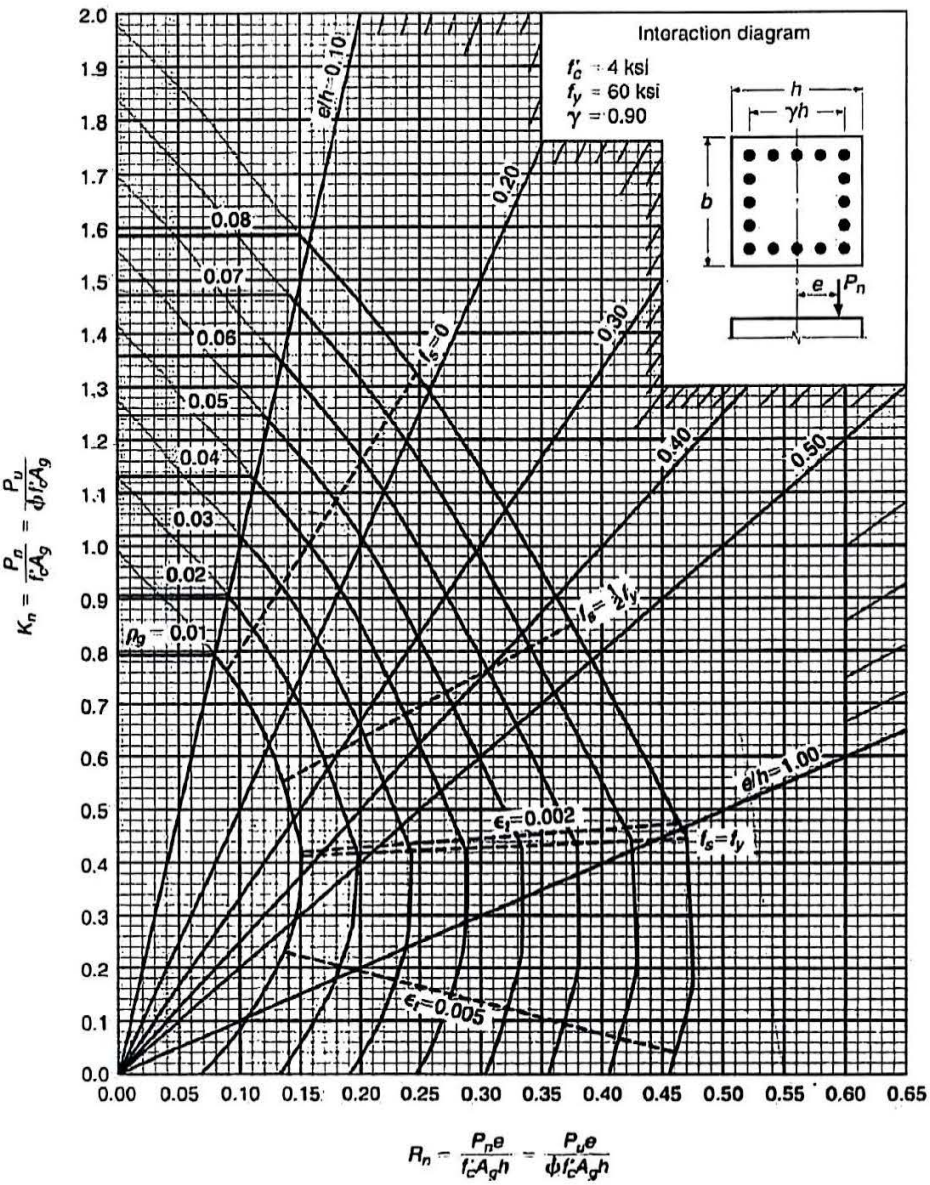


Figure: 2



GRAPH A.8
Column strength interaction diagram for rectangular section with bars on four faces and $\gamma = 0.90$

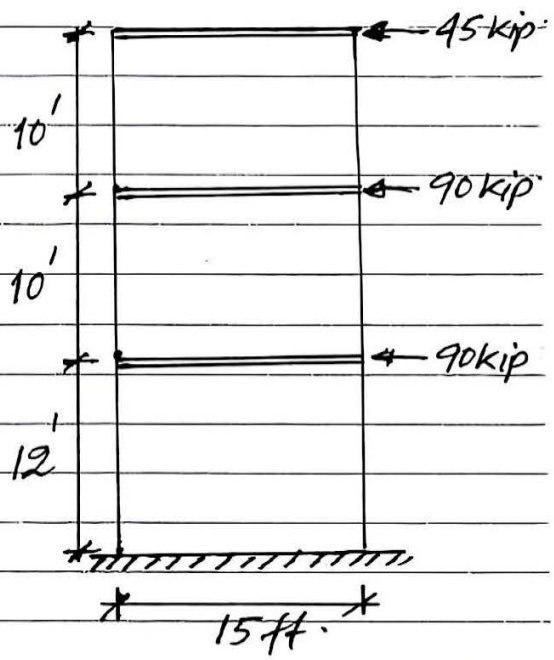
$$A_{vv7} \geq \left[0.0025 + 0.5\left(2.5 - \frac{h_w}{l_w}\right)\left(\frac{A_{sh}}{s_2 \times h} - 0.0025\right)\right] s_1 h$$

$$A_{vv7} \geq 0.0025\, s_1 h$$

$$M_v = \phi\left[0.5\, A_{st}\, f_y\, l_w \left(1 - \frac{z}{l_w}\right)\right]$$

$$\frac{z}{l_w} = \frac{1}{2 + \dfrac{0.85\,\beta_1\, l_w\, h\, f'c}{A_{st}\, f_y}}$$

$$\beta_1 = 0.85$$



~~Fig 3~~

Fig. 3

L-4/T-1/WRE **Date : 16/10/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2020-2021

Sub : **CE 325** (Design of Concrete Structure II)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

Symbols carry their usual meaning. Assume reasonable values for any missing data.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) A circular spirally reinforced column carries unfactored working loads: DL = 800 kip and LL = 500 kip. Design the column with about 2.5% reinforcement. Also design the ACI spiral. Given: $f_c' = 4.0$ ksi and $f_y = 60$ ksi. **(17)**

   (b) Why performance of spiral column is better than tie column? **(8)**

   (c) Show seismic detailing of a tie column which is a part of IMRF system according to BNBC. **(10)**

2. (a) A ground floor column of a 6-storied building is to be designed for the following load combinations (axial force and uniaxial bending)-

   Gravity load combination $P_u = 1200$ kip, $M_u = 200$ kip-ft

   Lateral load combination $P_u = 800$ kip, $M_u = 700$ kip-ft

   Architectural considerations require that a 25in. x 25in. square tied column is to be used. Material strengths are $f_c' = 4.0$ ksi and $f_y = 60$ ksi. Find the required column reinforcement and show in sketch. Use supplied column strength interaction design chart assuming reinforcement distributed along the perimeter and γ=0.8. **(20)**

   (b) Explain the Seismic Design Philosophy with allowed damage levels under different levels of earthquakes. **(8)**

   (c) Show seismic detailing of a RC beam which is a part of IMRF system according to BNBC. **(7)**

3. (a) A 18 x 24 inch column is reinforced with 8 # 9 bars as shown in Fig. 1. Construct the nominal strength interaction diagram for the column with three points corresponding to pure axial load, pure bending, balanced condition. Also find corresponding φ for the above points. Assume bending about Y-Y axis. Given: $f_c' = 4.0$ ksi and $f_y = 60$ ksi. **(18)**

   (b) A flat plate slab without edge beam layout plan of a commercial building is given in Fig. 2. The flat plate has to carry 70 psf dead load and 100 psf live load in addition to its self-weight. Given: $f_c' = 4.0$ ksi and $f_y = 60$ ksi. Determine a uniform thickness for the slab for adequacy against punching shear failure, when no shear reinforcement is used. **(17)**

Contd P/2

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4. (a) Design only the flexural reinforcement of a typical interior panel of the flat plate slab of Q. 3(b). Use Table 1 to determine the slab thickness. Loads and material strength are same as Q. 3. Show the reinforcements detailing with neat sketches. **(25)**

   (b) What are the different options of providing shear reinforcement in a flat plate? Discuss with neat sketches. **(10)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) A three storied reinforced concrete wall is subjected to factored lateral loads as shown in Fig. 3. The wall is 15 ft long and 10" thick. Design reinforcement for the wall at the first level between the base and the first floor. Given: $f_c' = 4000$ psi and $f_y = 60000$ psi. **(19)**

$$A_w \geq [0.0025 + 0.5\left(2.5 - \frac{h_w}{l_w}\right)\left(\frac{A_u h}{S_2 h} - 0.0025\right)]S_1 h$$

$$A_w \geq 0.0025 S_1 h$$

$$M_u = \phi\left[0.5 A_{st} f_y l_u \left(1 - \frac{z}{l_w}\right)\right]$$

$$\frac{z}{l_w} = \frac{1}{2 + \frac{0.85\beta_1 l_w h f_c'}{A_{st} f_y}}; \ \beta_1 = 0.85.$$

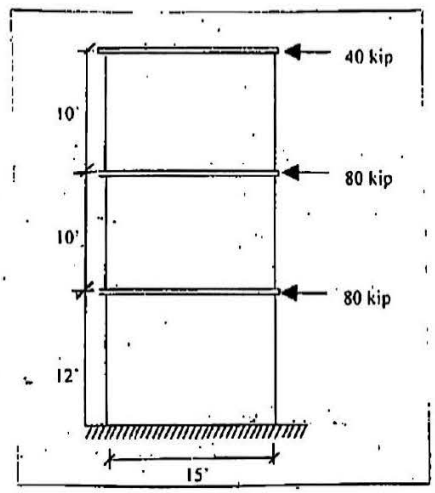

Fig. 3

(b) Design a square footing for an interior column that carries total working DL = 600 kip and LL =400 kip. The column is 25"X25" in cross section. Allowable bearing capacity of soil is 4200 psf. The bottom of the footing is 6 ft below the grade. Show the reinforcement in plan and section with neat sketch. Given: $f_c' = 3000$ psi and $f_y = 60000$ psi. **(16)**

6. (a) Differentiate between: **(12)**

   (i) Stand and cable

   (ii) Pre-tensioning and Post-tensioning

   (iii) Bonded and Unbonded tendons

Contd P/3

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Contd...Q. No. 6

(b) Write down the sources of loss of prestress. **(7)**

(c) A post-tensioned bonded concrete beam as shown in Fig. 4 has a prestress of 355 kip in the steel immediately after prestressing and reduces to 308 kip due to losses. In addition to self-weight of 300 lb/ft, there is a live load of 700 lb/ft. Compute the extreme fiber stresses at midspan, **(16)**

(i) Under the initial condition with full prestress and no live load.

(ii) At final condition with live load and considering losses.

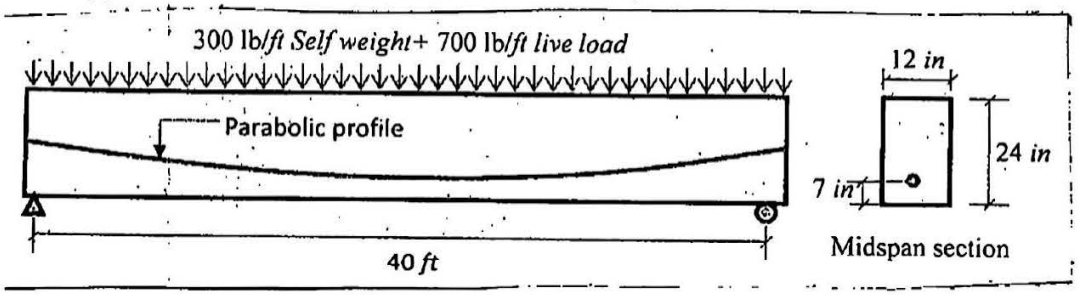


Fig. 4

7. (a) A 15" concrete wall supports a dead load, DL = 16 kip/ft and a live load, LL = 12 kip/ft. The allowable bearing capacity of soil is 4000 psf at the bottom level of footing which is 5ft below grade. Design the footing of the concrete wall with f_c' = 3000 psi and f_y= 40000 psi. Check development length. **(21)**

(b) Select the length and width of the combined footing supporting two columns as shown in Fig. 5. The bottom of the footing is 6 ft below grade where allowable bearing capacity is 5000 psf. The outer end of the combined footing cannot protrude beyond the outer face of exterior column which coincides with property line. **(14)**

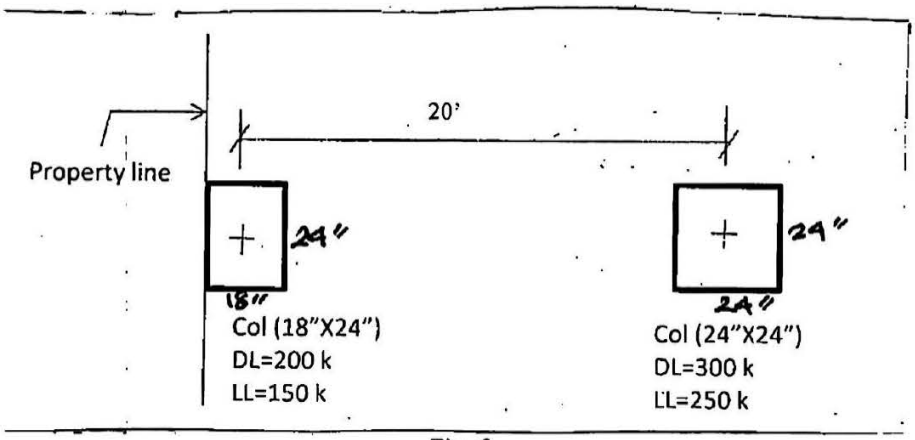


Fig. 5

8. (a) A posttensioned simple beam as shown in Fig. 6 has an initial prestress of 145000 *psi*, reducing to 126000 *psi* after deducting all losses and assuming no bending of the beam. The parabolic cable has an area of 2.8 sq in., n=6. The beam carries superimposed dead load of 800 *plf* in addition to its own weight of 375 *plf*. Compute the stresses in the steel at mispan, assuming: **(18)**

Contd P/4

CE 325(WRE)

Contd...Q. No. 8(a)

(i) the steel is bonded by grouting

(ii) the steel is unbonded and free to slip.

(b) For the beam shown in Fig. 6 compute the total dead and live uniform load hat can be carried by the beam. **(17)**

(i) For zero tensile stress at bottom fiber

(ii) For cracking at the bottom fiber at a modulus of rupture of 600 *psi.*

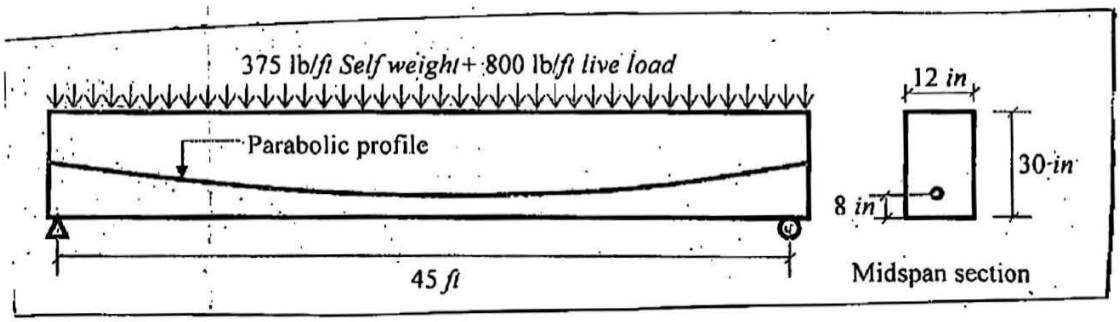


Fig. 6

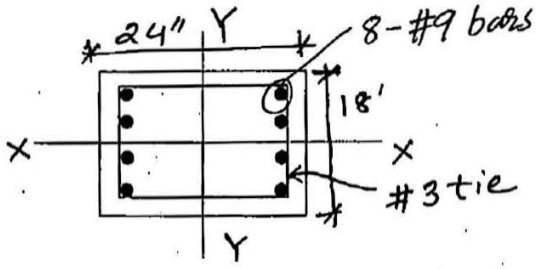


Figure: 1

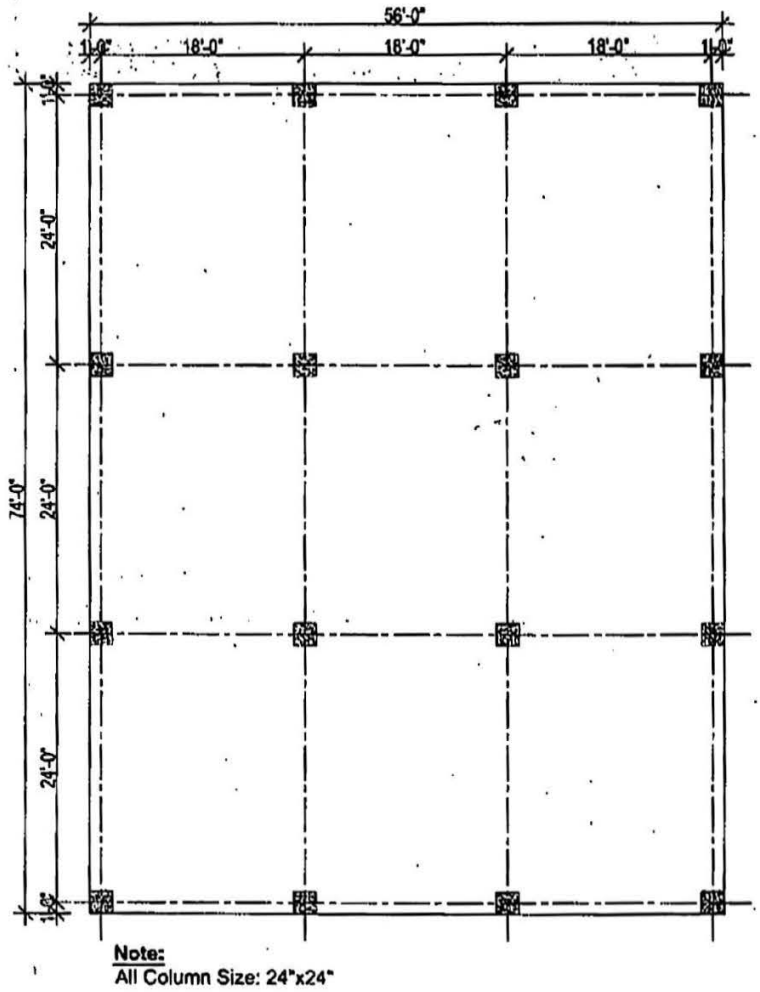


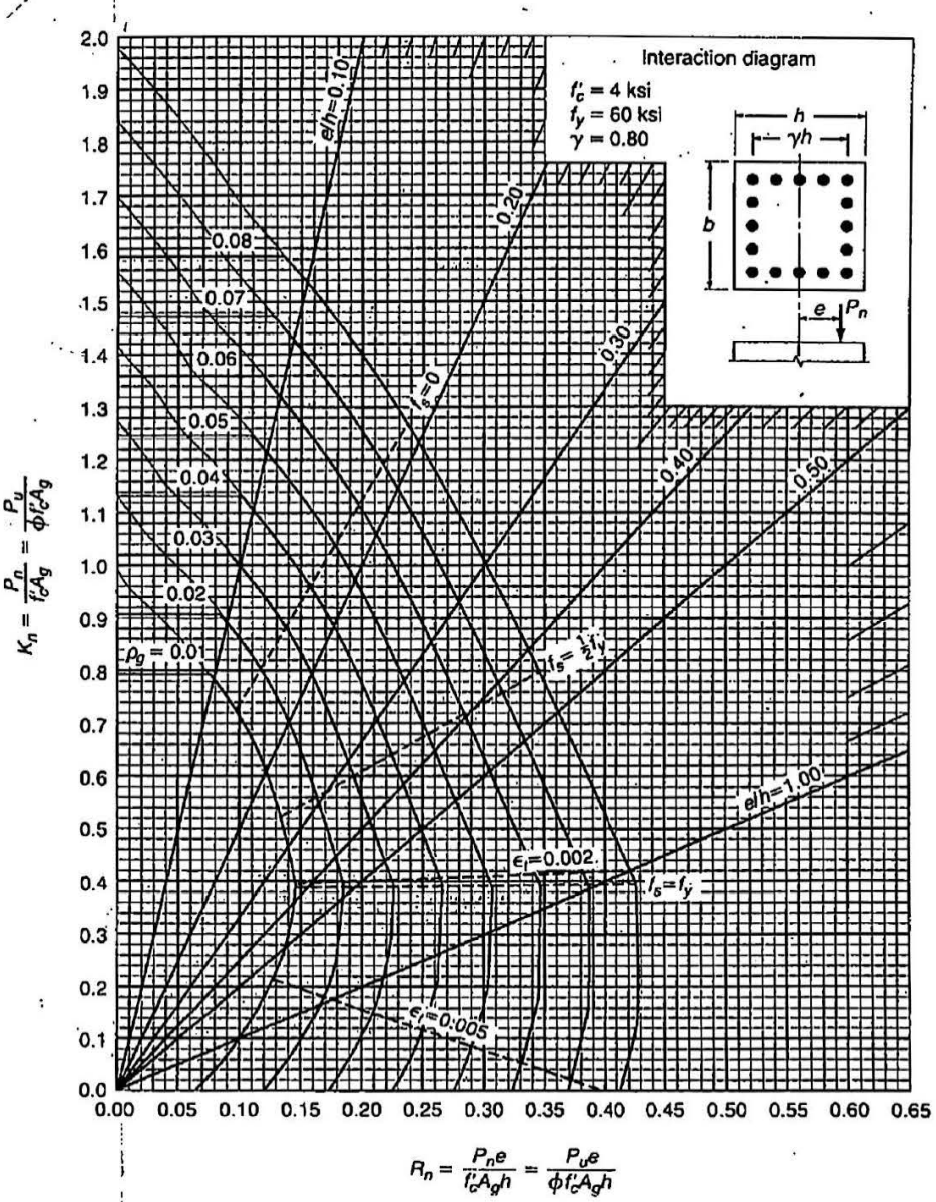
Figure: 2

Table: 1

Minimum thickness of slabs without interior beams

Yield Stress f_y psi	Without Drop Panels			With Drop Panels		
	Exterior Panels		Interior Panels	Exterior Panels		Interior Panels
	Without Edge Beams	With Edge Beams[a]		Without Edge Beams	With Edge Beams[a]	
40,000	$\ell_n/33$	$\ell_n/36$	$\ell_n/36$	$\ell_n/36$	$\ell_n/40$	$\ell_n/40$
60,000	$\ell_n/30$	$\ell_n/33$	$\ell_n/33$	$\ell_n/33$	$\ell_n/36$	$\ell_n/36$
75,000	$\ell_n/28$	$\ell_n/31$	$\ell_n/31$	$\ell_n/31$	$\ell_n/34$	$\ell_n/34$

[a] Slabs with beams along exterior edges. The value of α_f for the edge beam shall not be less than 0.8.



GRAPH A.7
Column strength interaction diagram for rectangular section with bars on four faces and $\gamma = 0.80$.

L-3/T-2/WRE Date : 06/04/2019

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2017-2018

Sub : **CE 325** (Design of Concrete Structures-II)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Show, with neat sketches, seismic detailing requirements for two-way slabs without beams in moderate seismic region as per ACI code. (6)

(b) How could you ensure ductility in RC members? (5)

(c) A reinforced concrete circular column as shown in Figure 2 (gross diameter = 25 inch) of a building is subjected to following axial loads & moments (unfactored). Determine the necessary main reinforcements for the column. Given: $f_c' = 4$ ksi, $f_y = 60$ ksi & interaction diagram is supplied at the end. (12)

(*unfactored)	Dead load	Live load
Axial force *	200 kip	255 kip
Moment*	165 kip-ft	215 kip-ft

(d) Compute frictional loss of the post-tensioned beam having three tendons (as shown in Figure 1) at location A-A and at anchor end. Given : jacking stress = 200 ksi, μ (friction co-efficient) = 0.15 and k (Wobble co-efficient) = 0.0001. (12)

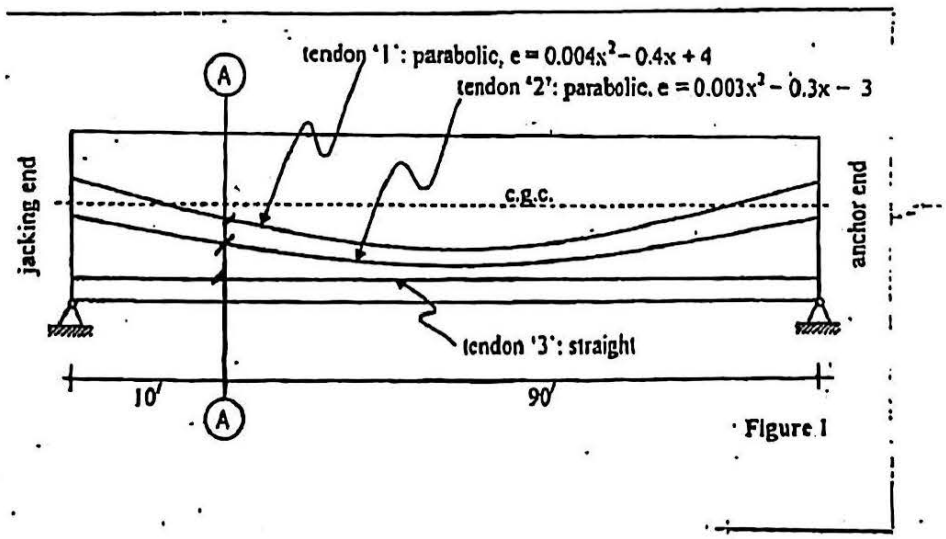


Figure 1

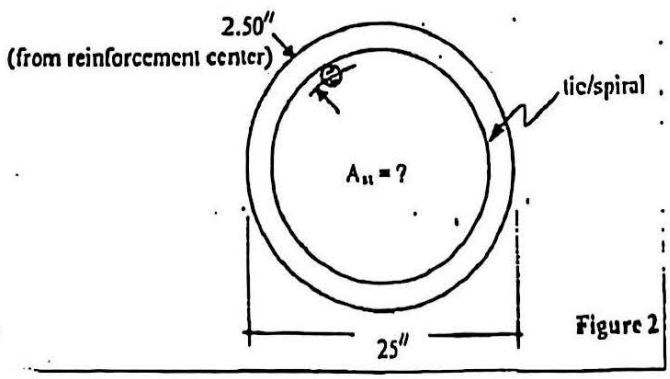


Figure 2

Contd. P/2

CE 325

2. (a) What are stages of loading needs to be considered in designing pc-stressed concrete members? (4)

(b) A reinforced concrete rectangular tied column (16 inch × 20 inch) of a building is reinforced with eight No. 8 and six No. 7 bars as shown in Figure 3. The column is subjected to following axial loads & bi-axial moments (unfactored). Check the adequacy of the column section using Bresler Reciprocal Load method. Given : $f_c' = 4$ ksi, $f_y = 60$ ksi & interaction diagram is supplied at the end. (15)

(*unfactored)	Dead load	Live load
Axial force *	130 kip	155 kip
Moment* about X-X axis	55 kip-ft	60 kip-ft
Moment* about Y-Y axis	85 kip-ft	105 kip-ft

(c) Compute elastic shortening loss of the pre-stressed concrete simple beam at location A-A as shown in Figure-4. (16)

(i) If the beam was a pre-tensioned one.

(ii) If the beam was a post-tensioned one and all tendons are tensioned simultaneously.

(iii) If the beam was a post-tensioned one and two tendons are tensioned at a time.

Given: initial pre-stress = 200 ksi, pre-stressing strand = 12 nos. 0.50 inch nominal diameter (270 grade 7-wire strand), $f_{ci}' = 4500$ psi, $E_{ps} = 28500$ ksi, beam cross-sectional area (A) = 1920 in^2, moment of inertia of beam section (I) = 1450000 inch^4, centroid to top ($\bar{y}_{top}$) = 26 inch & to bottom ($\bar{y}_{bottom}$) = 34 inch and eccentricity of tendon at end (over support) = 0 inch.

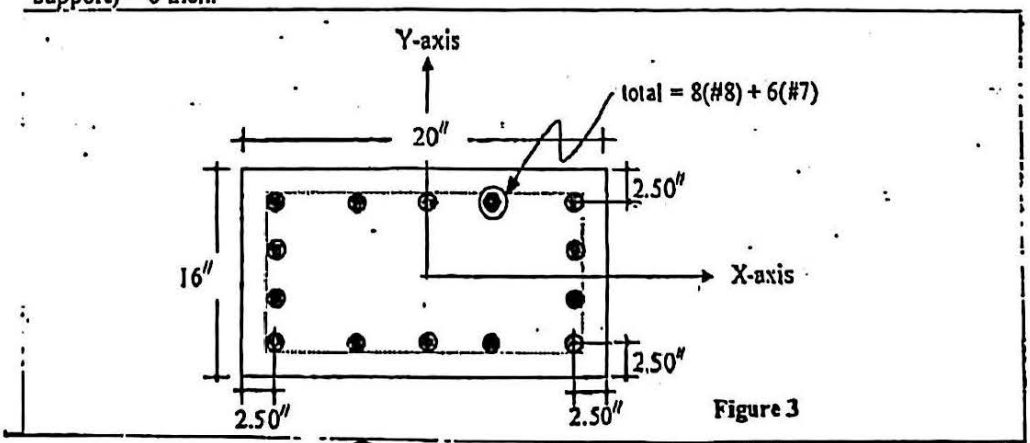


Figure 3

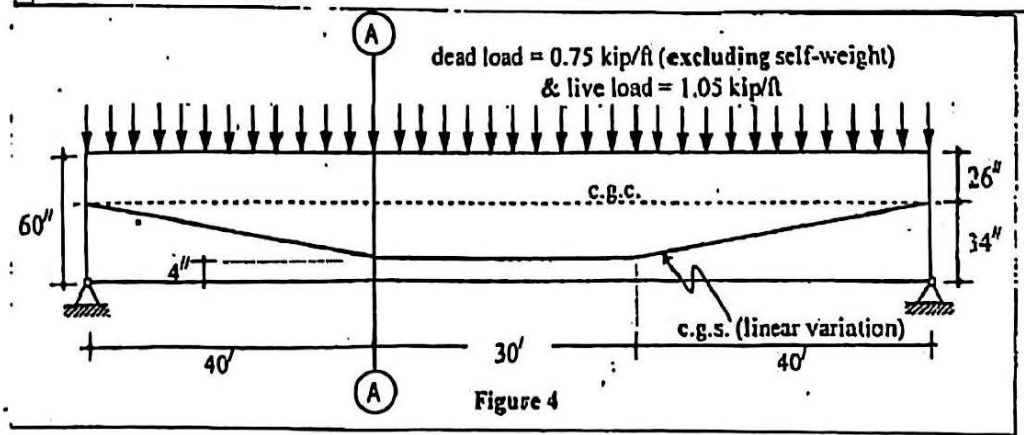


Figure 4

Contd. P/3

CE 325

3. (a) Why 'φ' factor is different in column & in beam? (5)

(b) A 15 × 20 inch column is reinforced with eight No. 9 bars as shown in Figure 5. Construct the nominal strength interaction diagram for the column with five points corresponding to pure axial load, pure bending, balance condition, $\varepsilon_s = 0.001$ (tensile) and $\varepsilon_s = 0.004$ (tensile). Also, find corresponding φ for the above points. Assume bending about major/strong axis. Given: $f_c' = 4$ ksi, $f_y = 60$ ksi and $E_s = 30000$ ksi. (30)

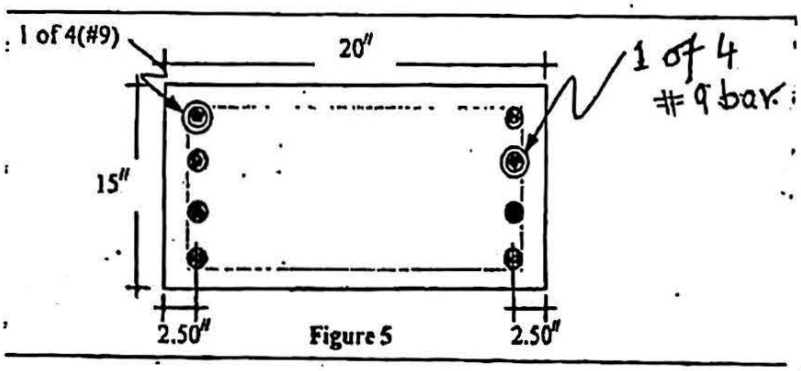


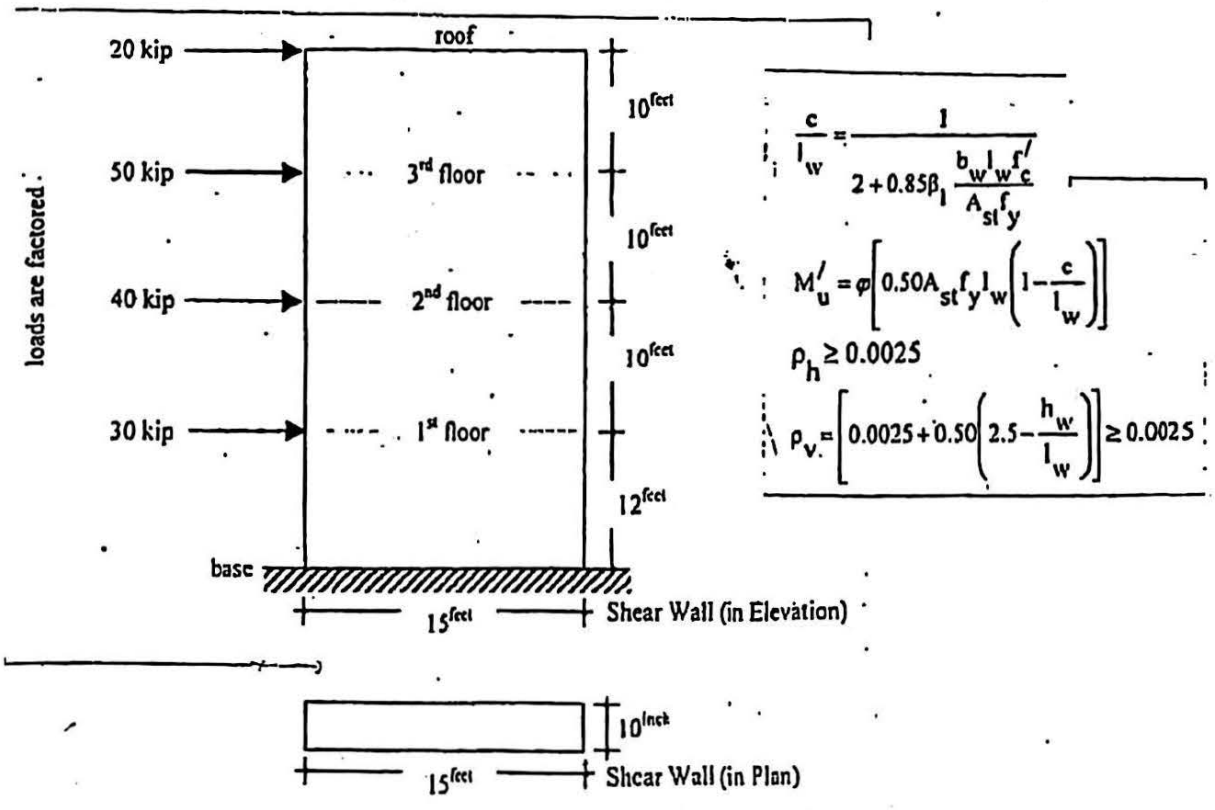
Figure 5

4. (a) A reinforced concrete shear wall (height = 42 feet, length = 15 feet, thickness = 10 inch) of a 4-storeid building are subjected to the factored lateral loads as shown in Figure 6. Design necessary reinforcements for the shear wall between the base and first floor. Show reinforcements both in plan and elevation. Given: $f_c' = 4$ ksi, $f_y = 60$ ksi. You need not to consider self-weight of the wall as it is less than the balanced axial load of the section. (22)

(b) Write down the ACI code provisions on slenderness ratio for slender columns. (6)

(c) Draw neat sketches of "shearhead" and "shear stud" type shear reinforcement as used in flat plate slab. (4)

(d) What are dimensional limits of beams and columns in SMRF? (3)



$$\frac{c}{l_w} = \frac{1}{2 + 0.85\beta_1 \frac{b_w l_w f_c'}{A_{st} f_y}}$$

$$M_u' = \varphi\left[0.50 A_{st} f_y l_w \left(1 - \frac{c}{l_w}\right)\right]$$

$$\rho_h \geq 0.0025$$

$$\rho_v = \left[0.0025 + 0.50\left(2.5 - \frac{h_w}{l_w}\right)\right] \geq 0.0025$$

Figure 6

Contd..... P/4

CE 325

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Design a rectangular footing for an interior column of 12 in. × 18 in. in cross section, reinforced with eight no. 8 bars, that carries working dead load of 500 kip and live load of 350 kip. Allowable bearing capacity and unit weight of the soil is 5000 psf and 100 pcf, respectively. The bottom of the footing is 6 ft below the grade. Show the reinforcement in plan and section with neat sketch. Given: $f_c' = 4000$ psi, and $f_y = 60000$ psi. **(27)**

Done (b) Show seismic detailing requirements of beams in IMRF. **(8)**

6. (a) An exterior and interior column, as shown in Figure 7 with assigned loads, are to be supported by a combined rectangular footing whose outer end cannot protrude beyond the outer facing of the exterior column. The bottom of the footing is 5ft below the grade in a soil having an allowable bearing capacity of 6000 psf. A surcharge of 120 psf is specified on the surface. Design the footing with detailing of reinforcement in section with neat sketch. Given , Given: $f_c' = 4000$ psi and $f_y = 60000$ psi. *(There is no need to design the transverse beam)* **(30)**

(b) Describe the situations when combined footings are used. **(5)**

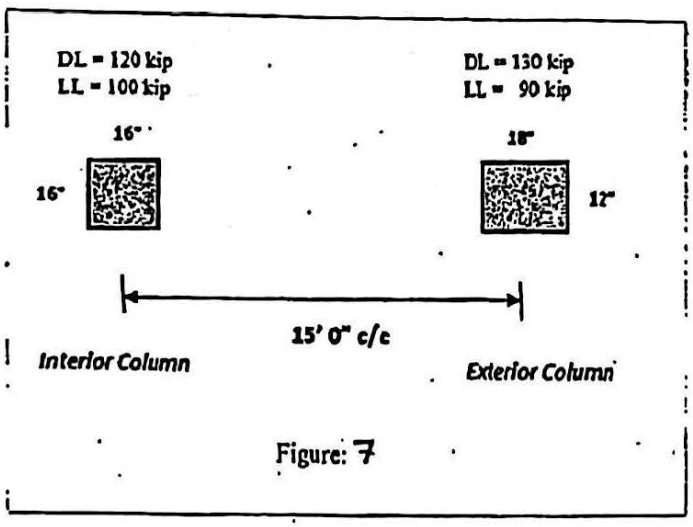


Figure: 7

CE 325

7. (a) The plan of a pile cap with 9 nos 24 in. diameter cast-in-situ piles with the column (25" × 25") is shown in Figure 8. The column carries a working dead load of 650 kip and live load of 500 kip. The individual pile capacity is adequate. Design the pile cap. Given: $f_c' = 4000$ psi and $f_y = 60000$ psi. **(27)**

(b) Describe the modes of failure of a shear wall with neat sketches. **(8)**

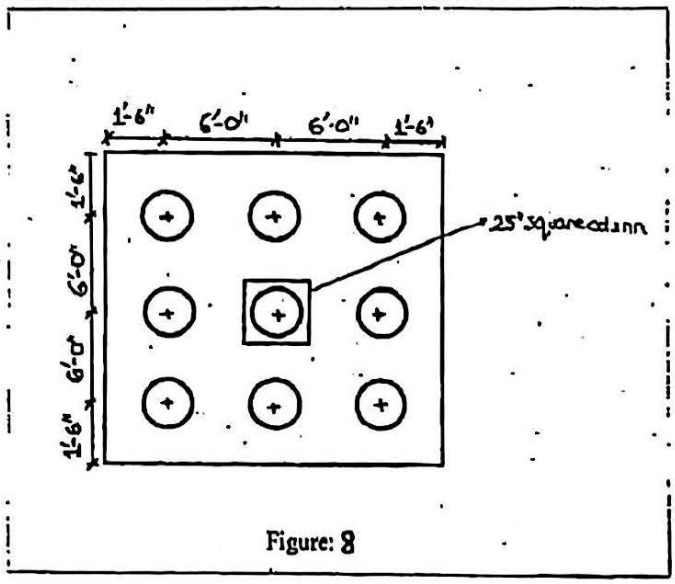


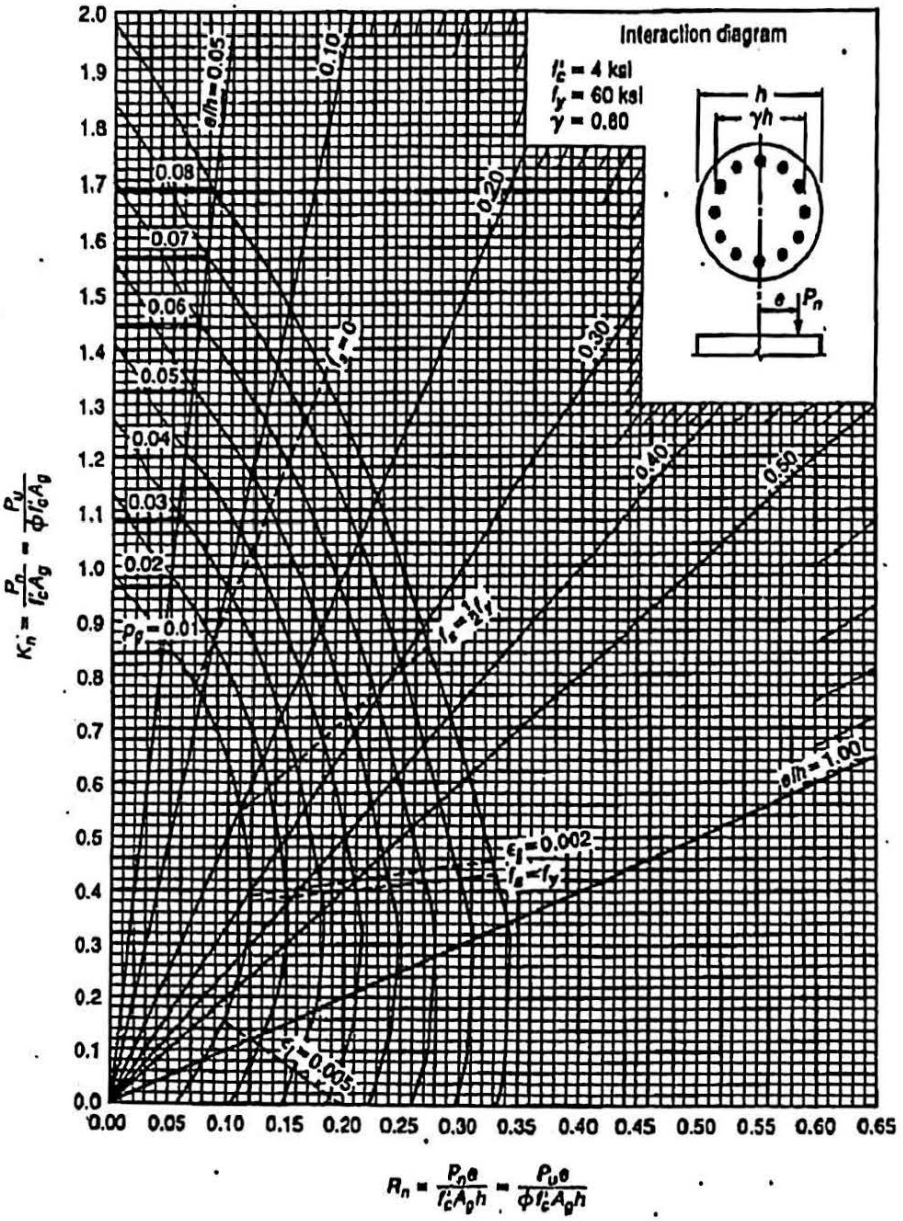
Figure: 8

8. (a) A residential building is to be designed using a flat plate floor system. The interior columns are 24" × 24" and they are spaced 22 ft c/c in one direction and 24 ft c/c in other direction. Design the interior panel (22' × 24') and show reinforcement in long direction only with neat sketch. Assume slab thickness of 8". Specified live load = 40 psf. Floor finish and partition wall load = 60 psf in addition to the self weight of floor. Design the slab panel in the long direction. Given, $f_c = 4000$ psi and $f_y = 60000$ psi. **(30)**

(b) Write down two basic differences between RCC and PCC. **(5)**

Done

Contd. P/6



GRAPH A.15

Column strength interaction diagram for circular section with $\gamma = 0.80$.

Contd..... P/7

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7. (a) The plan of a pile cap with 9 nos 24 in. diameter cast-in-situ piles with the column (25" × 25") is shown in Figure 8. The column carries a working dead load of 650 kip and live load of 500 kip. The individual pile capacity is adequate. Design the pile cap. Given: $f_c' = 4000$ psi and $f_y = 60000$ psi. **(27)**

   (b) Describe the modes of failure of a shear wall with neat sketches. **(8)**

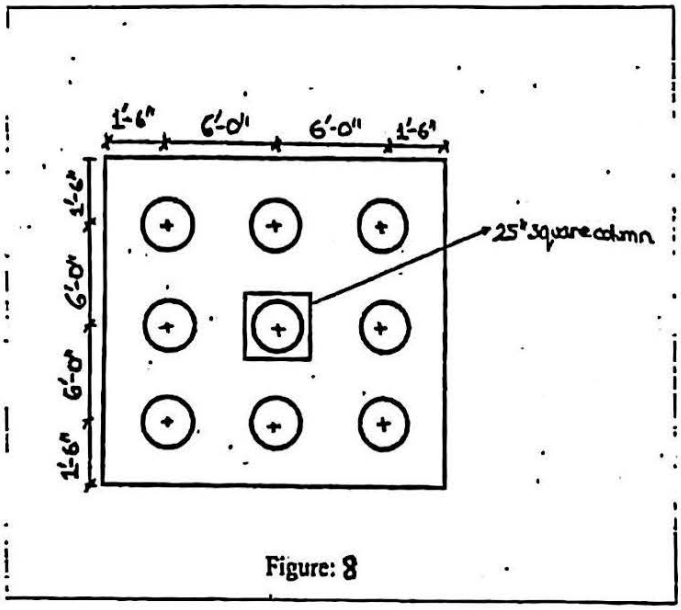
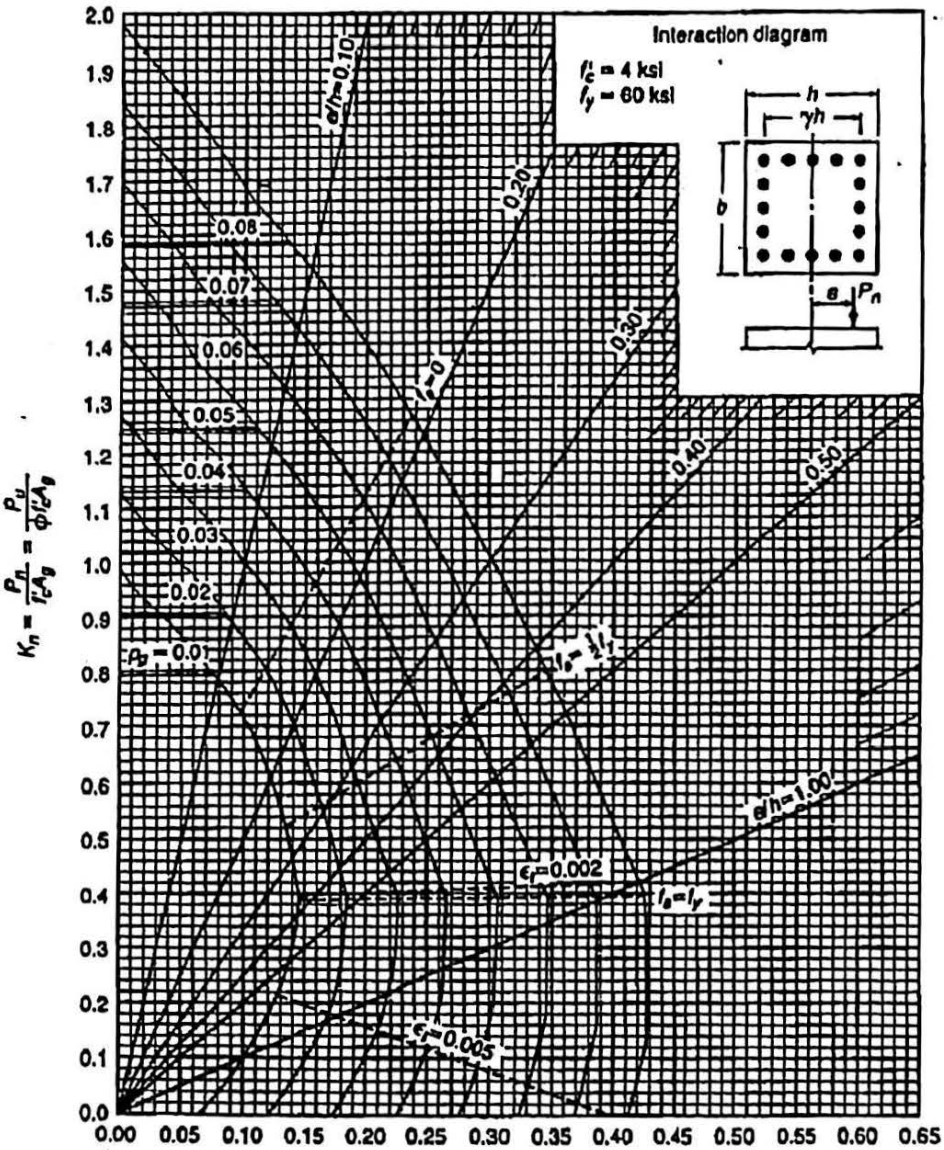


Figure: 8

8. (a) A residential building is to be designed using a flat plate floor system. The interior columns are 24" × 24" and they are spaced 22 ft c/c in one direction and 24 ft c/c in other direction. Design the interior panel (22' × 24') and show reinforcement in long direction only with neat sketch. Assume slab thickness of 8". Specified live load = 40 psf. Floor finish and partition wall load = 60 psf in addition to the self weight of floor. Design the slab panel in the long direction. Given, $f_c = 4000$ psi and $f_y = 60000$ psi. **(30)**

   (b) Write down two basic differences between RCC and PCC. **(5)**



GRAPH A.7
Column strength interaction diagram for rectangular section with bars on four faces

Contd.....P/8

CE325

TABLE : f_y = 60,000 psi; f'_c = 4000 psi—U.S. Customary Units

	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$
ρ_{min} for temp. and shrinkage	0.0018	108.3	0.0059	335.5	0.0100	546.9	0.0141	740.4
	0.0019	112.1	0.0060	340.9	0.0101	551.8	0.0142	744.9
	0.0020	117.1	0.0061	346.2	0.0102	556.7	0.0143	749.4
	0.0021	123.7	0.0062	351.6	0.0103	561.7	0.0144	753.9
	0.0022	129.4	0.0063	356.9	0.0104	566.6	0.0145	758.3
	0.0023	135.2	0.0064	362.2	0.0105	571.5	0.0146	762.8
	0.0024	141.0	0.0065	367.6	0.0106	576.3	0.0147	767.2
	0.0025	146.7	0.0066	372.9	0.0107	581.2	0.0148	771.7
	0.0026	152.4	0.0067	378.2	0.0108	586.1	0.0149	776.1
	0.0027	158.1	0.0068	383.4	0.0109	590.9	0.0150	780.5
	0.0028	163.8	0.0069	388.7	0.0110	595.7	0.0151	784.9
	0.0029	169.5	0.0070	394.0	0.0111	600.6	0.0152	789.3
	0.0030	175.2	0.0071	399.2	0.0112	605.4	0.0153	793.7
	0.0031	180.9	0.0072	404.5	0.0113	610.2	0.0154	798.1
	0.0032	186.6	0.0073	409.7	0.0114	615.0	0.0155	802.4
ρ_{min} for flexure	0.0033	192.2	0.0074	414.9	0.0115	619.8	0.0156	806.8
	0.0034	197.9	0.0075	420.1	0.0116	624.5	0.0157	811.1
	0.0035	203.5	0.0076	425.3	0.0117	629.3	0.0158	815.4
	0.0036	209.1	0.0077	430.5	0.0118	634.1	0.0159	819.7
	0.0037	214.7	0.0078	435.7	0.0119	638.8	0.0160	824.1
	0.0038	220.3	0.0079	440.9	0.0120	643.5	0.0161	828.3
	0.0039	225.9	0.0080	446.0	0.0121	648.2	0.0162	832.6
	0.0040	231.5	0.0081	451.2	0.0122	653.0	0.0163	836.9
	0.0041	237.1	0.0082	456.3	0.0123	657.7	0.0164	841.2
	0.0042	242.6	0.0083	461.4	0.0124	662.3	0.0165	845.4
	0.0043	248.2	0.0084	466.5	0.0125	667.0	0.0166	849.7
	0.0044	253.7	0.0085	471.6	0.0126	671.7	0.0167	853.9
	0.0045	259.2	0.0086	476.7	0.0127	676.3	0.0168	858.1
	0.0046	264.8	0.0087	481.8	0.0128	681.0	0.0169	862.3
	0.0047	270.3	0.0088	486.9	0.0129	685.6	0.0170	866.5
	0.0048	275.8	0.0089	491.9	0.0130	690.3	0.0171	870.7
	0.0049	281.2	0.0090	497.0	0.0131	694.9	0.0172	874.9
	0.0050	286.7	0.0091	502.0	0.0132	699.5	0.0173	879.1
	0.0051	292.2	0.0092	507.1	0.0133	704.1	0.0174	883.2
	0.0052	297.6	0.0093	512.1	0.0134	708.6	0.0175	887.4
	0.0053	303.1	0.0094	517.1	0.0135	713.2	0.0176	891.5
	0.0054	308.5	0.0095	522.1	0.0136	717.8	0.0177	895.6
	0.0055	313.9	0.0096	527.1	0.0137	722.3	0.0178	899.7
	0.0056	319.3	0.0097	532.0	0.0138	726.9	0.0179	903.9
	0.0057	324.7	0.0098	537.0	0.0139	731.4	0.0180	907.9
	0.0058	330.1	0.0099	542.0	0.0140	735.9	0.0181	912.0

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TABLE : $f_y = 60{,}000$ psi; $f'_c = 4000$ psi—U.S. Customary Units

	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$	ρ	$\frac{M_u}{\phi bd^2}$
ρ_{min} for temp. and shrinkage	0.0018	106.3	0.0059	335.5	0.0100	546.9	0.0141	740.4
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	0.0020	117.1	0.0061	346.2	0.0102	556.7	0.0143	749.4
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	0.0027	158.1	0.0068	383.4	0.0109	590.9	0.0150	780.5
	0.0028	163.8	0.0069	388.7	0.0110	595.7	0.0151	784.9
	0.0029	169.5	0.0070	394.0	0.0111	600.6	0.0152	789.3
	0.0030	175.2	0.0071	399.2	0.0112	605.4	0.0153	793.7
	0.0031	180.9	0.0072	404.5	0.0113	610.2	0.0154	798.1
	0.0032	186.6	0.0073	409.7	0.0114	615.0	0.0155	802.4
ρ_{min} for flexure	0.0033	192.2	0.0074	414.9	0.0115	619.8	0.0156	806.8
	0.0034	197.9	0.0075	420.1	0.0116	624.5	0.0157	811.1
	0.0035	203.5	0.0076	425.3	0.0117	629.3	0.0158	815.4
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	0.0039	225.9	0.0080	446.0	0.0121	648.2	0.0162	832.6
	0.0040	231.5	0.0081	451.2	0.0122	653.0	0.0163	836.9
	0.0041	237.1	0.0082	456.3	0.0123	657.7	0.0164	841.2
	0.0042	242.6	0.0083	461.4	0.0124	662.3	0.0165	845.4
	0.0043	248.2	0.0084	466.5	0.0125	667.0	0.0166	849.7
	0.0044	253.7	0.0085	471.6	0.0126	671.7	0.0167	853.9
	0.0045	259.2	0.0086	476.7	0.0127	676.3	0.0168	858.1
	0.0046	264.8	0.0087	481.8	0.0128	681.0	0.0169	862.3
	0.0047	270.3	0.0088	486.9	0.0129	685.6	0.0170	866.5
	0.0048	275.8	0.0089	491.9	0.0130	690.3	0.0171	870.7
	0.0049	281.2	0.0090	497.0	0.0131	694.9	0.0172	874.9
	0.0050	286.7	0.0091	502.0	0.0132	699.5	0.0173	879.1
	0.0051	292.2	0.0092	507.1	0.0133	704.1	0.0174	883.2
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	0.0054	308.5	0.0095	522.1	0.0136	717.8	0.0177	895.6
	0.0055	313.9	0.0096	527.1	0.0137	722.3	0.0178	899.7
	0.0056	319.3	0.0097	532.0	0.0138	726.9	0.0179	903.9
	0.0057	324.7	0.0098	537.0	0.0139	731.4	0.0180	907.9
	0.0058	330.1	0.0099	542.0	0.0140	735.8	0.0181	912.0

L-3/T-2/WRE Date : 18/02/2018

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2016-2017

Sub : CE 325 (Design of Concrete Structures II)

Full Marks: 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

Assume reasonable values for any missing data

1. (a) A flat plate floor has a thickness h = 8" and is supported by 18"×18" columns spaced 20ft on centers each way. The floor will carry a DL = 180 psf including self weight and a live load of 100 psf. Check the adequacy of the slab in resisting punching shear. If inadequate, design the punching sheer reinforcement using bent ber arrangement. Consider, d = 6.5"; fc' = 3500 psi and fy = 60,000 psi. **(18)**

   (b) Why is seismic detailing essential for earthquake resistant design of structure? Draw and explain seismic detailing provisions for beam of an intermediate moment resisting fame as per ACI/BNBC. **(10)**

   (c) As per ACI/BNBC code, slenderness effects can be neglected if slenderness ratio of a column is below certain limits, write these limits for columns of sway and non-sway frame. **(7)**

2. (a) What are the limitations of Direct Design method for analysis of two way slab. **(10)**

   (b) A flat plate floor system without edge beam is supported by 20"×20" square columns spaced at 25'×25' grid. The floor will carry 30 psf floor finish, 80 psf partition wall load and 40 psf live load in addition to its own weight. Design a typical interior panel using Direct Design Method and show reinforcement in detail. Use relevant charts provided. **(25)**

3. (a) Why ties are provided is column? State the requirements of ties according to ACI code. **(16)**

   (b) What is ACI spiral? Explain failure behaviors of ACI spirally reinforced column. **(7)**

   (c) For the column section shown in Fig.1, draw the strength interaction diagram (for bending about X-X axis) with five points corresponding to balanced failure, pure axial load, pure bending, tension failure and compression failure. **(20)**

4. (a) A ground floor column of a multistoried building is to be designed for the following load combinations (axial force and uni axial bending) **(25)**

   Starting load condition : P_u = 700 kip; M_u = 8- kip-ft. Lateral load combination: P_u = 600 kip; M_u = 500 kip-ft. Architectural considerations require that a rectangular column with b = 16 in and h = 25 in is to be used. Material strength are fc' = 4 ksi and f_y = 60 ksi. Find the required column reinforcement and show in a sketch. Use supplied chart and assume that the reinforcement are distributed along the perimeter. Also design ties as per ACI/BNBC code. **(25)**

Contd P/2

CE 325

Contd... Q. No. 4

(b) Why 'ϕ' value is low for columns? (6)

(c) Why factor 'α' is introduced in the column capacity equation? (4)

SECTION-B

There are **FOUR** questions in this section. Answer any **THREE** questions.

5. (a) A 16 inch concrete wall supports a dead load, DL = 14 kip/ft and a live load, LL = 10 kips/ft. The allowable bearing pressure, q_s = 5 kips/ft^2 at the level of the bottom of the footing, which is 4 ft below the grade. Design a footing for this wall using f'_c = 4000 psi and f_y = 60000 psi. Also, check the provisions for development length. (17)

(b) An exterior and interior columns are to be supported by a combined rectangular footing whose outer end cannot produce beyond the outer facing of the exterior column. Column sizes and their respective loads are shown in Fig. 2. The bottom of the footing is 6.0 ft below the grade where net allowable bearing pressure after deducing soil load, self wt. of footing and other surcharges is 4000 psf. Determine size of the footing. If d = 18 inch, check the adequacy against punching. Also, design the transverse beam. (18)

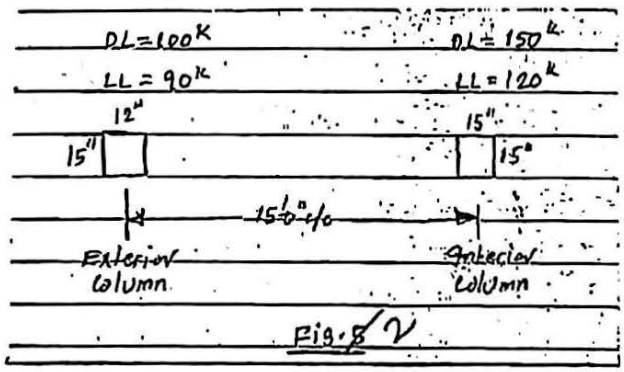


Fig. 2

6. (a) Design a square footing for an interior column that carries total working DL = 600 kip and LL = 400 kip. The column is 25" × 25" in cross section. Allowable bearing capacity of Soil is 4200 psf. The bottom of the footing is 6 ft below the grade. Show the reinforcement in plan and section with neat sketch. Given; f'_c = 3000 psi and f_y = 60000psi. (17)

(b) A three storied reinforced concrete wall is subjected to factored load as shown in Fig.3. The wall is 15 ft long and 10 inch thick. Design reinforcement for the wall at the first level between the base and first floor. Given: f_y = 60 ksi; f'_c = 4.0 ksi. (18)

Contd P/3

CE 325

Contd... Q. No. 6(b)

$$Auu \geq \left[0.0025 + 0.5\left(2.5 - \frac{h_w}{L_w}\right)\left(\frac{A_{uh}}{S_2 h} - 0.0025\right)\right] S_1 h$$

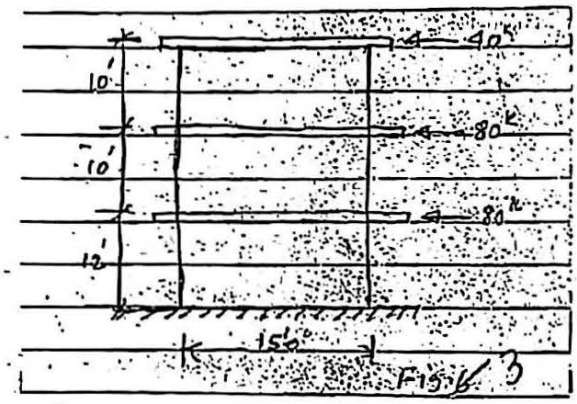
$$Auu \geq 0.0025 S_1 h$$

$$Auh \geq 0.0025 S_2 h$$

$$M_u = \Phi\left[0.5 A_{st} f_y l_w \left(1 - z/L_w\right)\right]$$

$$z/L_w = \frac{1}{2 + 0.85\left(\beta_1 L_w \frac{hf'_c}{A_{st} f_y}\right)}; \beta_1 = 0.85$$

Where symbols have their usual meanings.

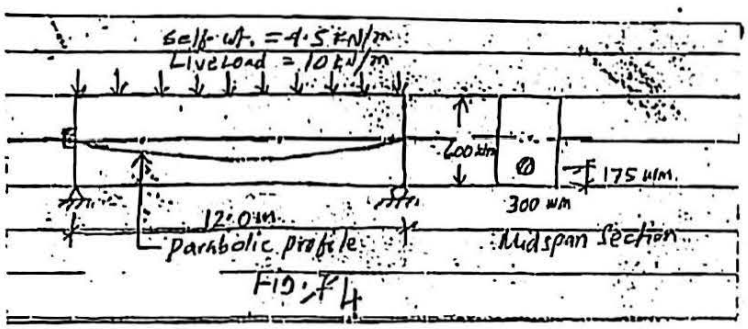


7. (a) Write down the sources of loss of prestress. (10)

(b) A post-tensiones bonded concrete beam as shown in Fig. 4 has a prestress of 1580 KN in the steel immediately after prestressing and reduces to 1370 KN due losses. In addition to self wt. of 4.5 KN/m, there is a live load of 10 KN/m. Compute the extreme fibre stresses at midspan. (25)

(i) Under the initial condition with full prestress and no live load.

(ii) At final condition with live load and considering losses.



Contd P/4

CE 325

8. (a) Write down the advantages and disadvantages of pretressed concerte as compared to reinforced concrete. (10)

(b) Differentiate. (9)

(i) Strand and Wires

(ii) Pre tensioning and post tensioning

(iii) Bonded and unbonded tendons.

(c) Make a preliminary design for section of a prestressed concrete beam to resist a total moment M_T = 450 KN-m, and girder moment M_{cr} = 80 KN-m. Total depth of the section is given as 950 mm. The effective prestress for steel, f_{se} = 860 MPa and allowable compressive stress for concrete under working load, f_c = -12 MPa. (16)

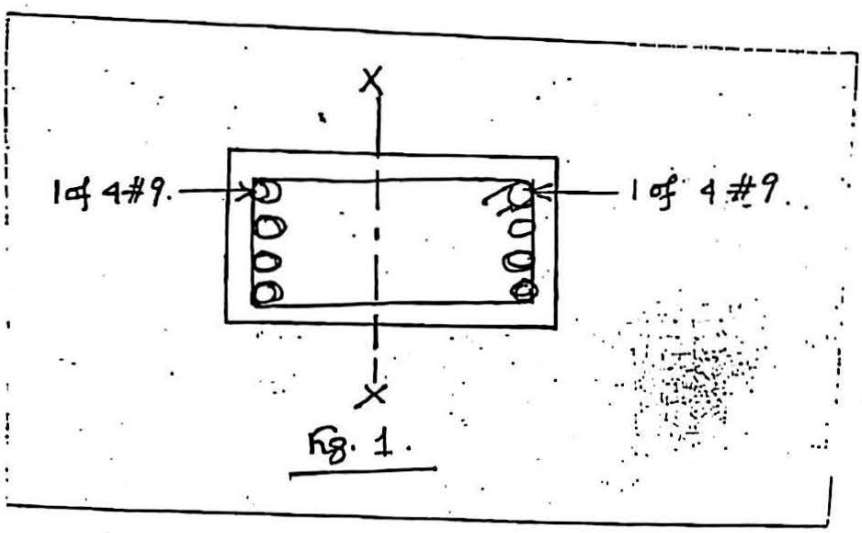
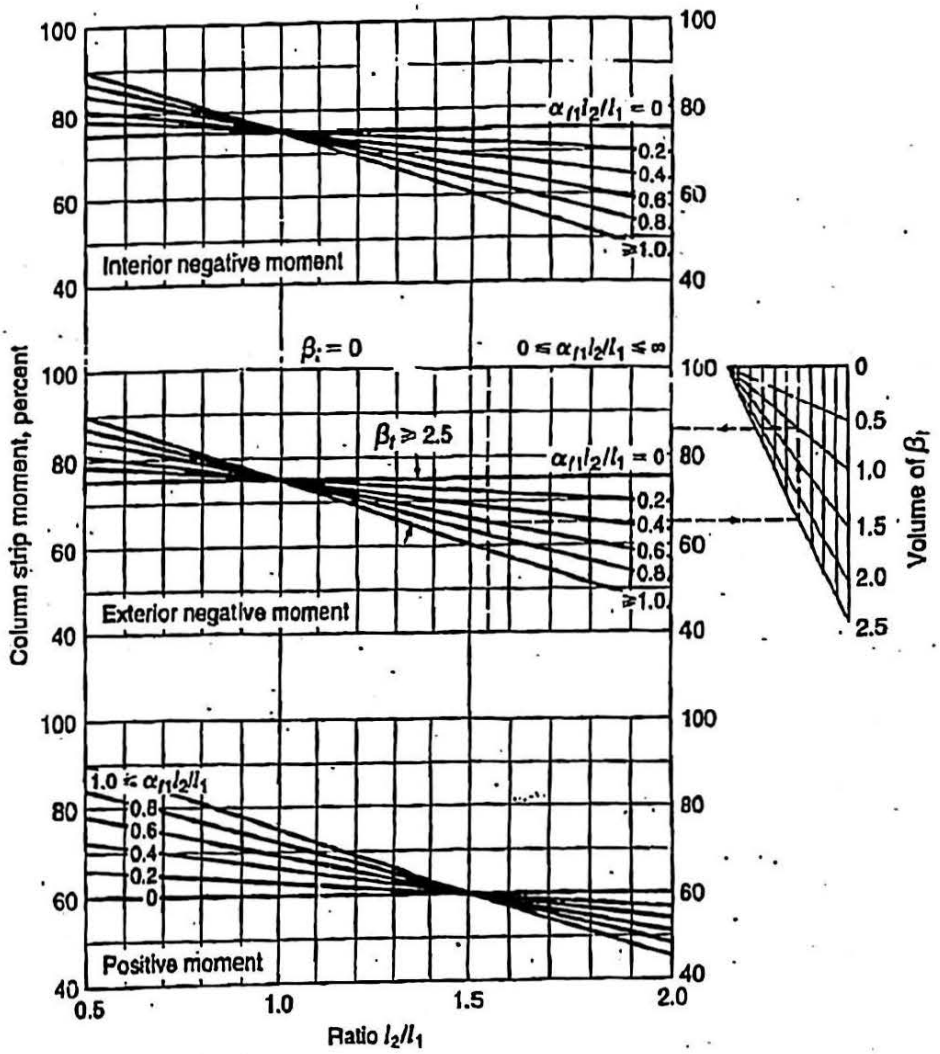
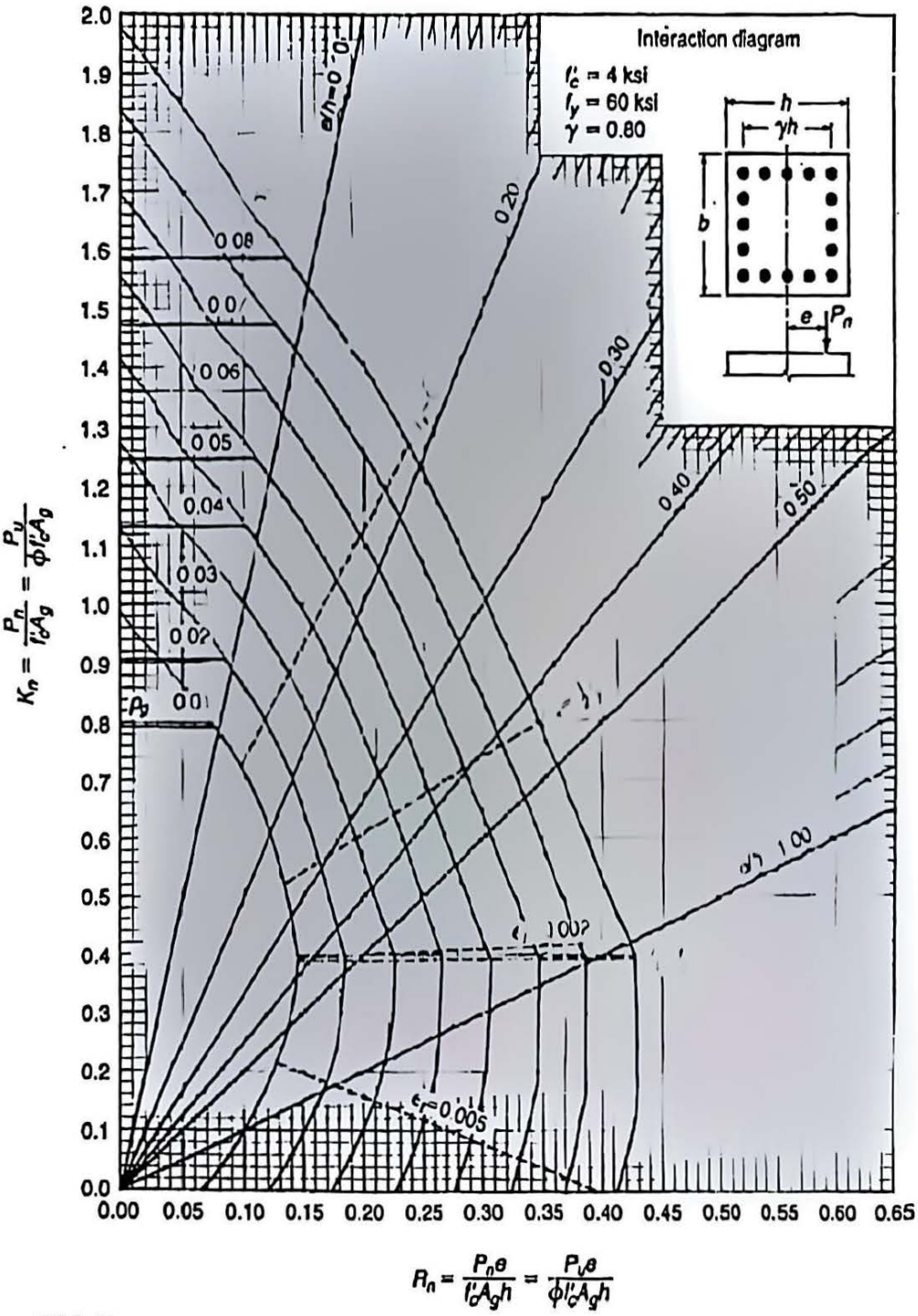


Fig. 1.

Interpolation charts for lateral distribution of slab moments.





Column strength interaction diagram for rectangular section with bars on four faces and $\gamma = 0.80$.

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2015-2016

Sub : **CE 325** (Design of Concrete Structures)

Full Marks: 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.
Assume reasonable values any missing data.

1. (a) What are the limitations of Direct Design method for analysis of two way slab? **(10)**

   (b) A two way reinforced concrete building floor system is composed of slab panels measuring 20'×20' in plan; supported by shallow column line beams cast monolithically with the slab as shown in Fig 1. using concrete strength of f'_c = 4000 psi and steel with fy = 60,000 psi, 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. Follow Direct Design Method. **(25)**

2. (a) A circular column carries a working unfactored DL = 650 kip and LL = 400 kip. Design the spiral column using about 2 percent main reinforcement. Also design the ACI spiral. Given: f'_c = 4.0 ksi and fy = 60 ksi. **(12)**

   (b) A 18×25 inch column is reinforced with ten No.9 bars as shown in Fig. 2. Draw the strength interaction diagram (for bending about X-X axis) with five points corresponding to balanced failure, pure axial load, pure bending, tension failure and compression failure. **(23)**

3. (a) Differentiate between the behavior of a short column and a slender column. **(10)**

   (b) A ground floor column of a multistoried building is to be designed for both Gravity and Lateral load combinations as follows: **(18)**

   $$\text{Gravity}: P_u = 600\,\text{kip}; M_u = 70\,\text{kip}-\text{ft}.$$
   $$\text{Lateral}: P_u = 550\,\text{kip}; M_u = 400\,\text{kip}-\text{ft}.$$

   Architectural considerations require that a rectangular column with b = 15in and h = 25in is to be used. Material strength are f'_c = 4 ksi and fy = 60 ksi.
   Find the required column reinforcement, tie size and spacing and show in neat sketch. Use relevant design chart assuming reinforcement distributed along the perimeter.

   (c) What is ACI spiral? Explain the failure behavior of ACI spirally reinforced column. **(7)**

4. (a) Write down ACI/BNBC code detailing requirements for beams for an intermediate moment resisting frame. **(8)**

   (b) Discuss different modes of failure of a high rise shear wall. **(7)**

   (c) A three storied reinforced concrete wall is subjected to factored lateral loads as shown in Fig.3. The wall is 15 ft long and 10" thick. Design reinforcement for the wall at the first level between the base and first floor. **(20)**

Contd P/2

CE 325/WRE

Contd... Q. No. 4 (c)

Given = $f_y = 60$ ksi ; $f'_c = 4$ ksi

$$Avv \geq \left[0.0025 + 0.5\left(2.5 - \frac{h_w}{l_w}\right)\left(\frac{A_{vh}}{S_2 h} - 0.0025\right)\right] S_1 h$$

$$Avv \geq 0.0025 S_1 h$$

$$M_n = \varphi\left[0.5 A_{st} f_y l_w \left(1 - \frac{z}{l_w}\right)\right]$$

$$\frac{Z}{l_w} = \frac{1}{2 + \frac{0.85\beta_1 l_w h f'c}{A_{st} f_y}} \; ; \beta_1 = 0.85.$$

SECTION-B

There are **FOUR** questions in this section. Answer any **THREE** questions.

5. (a) A flat plate floor has thickness, h=8" and is supported by 18"×18" columns spaced 20 ft. on centers each way. The floor will carry a DL = 180 psf including self weight and a live load of 100 psf. Check the adequacy of the slab in resisting punching shear. If inadequate, design the punching shear reinforcement using bent bar arrangement. **(17)**

Consider, d = 6.5"; $f'_c = 3500$ psi and $f_y = 60{,}000$ psi .

(b) Design a square footing for an interior column that carries total working DL = 600 kips and LL = 400 kips. The column is 25"×25" 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. **(18)**

6. (a) A 15" concrete wall supports a dead load, DL = 16 kip/ft. and a live load. LL = 12 kip/ft. The allowable bearing capacity of soil is 4000 psf at the bottom level of footing which is 5' below grade. Design the footing of the concrete wall with $f'_c = 3000$ psi and $f_y = 40{,}000$ psi. Check development length. **(21)**

(b) Select the length and width of the combined footing supporting two columns as shown in Fig. 4. The bottom of the footing is 6 ft. below grade where allowable bearing capacity is 5000 psf. The outer end of the combined footing cannot protrude beyond the outer face of exterior column which coincides with property line. **(14)**

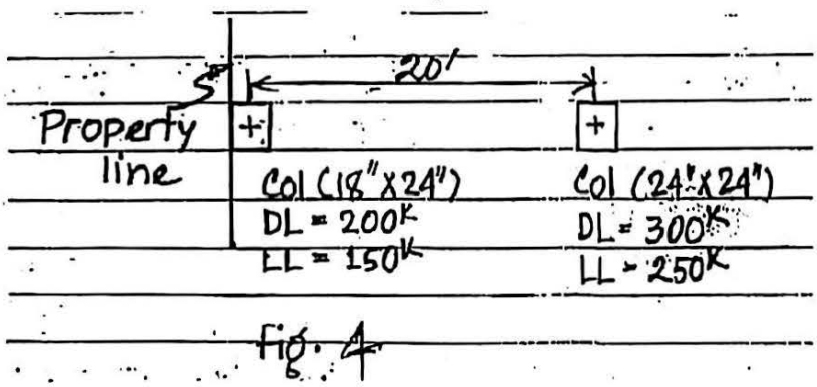


fig. 4

CE 325/WRE

Contd... Q. No. 6 (b)

7. (a) Compare in brief, prestressed concrete with reinforced concrete with respect to serviceability, safety and economy. (10)

(b) A simply supported rectangular beam as shown in Fig. 5 is to carry a uniformly distributed live load of 11.5 KN/m in addition to its own weight. The beam will be pretensioned with multiple seven wire strands with the centroid at a constant eccentricity of 200 mm. The prestress force, p_i immediately after transfer will be 715 KN after time dependent losses, the force will reduce to $p_e = 600$ KN. (25)

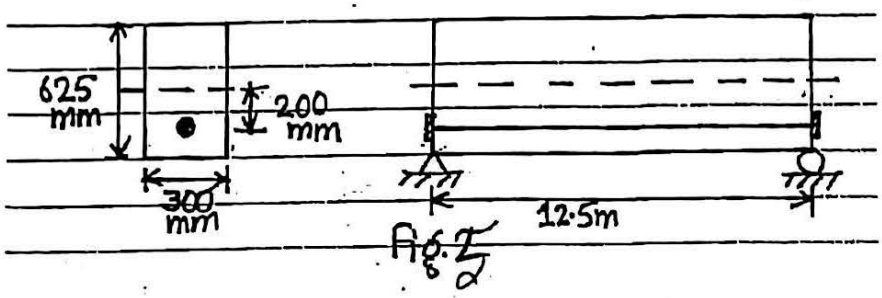


Fig. 5

Calculate the concrete flexural stress at mid-span section of the beam at the time of transfer, and after all losses with full services load (dead and live) in place.

8. (a) Write down the sources of prestress loss. (8)

(b) Differentiate between: (4x3=12)

(i) Strand and cable

(ii) Pre-tensioning and post-tensioning.

(iii) Bonded and unbounded tendons.

(c) A post-tensioned concrete member shown in Fig. 6 is prestressed with 820 mm^2 of steel wires which are anchored with a stress of 1300 Mpa. Compute the loss of prestress at sec-1-1 of the beam due to elastic shortening of concrete. Use n = 6 and solve the problem using both gross and transformed area of the beam section. Consider self weight of the beam in your calculation.

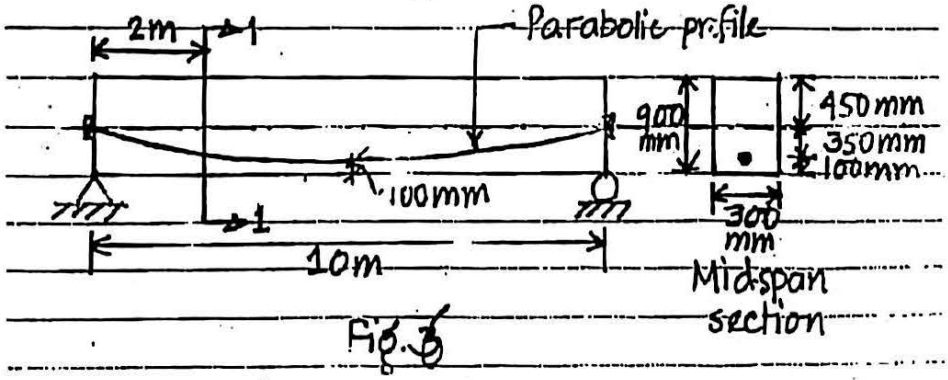


Fig. 6

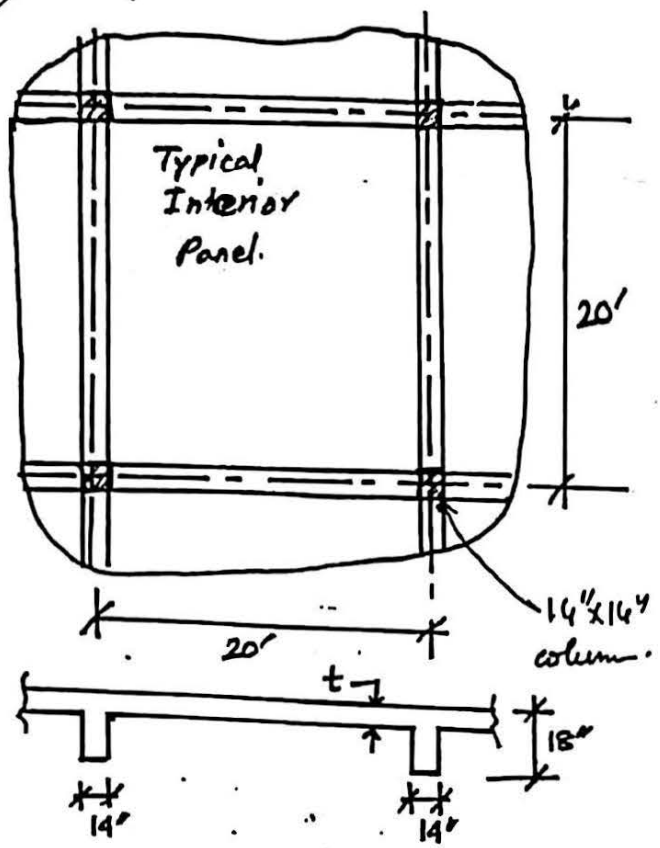


Fig. 1.

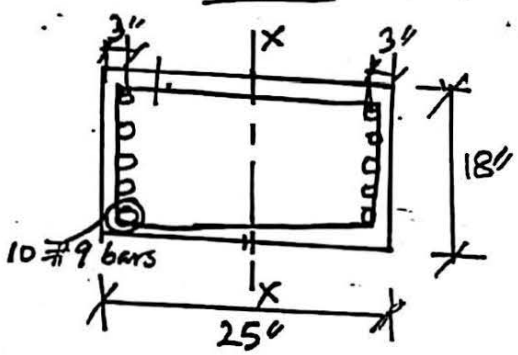


Fig. 2

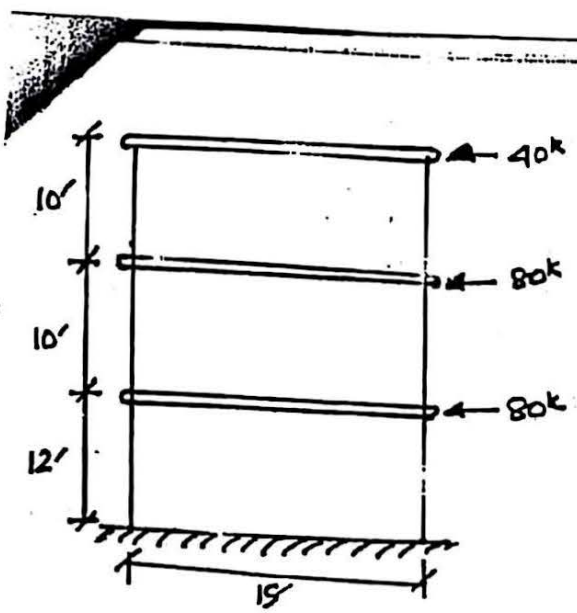
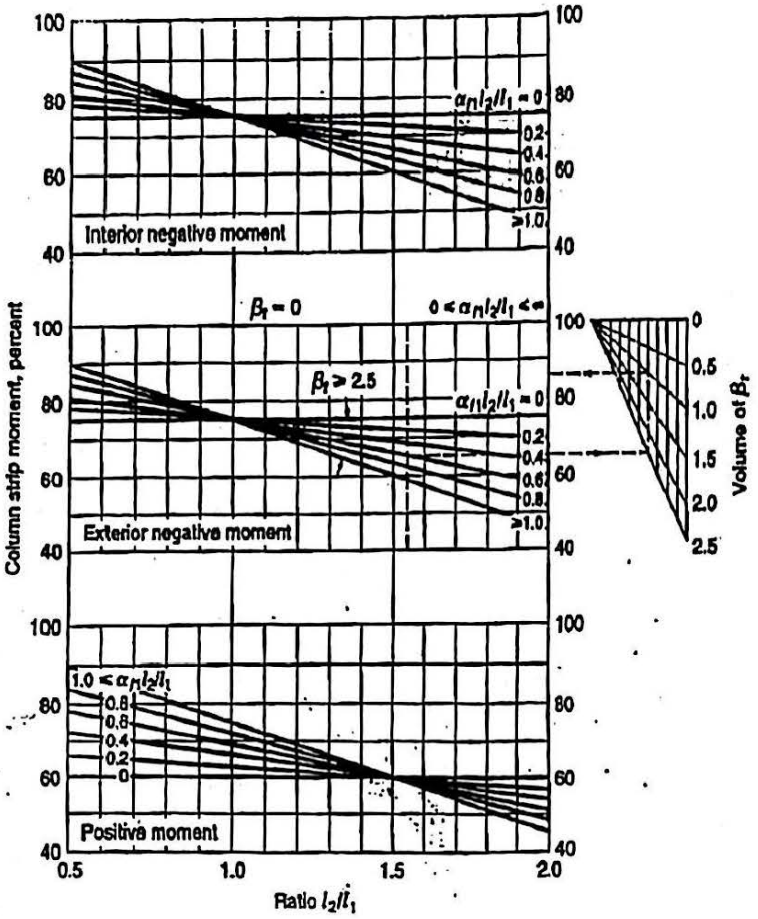
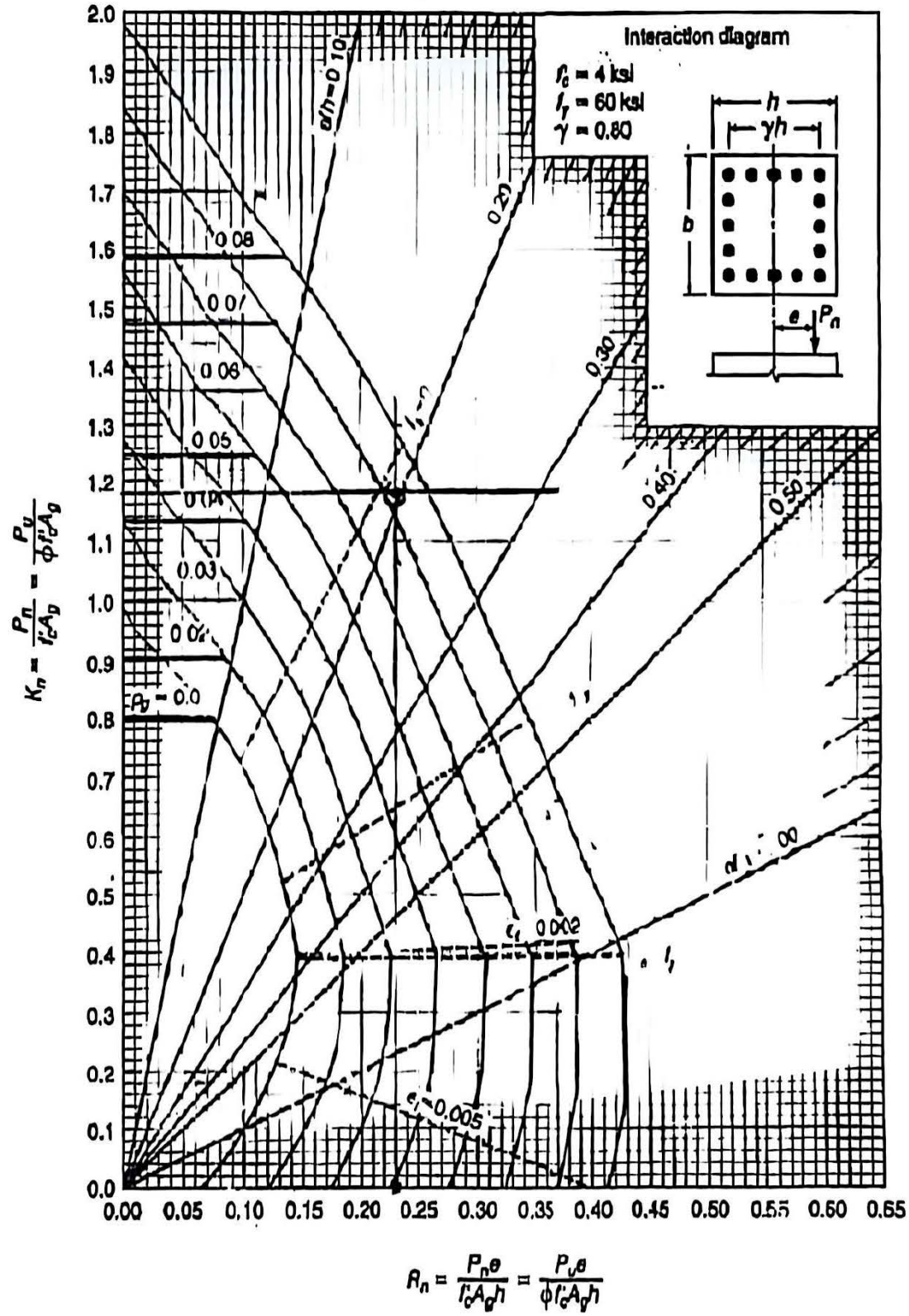


Fig. 3.

GRAPH A.4
Interpolation charts for lateral distribution of slab moments.





GRAPH A.7
Column strength interaction diagram for rectan-

L-3/T-2/WRE Date : 17/07/2016

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2014-2015

Sub : **CE 325** (Design of Concrete Structures II)

Full Marks: 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

Assume reasonable values for missing data.

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Differentiate between the behaviour of a short column and a long (slender) column. **(10)**

   (b) For the column section shown in Fig. 1, draw the strength interaction diagram (for bending about X-X axis) with five points corresponding to balanced failure, pure axial load, pure bending, tension failure and compression failure. **(25)**

2. (a) In a three-story structure, an exterior column is to be designed for a service dead load of 222 kips, maximum live load of 350 kips, dead load moment of 170 ft-kips and live load moment of 240 ft-kips. The minimum live load compatible with the full live load moment is 166 kips that may act on this column. Given, b = 20 in and h = 25 in. Find the required column reinforcement for the condition that full live load acts. Also, check against adequacy of your design for the condition of minimum live load. f'_c =4000 psi, f_y = 60000 psi (use design graph provided). **(20)**

   (b) Why are ties provided in column? State the requirements of ties according to ACI code. **(8)**

   (c) What is ACI spiral? Explain the failure behavior of ACI spirally reinforced column. **(7)**

3. (a) Write down the ACI/BNBC code detailing requirements for beams and columns in regions of moderate seismic risk. **(12)**

   (b) A 15 in. concrete wall supported a dead load, DL = 16^k/ft and a live load, LL = 12^k/ft. The allowable bearing capacity of soil is q_a = 4 ksf at the bottom level of footing which is 5' below grade. Design the footing of the concrete wall with f'_c =3000 psi and f_y = 40000 psi. Check development length. **(23)**

4. (a) Select the length and width of the combined footing supporting two columns as shown in Fig. 2. The bottom of the footing is 6 ft below grade where the allowable bearing capacity of soil is 5 ksf. The outer end of the combined footing cannot protrude beyond the outer face of the exterior column which coincide with property line. If d = 26 inch, check adequacy against punching. Also, design the transverse beam. Given: f'_c =3.5 ksi; f_y = 60 ksi. **(18)**

   (b) The plan of a pile cap with 12 nos 20 in. diameter cast-in-situ piles with the column (24" × 24") is shown in Fig. 3. The column carries a DL = 800 kip and a LL = 600 kip (working). The individual pile capacity is adequate. Design the pile cap. Given, f'_c =3.0 ksi and f_y = 60 ksi. **(17)**

Contd..... P/2

SECTION - B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) What are the limitations of Direct Design method for the analysis of two way slab? **(10)**

(b) A residential building is to be designed using a flat plate floor system. The interior columns are 24" × 24" and they are spaced 22 ft c/c in one direction and 24 ft c/c in other direction. Design the interior panel (22' × 24') and show reinforcement in long direction only with neat sketch. Assume slab thickness of 8". Specified live load = 40 psf, Floor finish and partition wall load = 60 psf in addition to the self weight of floor slab. $f'_c = 3500$ psi and $f_y = 60{,}000$ psi. **(25)**

6. (a) What are the common types of shear reinforcement used for flat plates? Show with neat sketches. **(4)**

(b) A flat plate floor has thickness h = 7.5" and is supported by 18 inch square columns spaced 20 ft on center each way. The floor will carry a DL = 160 psf including its self weight and a live load of 90 psf. Check the adequacy of the slab in resisting punching shear and provide shear reinforcement, if needed using 'bent bars'. Consider d = 6", $f'_c = 4$ ksi and $f_y = 60$ ksi. **(16)**

(c) Make final design for the preliminary section shown in Fig. 4, allowing $f_b = -1.80$ ksi and $f_o = 150$ ksi, other values are, **(15)**

$M_T = 320$ kip-ft, $M_G = 40$ kip-ft, $ft = -1.60$ ksi, $f_{se} = 125$ ksi; $F = 187$ kip

Preliminary section has following properties.

$Ac = 248$ inch^2, $I = 42{,}200$ inch^4, $K_t = K_h = 9.4$ inch.

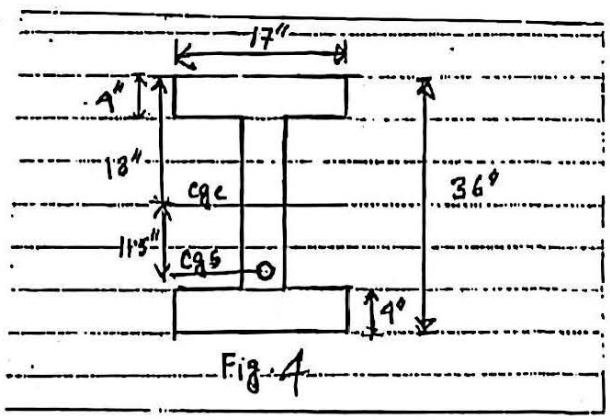


Fig. 4

Contd P/3

CE 325/WRE

7. (a) Compare in brief, prestressed concrete with reinforced concrete with respect to serviceability, safety and economy. (8)

(b) Write down the sources of prestress loss. (7)

(c) A post tensioned bonded concrete beam has a prestress of 400 kip in the steel immediately after transfer, which eventually reduces to 335 kip due to losses. The beam carries two live load of 12 kip each at the third points in addition to its own weight. Compute the extreme fiber stresses at midspan: (20)

(i) under initial condition of full prestress without live load.

(ii) under final working condition.

The beam has a rectangular cross section of (12 inch × 32 inch) and total prestressing steel of 2.4 inch^2 laid parabolically with e = 10" at midspan and e = 0 at the end. Span = 40' (simply supported).

8. (a) Discuss different modes of failure of a high-rise shear wall. (10)

(b) A three storied reinforced concrete wall is subjected to factored lateral loads as shown in fig. 5. The wall is 15 ft long and 10" thick. Design reinforcement for the wall at the first level between the base and the first floor. f_y = 60 ksi, f'_c = 4 ksi. (25)

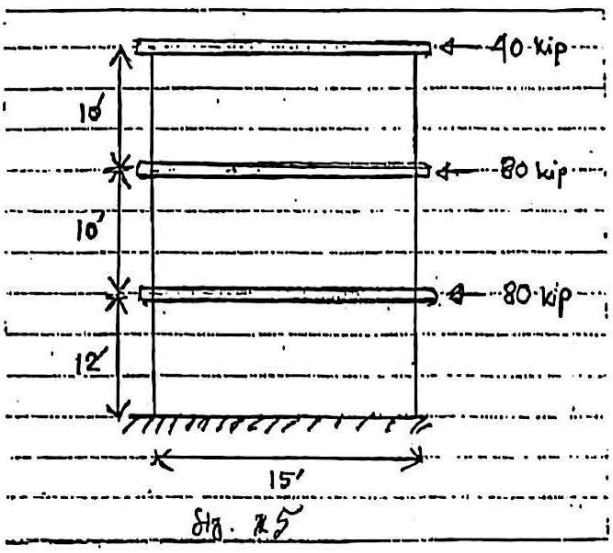


Fig. 8.5

Given, $A_{vv} \geq \left[0.0025 + 0.5\left(2.5 - \frac{h_w}{l_w}\right)\left(\frac{A_v h}{S_2 h} - 0.0025\right)\right] S_1 h$

$A_{vv} \geq 0.0025\, S_1 h$

$M_u = \phi\left[0.5\, A_{vv}\, f_y\, l_w\left(1 - Z/l_w\right)\right]$

$\frac{Z}{lw} = \frac{1}{2 + \frac{0.85\,\beta_1\, l_w\, h\, f'_c}{A_{vv}\, f_y}}$ $\quad \beta_1 = 0.85$

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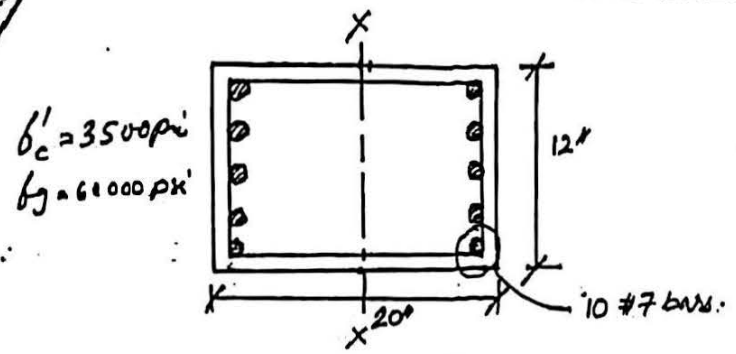


Figure 1.

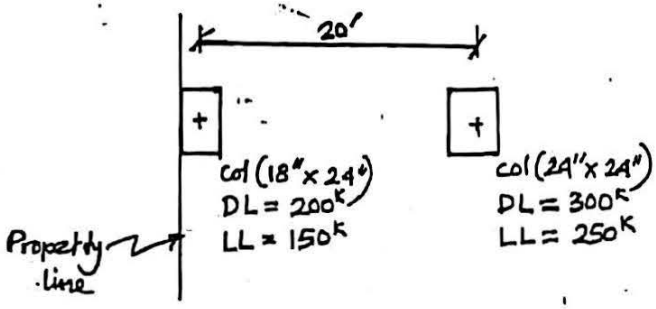


Figure 2

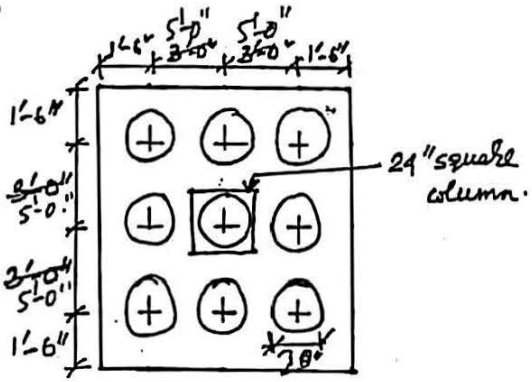
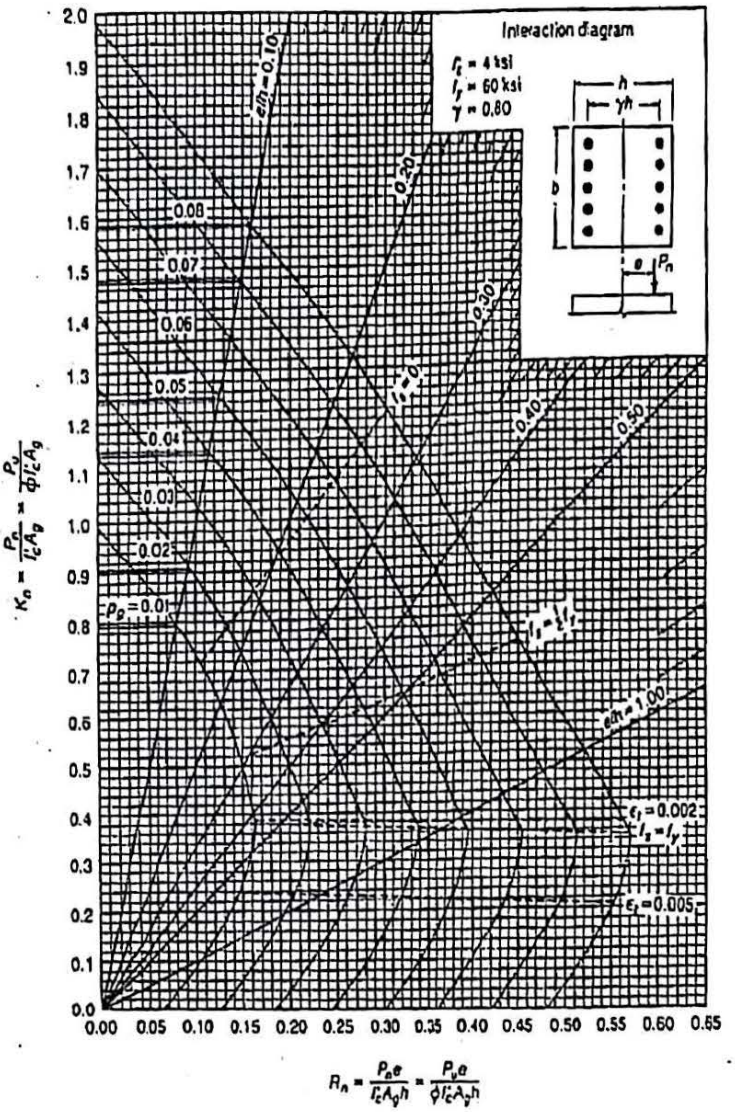


Figure 3


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
$f_s = f_y$
e/h = 1.00
ϵ_t = 0.002
$f_s = f_y$
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