Tanta University	Department: **Civil Engineering** Total Marks: **75 Marks**	**Faculty of Engineering**

Course Title: **Design of Reinforced Concrete Structures (1) b** Date: **June 8th 2014 (Second term exam)**	Course Code: **CSE2205** Allowed time: **4 hrs**	**2nd year** **No. of Pages: (3)**

Remarks: If not mentioned; consider f_{cu} = 25.0 N/mm^2, Steel grade is 360/520, and dimensions are in mm. Any missing data may be reasonably assumed
الإمتحان مكون من ثلاث ورقات غير مسموح باصطحاب أى جداول أو مساعدات تصميم بخلاف المُسَلَّمَة فى لجنة الإمتحان

Question One (15 Marks)

Answer briefly the following:

a) At what thickness, solid slabs should be provided with shrinkage reinforcement? **(3 Marks)**
b) What is meant by long term and short term deflection? **(3 Marks)**
c) Members subjected to concentric compression forces could be made of plain concrete; however, longitudinal and transversal reinforcement are used in these members. **Why?** **(3 Marks)**
d) Define the braced and unbraced building according to the Egyptian code. **(3 Marks)**
e) Classify the difference types of reinforced concrete walls. **(3 Marks)**

Question Two (15 Marks)

a) In a braced building, check the buckling condition for the 5.0 m height **solid rectangular reinforced concrete wall 0.30 x 4.50 m**, Calculate the maximum ultimate load that can be resisted by this wall. Find the amount of minimum reinforcement required for the wall and show its details on the cross section to a reasonable scale. Consider the wall is fixed at foundation level and hinged at floor level. **(6 marks)**

b) For the interaction diagram of the cross section shown in Fig. (1), it is required to determine the section capacity at the marked three points. **(9 Marks)**

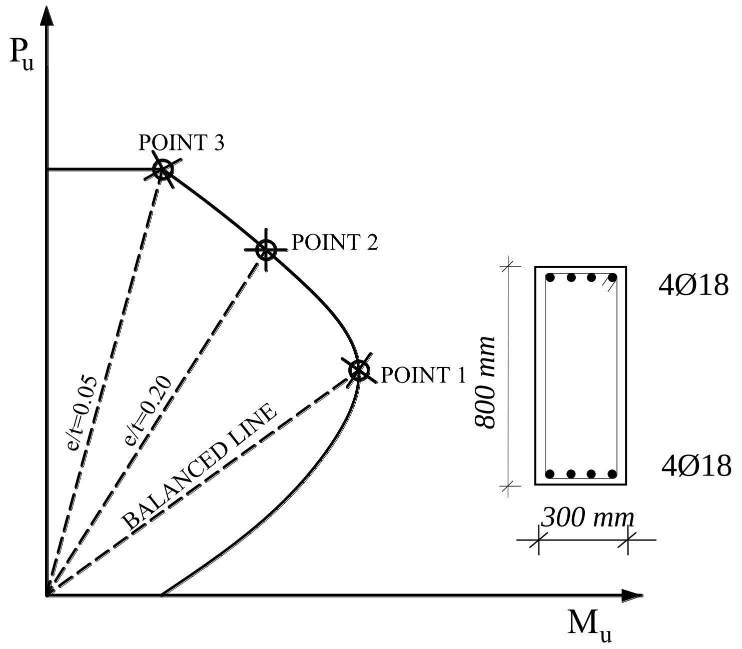

Figure.(1) Schematic drawing of interaction diagram

Question Three (15 Marks)

For the part of the typical floor of a residential building shown in the Fig. (2), **if you know that**:
Floor cover = 1.50 kN/m^2 , L.L. = 2.00 kN/m^2, Walls exist over all beams with height of 2.40 m and intensity 3.00 kN/m^2, all beams' cross section 250 × 600 mm, Hatched slab is 100 mm lower than the rest of the floor, **it is required to:**

1. Design the necessary critical sections for the slab **at strips I-I and II-II**. **(5 marks)**
2. Draw neatly, to a convenient scale on plan, **the details of reinforcement for all shown slabs**. **(5 Marks)**
3. **Without any calculations,** show the reinforcement detailing of the **beam at axis (4-4)** in elevation (scale 1:50) and cross sections (scale 1:25). Show the necessary steel curtailments. **(5 Marks)**

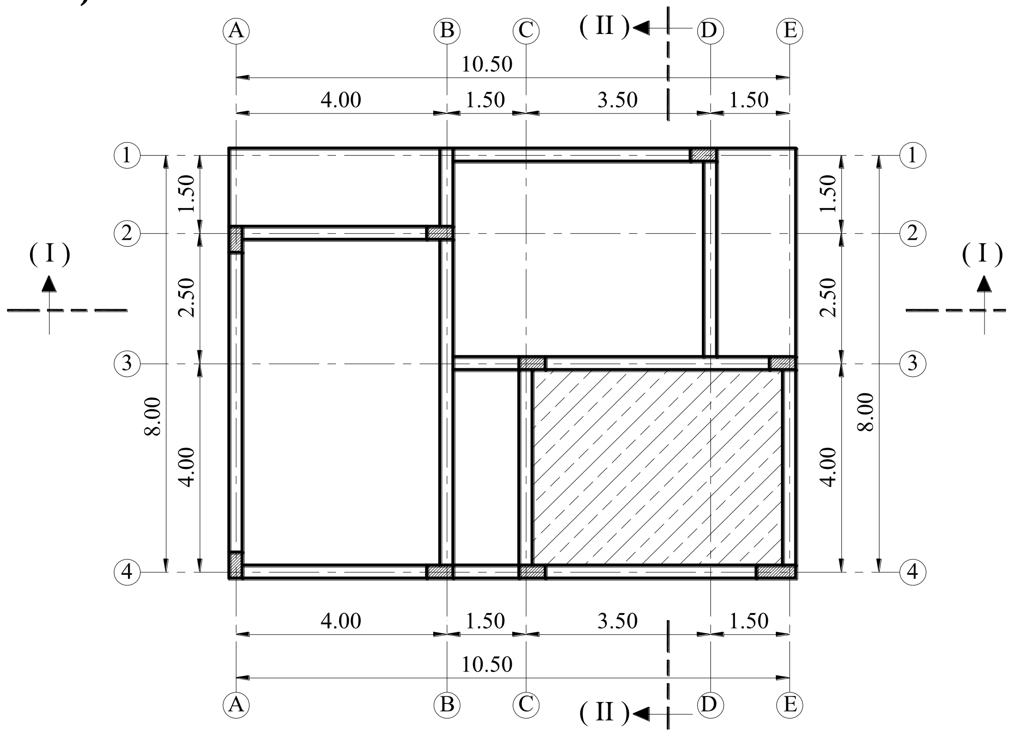

Figure (2)

Question Four (30 Marks)

Figure (3) shows a structural plan and a sectional elevation for a multi-story center, **if you know that:**
Floor cover = 2 kN/m^2, L.L. = 5.0 kN/m^2, Slab thickness = 150 mm, 250 mm red brick walls exist over all outer beams with intensity 5.0 kN/m^2, all beams' cross section 300×800 mm, and columns are totally fixed at foundation level, **it is required to:**

1. Make complete design of reinforced concrete column **C1 at the first floor as a circular spiral composite column, (Reinforced concrete inside steel pipe section).** Consider f_y=240 N/mm^2 for steel pipe and spiral reinforcement. **(7.5 Marks)**
2. Make complete design of reinforced concrete column **C2 at the ground floor as a square tied column.** **(7.5 Marks)**
3. Make complete design of reinforced concrete column **C3 at the ground floor as a rectangular tied column with width 400mm.** **(7.5 Marks)**
4. Make complete design of the shown reinforced concrete tie on axis 3-E. **(7.5 Marks)**

Course Title: **Design of Reinforced Concrete Structures (1) b** | Course Code: **CSE2205** | **2nd year**

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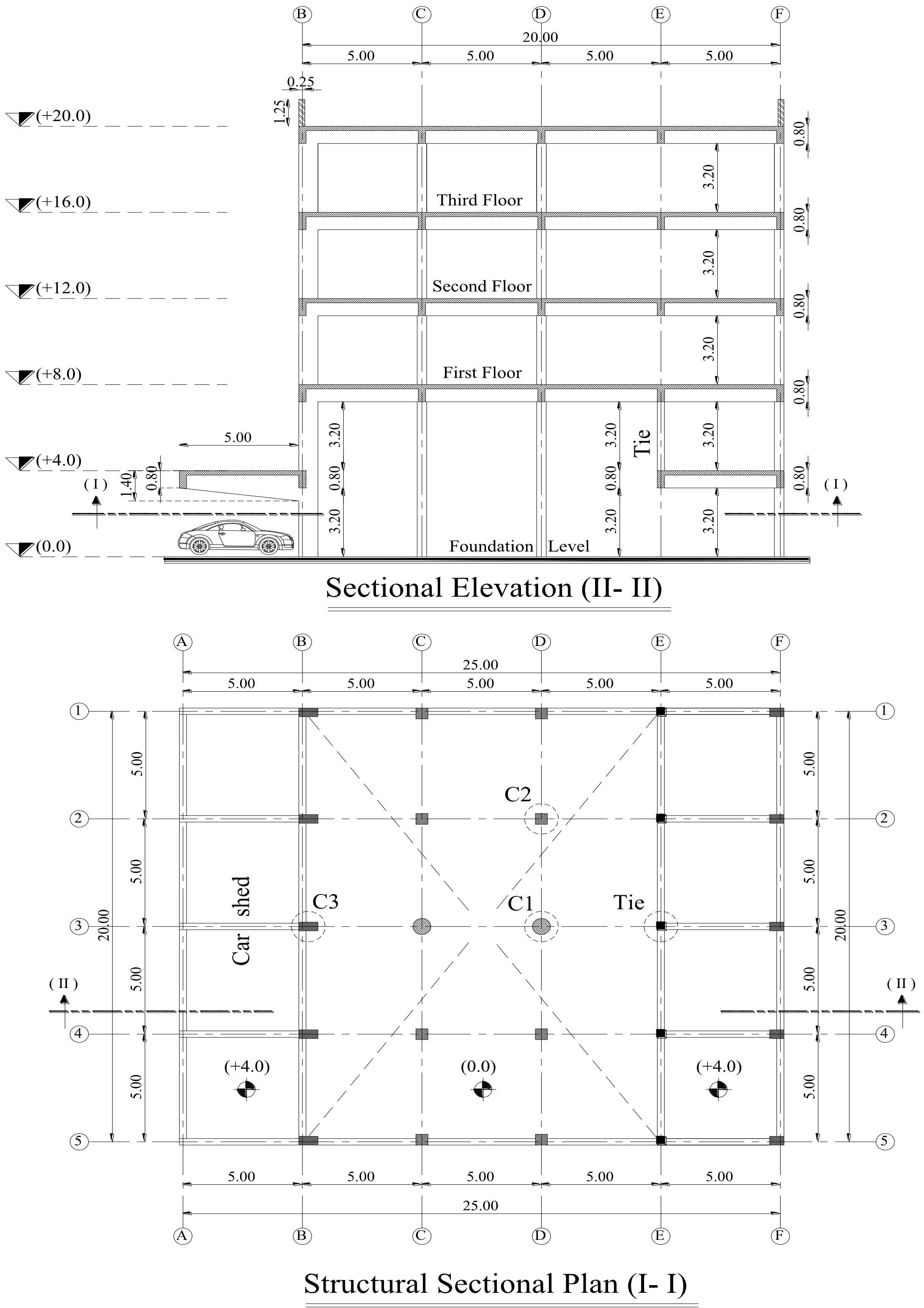

Figure (3)

Course Examination Committee

Prof. Dr. Abdel-Hakim Abdel-Khalik Khalil — Prof. Dr.: Emad El-Sayed Etman

Dr. Nesreen Mohamed Kassem

Course Coordinator: Prof. Dr. Abdel-Hakim Abdel-Khalik Khalil

Tanta University		Department: **Civil Engineering** Total Marks: **75 Marks**		**Faculty of Engineering**

Course Title: **Design of Reinforced Concrete Structures (1) b**	Course Code: **CSE2205**	**2nd year**
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MODEL ANSWER OF EXAM

Tanta University	Department: **Civil Engineering** Total Marks: **75 Marks**	**Faculty of Engineering**

Course Title: **Design of Reinforced Concrete Structures (1) b**	Course Code: **CSE2205**	**2nd year**
Date: **June 8th 2014 (Second term exam)**	Allowed time: **4 hrs**	**No. of Pages: (3)**

Question One **(15 Marks)**

Answer briefly the following:

a) At what thickness, solid slabs should be provided with shrinkage reinforcement? **(3 Marks)**

Solid slabs is supplied with shrinkage reinforcement when thickness of slabs exceeds 160mm.

b) What is meant by long term and short term deflection? **(3 Marks)**

Long term is caused by shrinkage and creep.
Short term is caused by dead load and live load.

c) Members subjected to concentric compression forces could be made of plain concrete; however, longitudinal and transversal reinforcement are used in these members. **Why?** **(3 Marks)**

Benefits of using longitudinal reinforcement

- Increase the ultimate capacity load
- Resist the lateral loads.

Benefits of using transversal reinforcement

- Fix longitudinal reinforcement
- Confinement for section

d) Define the braced and unbraced building according to the Egyptian code. **(3 Marks)**

Braced building defined if the following conditions achieved

- There was R.C walls in both direction extend from foundation level to the final height of building.
- The building is symmetry in both direction
- $\alpha = H_b\sqrt{\frac{N}{EI}} < 0.60$ **in case of building equal or more than 4**
- $\alpha = H_b\sqrt{\frac{N}{EI}} < 0.20 + 0.10n$ **in case of building less than 4**

e) Classify the difference types of reinforced concrete walls. **(3 Marks)**

أ حوائط حاملة وهي معرضة أساسا إلى قوى ضغط مصحوبة أو غير مصحوبة بقوى أفقية.
ب- حوائط تدعيم وتقوم بتدعيم الحوائط الحاملة ضد الانبعاج، ويمكن أن تعمل كحوائط حاملة في نفس الوقت.

Question Two **(15 Marks)**

a) In a braced building, check the buckling condition for the 5.0 m height **solid rectangular reinforced concrete wall 0.30 x 4.50 m**, Calculate the maximum ultimate load that can be resisted by this wall. Find the amount of minimum reinforcement required for the wall and show its details on the cross section to a reasonable scale. Consider the wall is fixed at foundation level and hinged at floor level. **(6 marks)**

Solution

The ultimate capacity

$$P_u = 0.80\left[0.35\, f_{cu}\, A_c \left(1-\left(\frac{K\,H}{32t}\right)^2\right)\right]$$

$$P_u = 0.80\left[0.35\times 25\times 300\times 4500\left(1-\left(\frac{0.8\times 5}{32\times 0.30}\right)^2\right)\right] = 7809375\,N = 7809.375\ KN$$

The check buckling

$$\lambda = \frac{K\,H}{b} = \frac{0.90\times 5}{0.25}$$

$$\lambda = 18 > 15 \rightarrow long\ wall$$

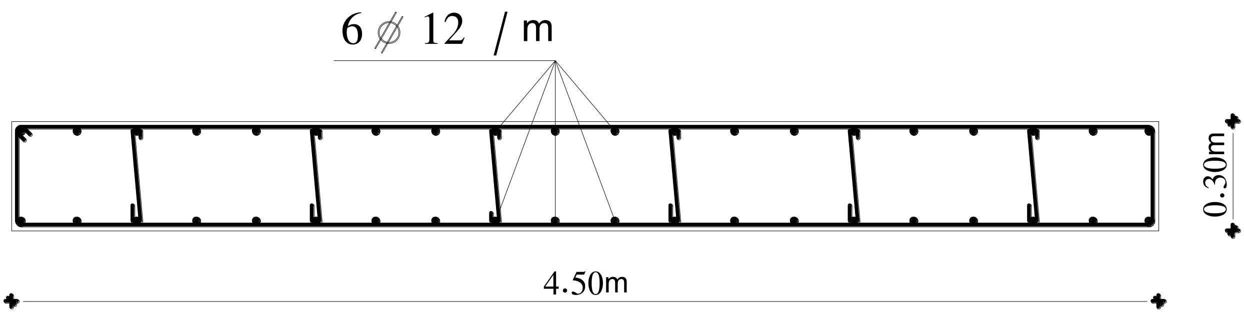
MINIMUM VERTICAL & HORIZONTAL R.F.T

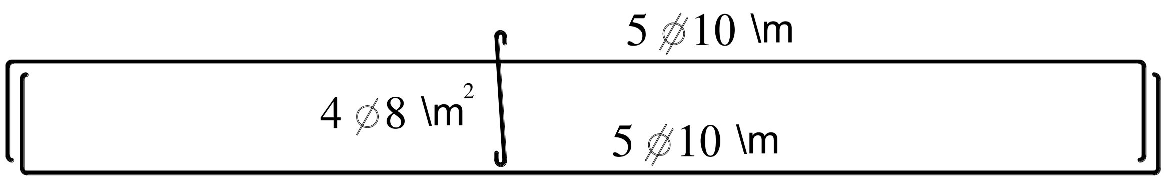
$$A_{sv} = \frac{0.40}{100}\times b\times 1.00m = \frac{0.40}{100}\times 300\times 1000 = 1200mm^2$$

$$A_{sv}\ /side/m = \frac{1200}{2} = 600mm^2\ use 6\phi 12/m'$$

$$A_{sh} = \frac{0.25}{100}\times b\times 1.00m = \frac{0.25}{100}\times 300\times 1000 = 750mm^2$$

$$A_{sh}\ /side/m = \frac{750}{2} = 375mm^2\ \ use 5\phi 10/m'$$





b) For the interaction diagram of the cross section shown in Fig. (1), it is required to determine the section capacity at the marked three points. **(9 Marks)**

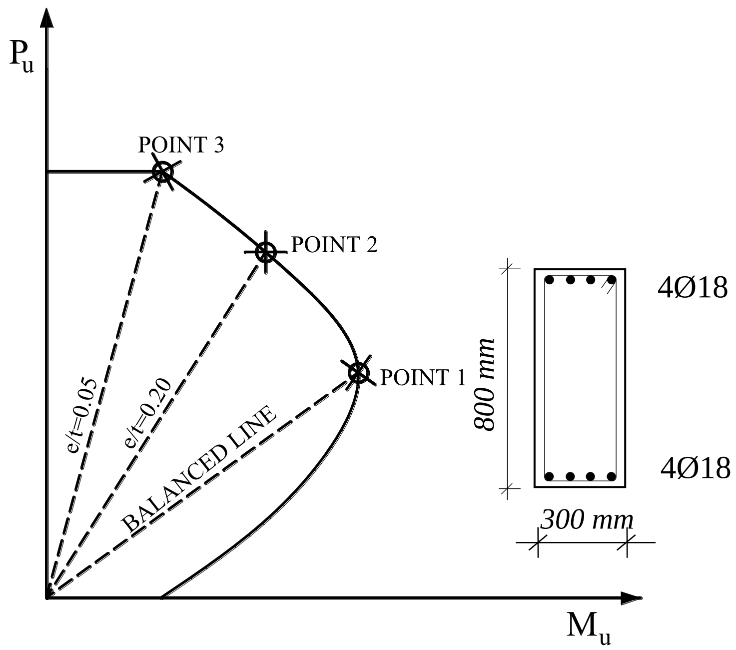
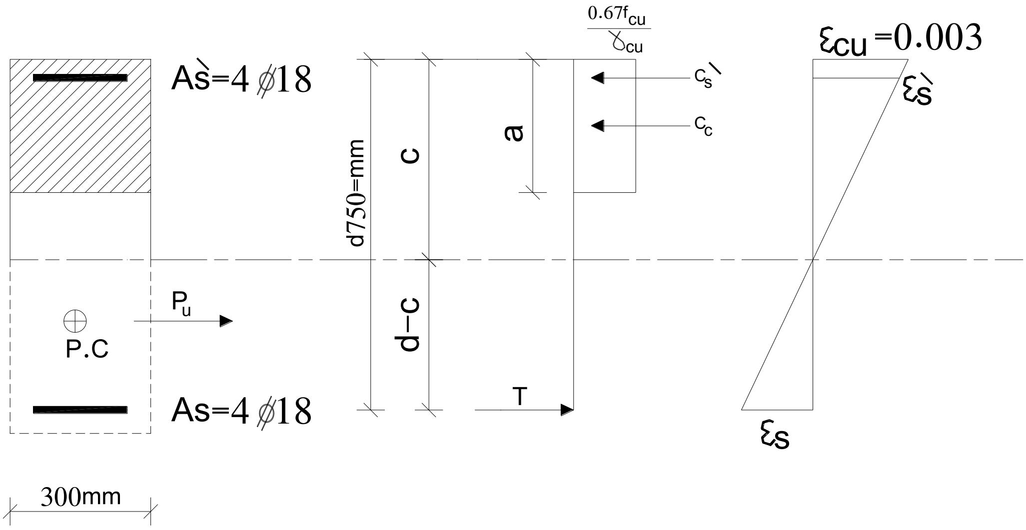


Figure.(1) Schematic drawing of interaction diagram

Point (1) (balanced point)

$$plastic centeriod = 400mm \; as \; A_s = A_s'$$

The stress and strain distribution



The balanced compression depth (c_b)

$$\frac{c_b}{d} = \frac{600}{600 + \frac{f_y}{\gamma_s}}$$

$$c_b = \frac{600}{600 + \frac{360}{1.15}} \times 750 = 492.86mm$$

$$a_b = 0.80 c_b = 0.80 \times 492.86 = 394.29mm$$

Stress of compression steel (f_s')

$$\frac{\varepsilon_s'}{\varepsilon_{cu}} = \frac{c_b - d'}{c_b}$$

$$\varepsilon_s' = \varepsilon_{cu} \frac{c_b - d'}{c_b}$$

$$f_s' = \varepsilon_s' \times E_s = \varepsilon_{cu} E_s \frac{c_b - d'}{c_b} = 0.003 \times 2 \times 10^5 \frac{492.86 - 50}{492.86} = 539.13Mpa > \frac{f_y}{\gamma_s}$$

$$take \quad f_s' = \frac{f_y}{\gamma_s}$$

$$P_{ub} = C_c + C'_s - T$$

$$P_{ub} = 0.67\frac{f_{cu}}{\gamma_c} \times b \times a_b + A'_s\frac{f_y}{\gamma_s} - A_s\frac{f_y}{\gamma_s}$$

$$P_{ub} = 0.67 \times \frac{25}{1.50} \times 300 \times 394.29 + 1016 \times \frac{360}{1.15} - 1016 \times \frac{360}{1.15}$$

$$P_{ub} = 1320.87 \times 10^3 N = 1320.87 kN$$

$$M_{ub} = C_c\left(y_{p.c} - \frac{a}{2}\right) + C'_s(y_{p.c} - d') + T\left(d - y_{p.c}\right)$$

$$= 0.67\frac{f_{cu}}{\gamma_c} \times b \times a_b \times \left(y_{p.c} - \frac{a}{2}\right) + A'_s\frac{f_y}{\gamma_s}(y_{p.c} - d') + A'_s\frac{f_y}{\gamma_s}\left(d - y_{p.c}\right)$$

$$= 0.67 \times \frac{25}{1.50} \times 300 \times 394.29 \times \left(350 - \frac{394.29}{2}\right)$$

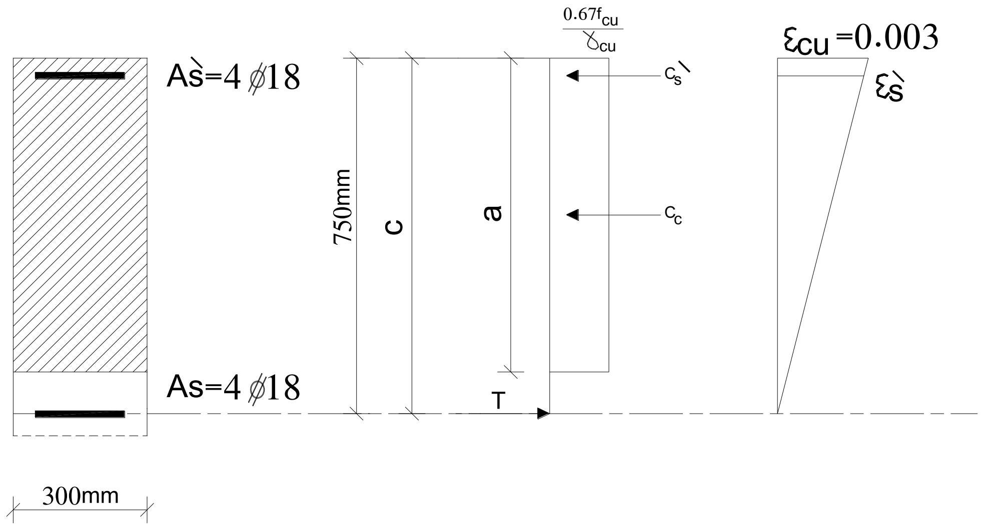
$$+1016 \times \frac{360}{1.15} \times (400 - 50)$$

$$+1016 \times \frac{360}{1.15} \times (750 - 400)$$

$$M_{ub} = 313.22 \times 10^6 \; N.mm = 313.22 \; kN.m$$

Point (2) (Compression point)

The stress and strain distribution



The compression depth (c)

$$Take\, c > c_b \Rightarrow Compression\ failure$$

$$c = d = 750mm$$

$$a = 0.80c = 600mm$$

Stress of compression steel (f_s')

$$\frac{\varepsilon_s'}{\varepsilon_{cu}} = \frac{c - d'}{c}$$

$$\varepsilon_s' = \varepsilon_{cu}\frac{c - d'}{c}$$

$$f_s' = \varepsilon_s' \times E_s = \varepsilon_{cu} E_s \frac{c - d'}{c} = 0.003 \times 2 \times 10^5 \frac{750-50}{750} = 560 Mpa > \frac{f_y}{\gamma_s}$$

$$take \quad f_s' = \frac{f_y}{\gamma_s}$$

$$P_u = C_c + C_s'$$

$$P_u = 0.67\frac{f_{cu}}{\gamma_c} \times b \times a + A_s'\frac{f_y}{\gamma_s} - A_s\frac{f_y}{\gamma_s}$$

$$P_u = 0.67 \times \frac{25}{1.50} \times 300 \times 600 + 1016 \times \frac{360}{1.15}$$

$$P_u = 2328.05 \times 10^3 N = 2328.05 kN$$

$$M_u = C_c\left(y_{p.c} - \frac{a}{2}\right) + C_s'(y_{p.c} - d')$$

$$= 0.67\frac{f_{cu}}{\gamma_c} \times b \times a \times \left(y_{p.c} - \frac{a}{2}\right) + A_s'\frac{f_y}{\gamma_s}(y_{p.c} - d')$$

$$= 0.67 \times \frac{25}{1.50} \times 300 \times 600 \times \left(400 - \frac{600}{2}\right) + 1016 \times \frac{360}{1.15} \times (400 - 50)$$

$$M_u = 312.32 \times 10^6 \ N.mm = 312.32 \ kN.m$$

Check

$$e=\frac{M_u}{P_u}=\frac{312.32}{2328.05}=0.134m$$

$$\gamma_c=1.50\left[\frac{7}{6}-\frac{e}{3t}\right]=1.50\left[\frac{7}{6}-\frac{0.134}{3\times0.80}\right]=1.67\cong1.50\,o.K$$

$$\gamma_c=1.15\left[\frac{7}{6}-\frac{e}{3t}\right]=1.15\left[\frac{7}{6}-\frac{0.134}{3\times0.80}\right]=1.28\cong1.15\,o.K$$

Point (1)@minimum eccentricity

$$P_u=0.35f_{cu}A_c+0.67f_yA_{sc}$$

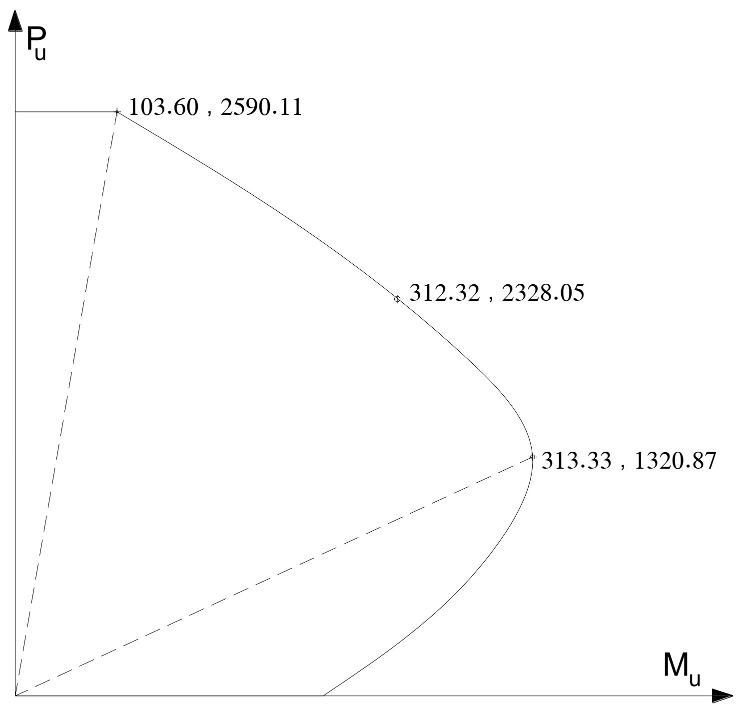
$$=0.35\times25\times300\times800+0.67\times360\times8\times254$$

$$P_u=2590.11\times10^3N=2590.110kN$$

$$e_{\min}\geq\ 20mm\ or\ \ 0.05t=0.05\times800=40mm$$

$$e_{\min}=40mm=0.04m$$

$$M_u=P_u\times e_{\min}=2590.11\times0.04=103.60kN.m$$



Question Three (15 Marks)

For the part of the typical floor of a residential building shown in the Fig. (2), **if you know that**: Floor cover = 1.50 kN/m^2 , L.L. = 2.00 kN/m^2, Walls exist over all beams with height of 2.40 m and intensity 3.00 kN/m^2, all beams' cross section 250 × 600 mm, Hatched slab is 100 mm lower than the rest of the floor, **it is required to:**

1. Design the necessary critical sections for the slab **at strips I-I and II-II**. **(5 marks)**
2. Draw neatly, to a convenient scale on plan, **the details of reinforcement for all shown slabs**. **(5 Marks)**
3. **Without any calculations,** show the reinforcement detailing of the **beam at axis (4-4)** in elevation (scale 1:50) and cross sections (scale 1:25). Show the necessary steel curtailments. **(5 Marks)**

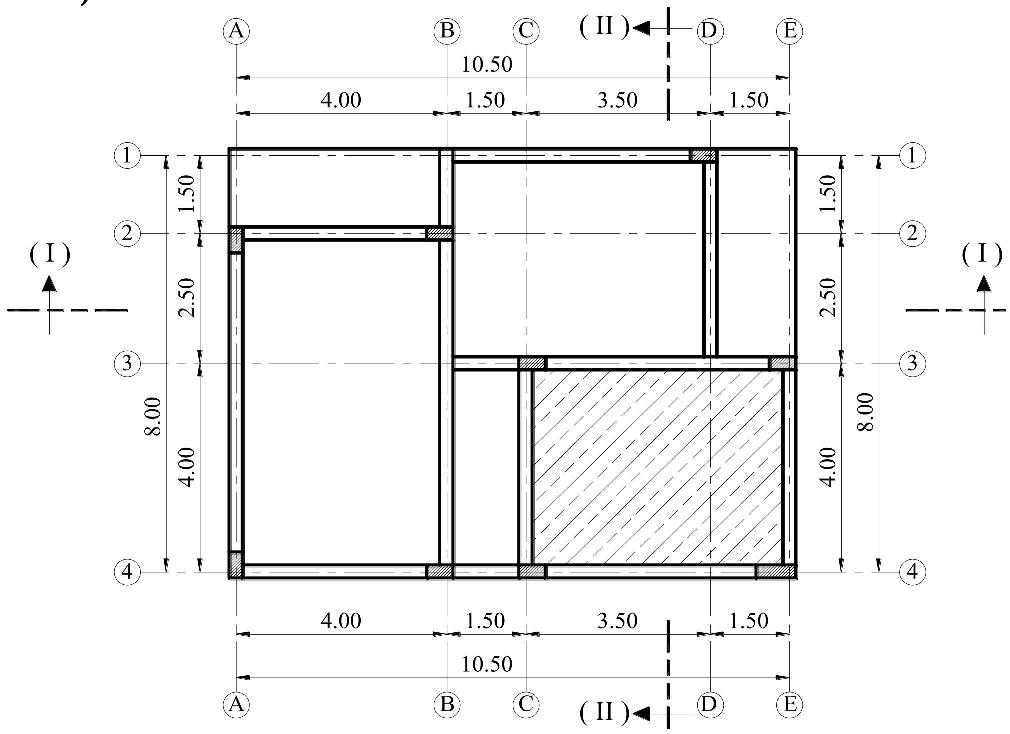
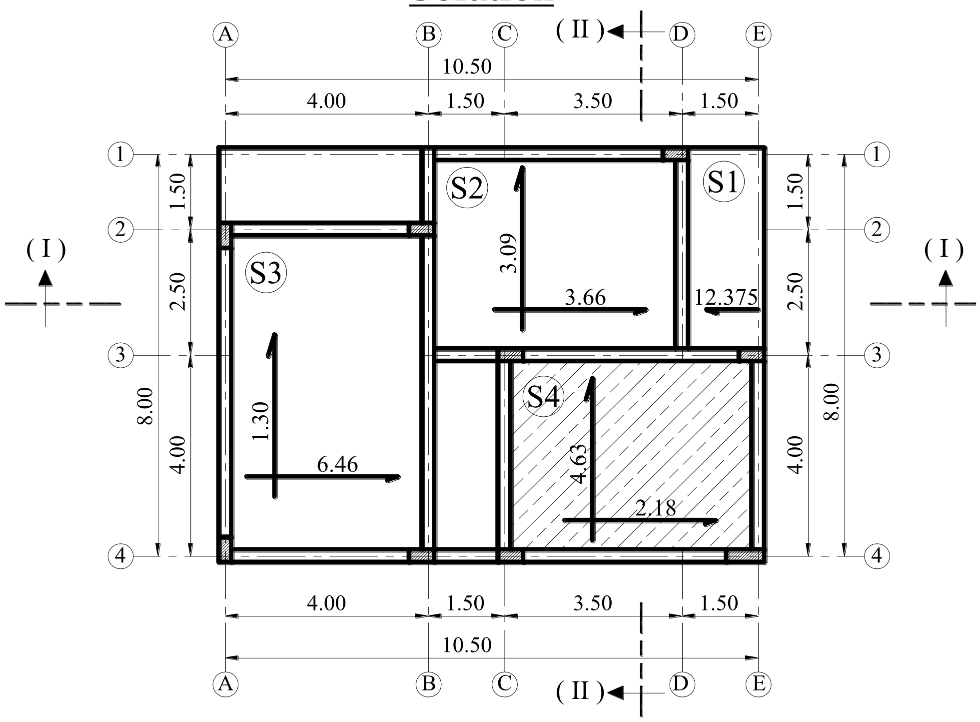


Figure (2)

Solution



1-Concrete Dimension

SLAB	long	short	L_L/L_s	TYPE	L_n	K	ts	CHOOSE
1	——	1.50	——	cantilever	1.375	10.48	131	150mms
2	5.00	4.00	1.25	TWO WAY	4.00	35	114	120mms
3	6.50	4.00	1.625	TWO WAY	4.00	40	100	120mms
4	5.00	4.00	1.25	TWO WAY	4.00	35	114	120mms

2-Loads

$g_s = t_s \times \gamma_{con.} + F.C$ $\qquad$ $P_s = L.L$

$W_u = 1.50(g_s + P_s) \quad P_s < 0.75 g_s$

$W_u = 1.50(g_s + P_s) \quad P_s > 0.75 g_s$

Slab No	t_s	F.C	g_s	p_s	W_u
S_1	0.15	1.5	5.25	2.00	10.875 kN/m^2
$S_2 + S_3 + S_4$	0.12	1.5	4.50	2.00	9.75 kN/m^2

Load of handrailwall

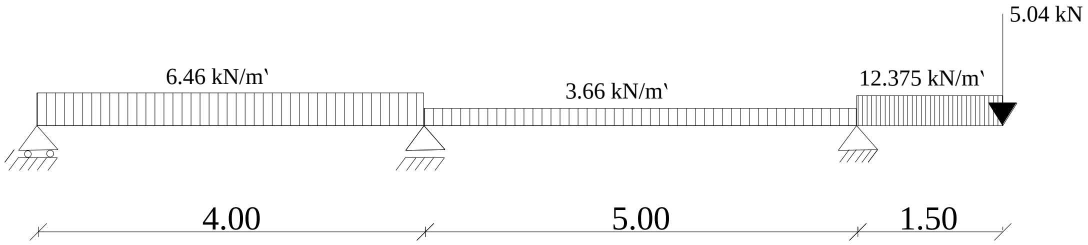
$P_{uwall} = 1.40 \times \text{int}\,ensity \times H_w = 1.40 \times 3.00 \times 1.20 = 5.04 kN/m$

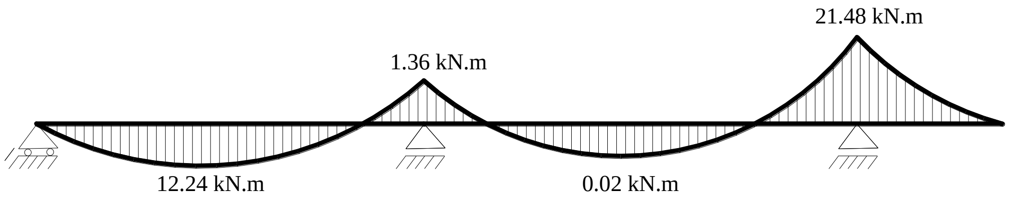
3-Loads distribution:-

SLAB	L_L	Ls	m_L	m_S	r	α	β	Wα	Wβ
2	4.00	5.00	1.00	0.76	1.05	0.375	0.317	3.66	3.09
3	6.50	4.00	0.87	0.87	1.625	0.663	0.133	6.46	1.30
4	5.00	4.00	1.00	1.00	1.25	0.475	0.224	4.63	2.18

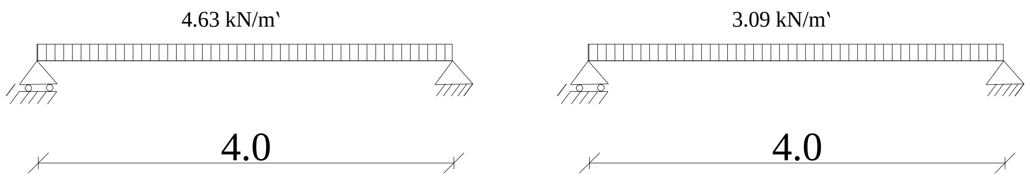
4- Straining action of strips:-

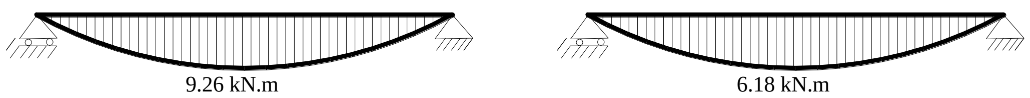
Strip (1-1)





Strip (2-2)



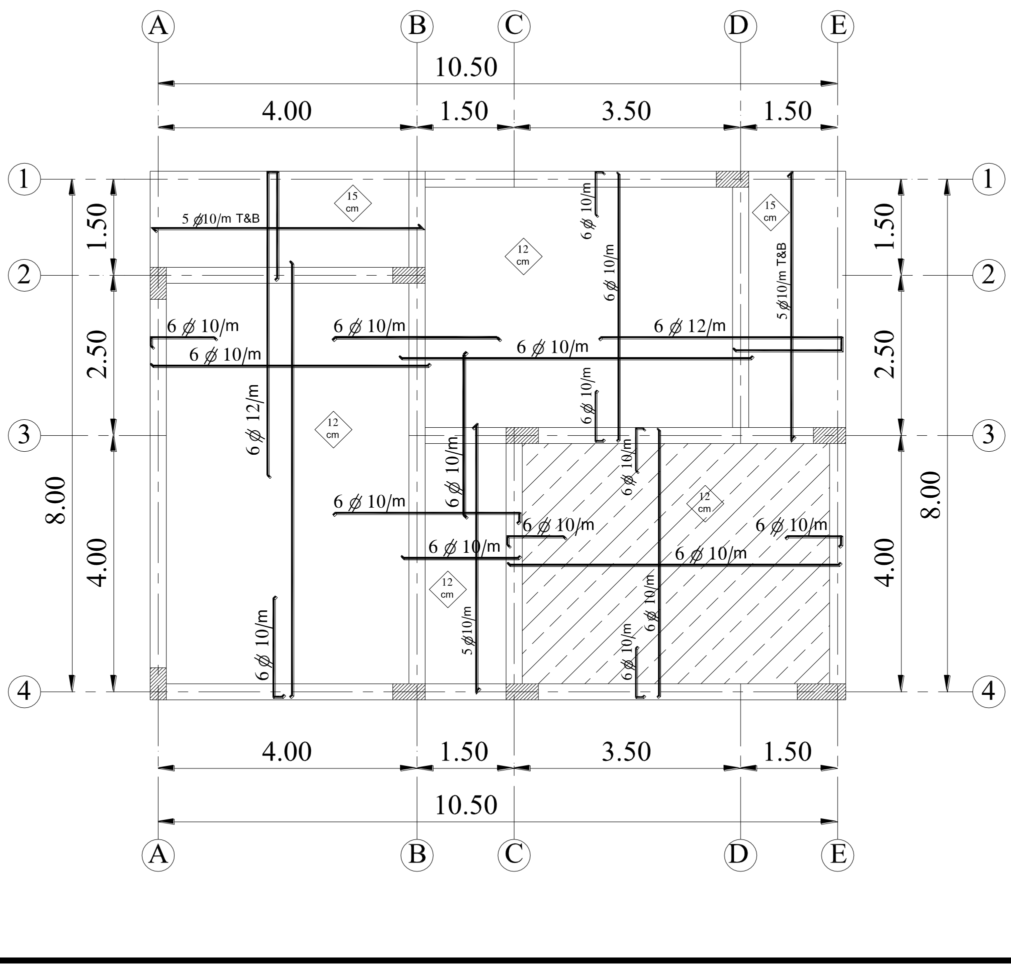


5-Design of critical sections

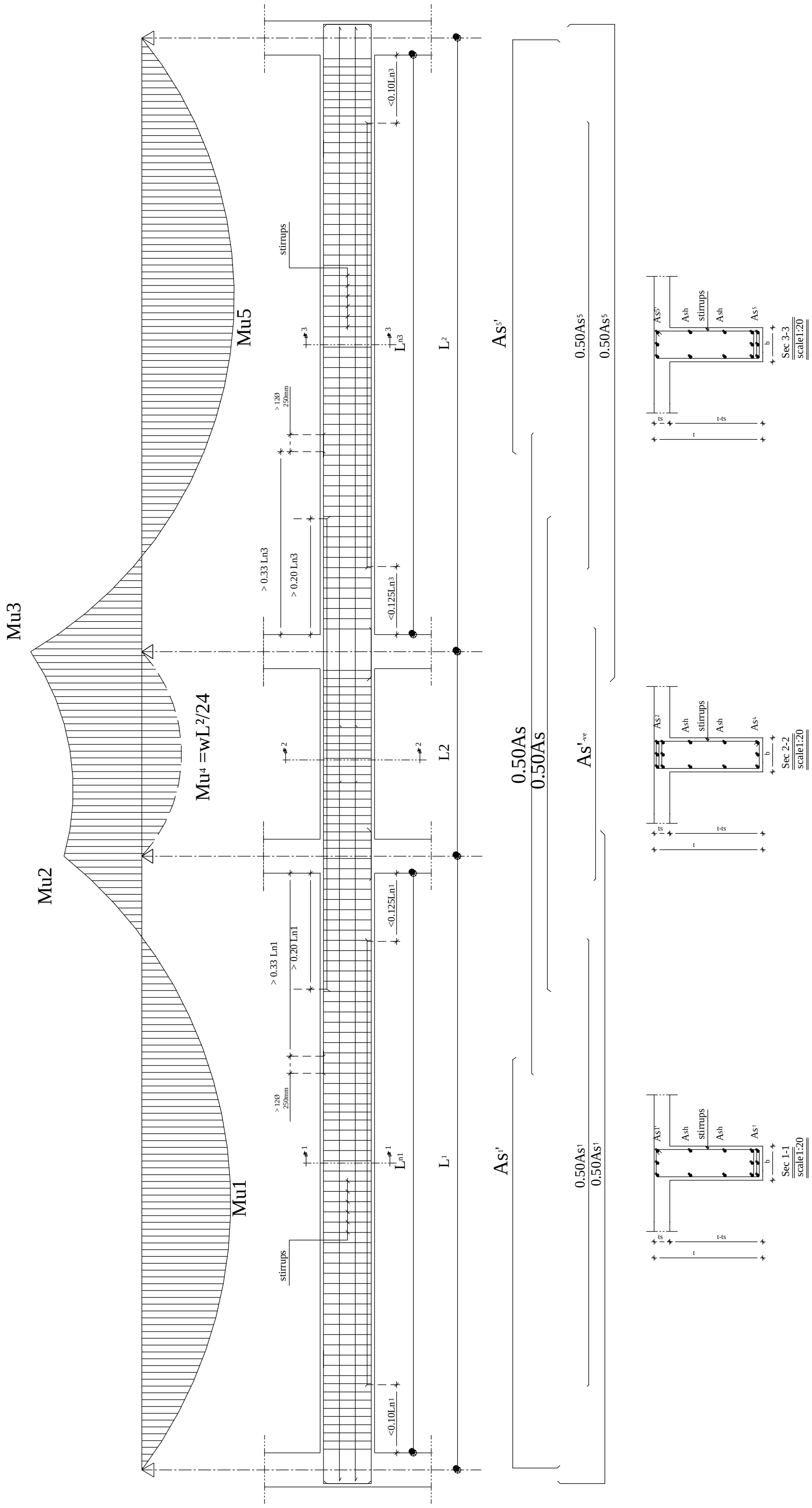
$$d = t_s - cover$$
$$d = t_s - 20mm$$
$$d_1 = d - 10mm$$
$$C_1 = \frac{d\, or\, d1}{\sqrt{\frac{M_u \times 10^6}{f_{cu} \times B}}} \qquad B = 1000mm$$
$$A_s = \frac{M_u \times 10^6}{f_y \times j \times (d\, or d_1)}$$

STRIP.NO	SEC. NO	M_u	d	C_1	J	A_s	R.F.T
STRIP.NO(1)	1	21.48	130	4.45	0.810	567	6 Φ 12 /m
	2	1.36	100	13.56	0.826	46	6 Φ 10 /m
	3	12.24	100	4.52	0.820	415	6 Φ 10 /m
STRIP.NO(2)	1	9.26	100	5.20	0.826	314	6 Φ 10 /m
	2	6.18	100	6.36	0.826	210	6 Φ 10 /m

6-Reinforcement details



The reinforcement detailing of the beam at axis (4-4)



Question Four (30 Marks)

Figure (3) shows a structural plan and a sectional elevation for a multi-story center, **if you know that:**

Floor cover = 2 kN/m^2, L.L. = 5.0 kN/m^2, Slab thickness = 150 mm, 250 mm red brick walls exist over all outer beams with intensity 5.0 kN/m^2, all beams' cross section 300×800 mm, and columns are totally fixed at foundation level, **it is required to:**

1. Make complete design of reinforced concrete column **C1 at the first floor as a circular spiral composite column, (Reinforced concrete inside steel pipe section).** Consider f_y=240 N/mm^2 for steel pipe and spiral reinforcement. **(7.5 Marks)**
2. Make complete design of reinforced concrete column **C2 at the ground floor as a square tied column. (7.5 Marks)**
3. Make complete design of reinforced concrete column **C3 at the ground floor as a rectangular tied column with width 400mm. (7.5 Marks)**
4. Make complete design of the shown reinforced concrete tie on axis 3-E. **(7.5 Marks)**

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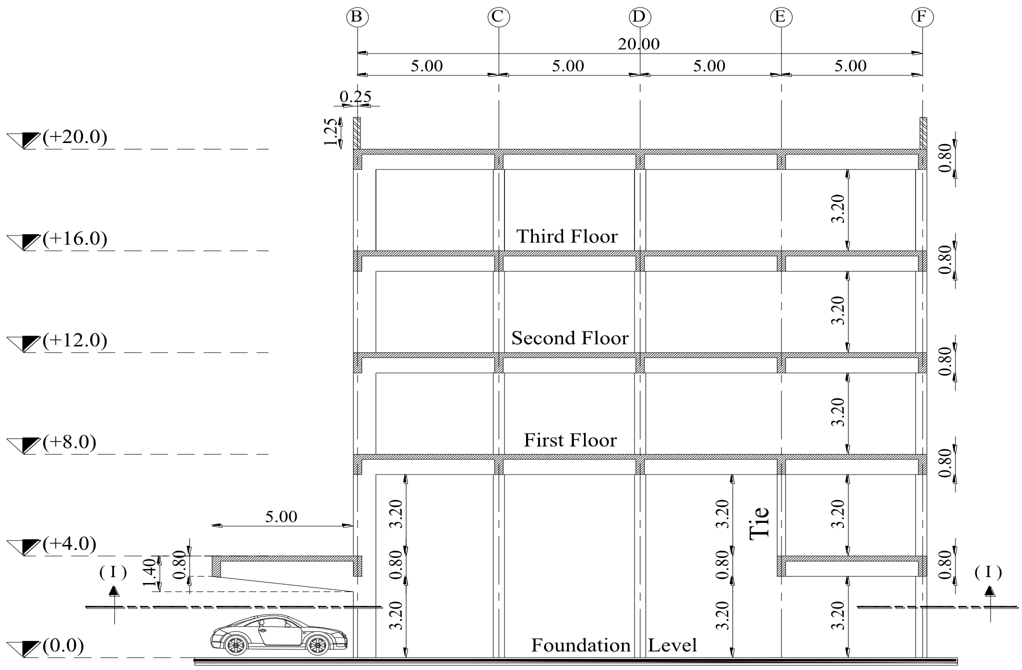
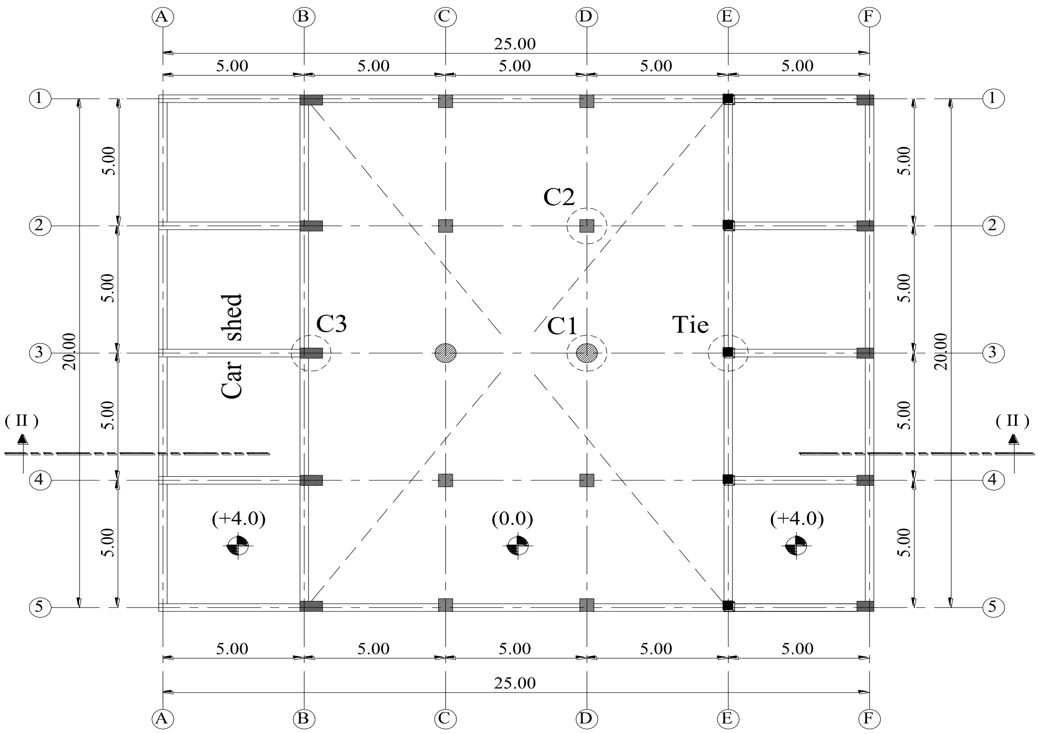


Sectional Elevation (II- II)



Structural Sectional Plan (I- I)

Figure (3)

Solution

Design of column (C1)

1-Loads

Slab loads

$$P_{slab} = \sum A_{slab} \times \left(t_s \times \gamma_{con.} + F.C + L.L\right)$$

$$P_{slab} = (5.0\times 7.50\times 3)\times\left(0.15\times 25 + 2.00 + 5.00\right) = 1209.375kN$$

Beam loads

$$P_{beam} = \sum L_{beam} \times b \times (t - t_s) \times \gamma_{con.}$$

$$P_{beam} = 15\times 3\times 0.30\times(0.80 - 0.15)\times 25 = 219.375kN$$

Wall loads

$$P_{wall} = zero$$

Total ultimate load

$$P_u = \left(P_{slab} + P_{beam} + P_{wall}\right)\times 1.10\times 1.50$$

$$P_u = \left(1209.375 + 219.375 + 0.00\right)\times 1.10\times 1.50$$

$$P_u = 2357.44kN$$

2-Design of section

$$P_u \times 10^3 = 0.40\times f_{cu}\times A_c + 0.76\times f_y \times A_{sc} + 0.67\times f_{ys}\times A_{ss}$$

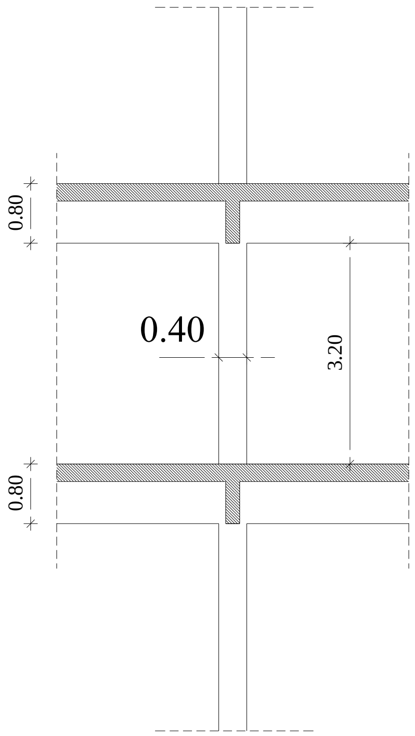
$$thickness(t) = D\sqrt{\frac{f_y}{8E_s}} = D\sqrt{\frac{240}{8\times 2\times 10^5}} = 0.012D$$

$$A_{ss} = \pi D \times thickness = \pi D\times 0.012D = 0.012\pi D^2$$

$$2357.44\times 10^3 = 0.40\times 25\times\frac{\pi D^2}{4} + 0.76\times 360\times 0.01\times\frac{\pi D^2}{4} + 0.67\times 240\times 0.012\pi D^2$$

$$D^2 = 146747mm^2 \;\rightarrow D = 383mm \rightarrow take\ D = 400mm$$

3-Check buckling



A-In plan = Out of plan

H_o =3.20m

K=1.20 (fixed @ top, fixed @bottom, un braced building)

$$\lambda_D = \frac{KH_o}{D} = \frac{1.20\times3.20}{0.40} = 9.60 > 8 \ \ Long\ column$$

$$increase\ D = 0.50m$$

$$\lambda_D = \frac{KH_o}{D} = \frac{1.20\times3.20}{0.50} = 7.68 < 8\ Short\ column$$

$$= 0.01A_c = 0.01\times\frac{\pi\times500^2}{4} = 1964mm^2$$

$$A_{sc} >$$

$$= 0.012A_k = 0.012\times\frac{\pi\times450^2}{4} = 1909mm^2$$

$$A_{sc} = 1964mm^2 \rightarrow use 10\phi16$$

$$thickness(t) = 0.012D = 0.012\times500 = 6.00mm \rightarrow take\ t = 6mm$$

$$P_u \times 10^3 = 0.35 \times f_{cu} \times A_k + 0.67 \times f_y \times A_{sk} + 0.67 \times f_y \times A_{ss} + 1.38 \times f_{yp} \times V_{sp}$$

$$2357.44 \times 10^3 = 0.35 \times 25 \times \frac{\pi \times 450^2}{4} + 0.67 \times 360 \times 10 \times 201$$

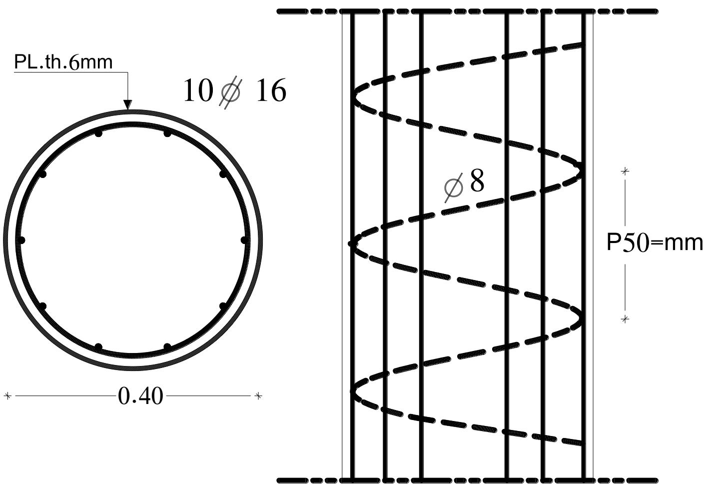
$$+ 0.67 \times 240 \times 6 \times \pi \times 500 + 1.38 \times 240 \times V_{sp}$$

$$V_{sp} = -3124 mm^2 / m \rightarrow Use\ MIN$$

$$\mu_{sp\,\min} = 0.36\left(\frac{f_{cu}}{f_{yp}}\right)\left(\frac{A_c}{A_k} - 1\right) = 0.36\left(\frac{25}{240}\right)\left(\frac{\frac{\pi}{4} \times 500^2}{\frac{\pi}{4} \times 450^2} - 1\right) = 0.0088$$

$$\mu_{sp} = \frac{V_{sp}}{A_k} = \frac{\pi D_k \times A_{st}}{A_k \times p} = \mu_{sp\,\min}$$

$$\frac{\pi \times 450 \times 50.30}{\frac{\pi}{4} \times 450^2 \times p} = 0.0088 \rightarrow p = 51 mm \rightarrow take\ p = 50 mm$$



Design of column (C2)

1-Loads

Slab loads

$$P_{slab} = \sum A_{slab} \times (t_s \times \gamma_{con.} + F.C + L.L)$$

$$P_{slab} = (5.0 \times 7.50 \times 4) \times (0.15 \times 25 + 2.00 + 5.00) = 1612.50 kN$$

Beam loads

$$P_{beam} = \sum L_{beam} \times b \times (t - t_s) \times \gamma_{con.}$$

$$P_{beam} = 15 \times 4 \times 0.30 \times (0.80 - 0.15) \times 25 = 292.50 kN$$

Wall loads

$$P_{wall} = zero$$

Tie reaction

$$P_{tie} = 1.10 \times \left[\sum A_{slab} \times (t_s \times \gamma_{con.} + F.C + L.L) + \sum L_{beam} \times b \times (t - t_s) \times \gamma_{con.}\right]$$

$$P_{tie} = 1.10 \times \left[\begin{array}{l}(5.0 \times 2.50) \times (0.15 \times 25 + 2.00 + 5.00) \\ + 7.50 \times 0.30 \times (0.80 - 0.15) \times 25\end{array}\right] = 188.03 kN$$

Total ultimate load

$$P_u = (P_{slab} + P_{beam} + P_{wall} + 0.50 P_{tie}) \times 1.10 \times 1.50$$

$$P_u = (1612.50 + 292.50 + 0.00 + 0.50 \times 188.03) \times 1.10 \times 1.50$$

$$P_u = 3298.37 kN$$

2-Design of section

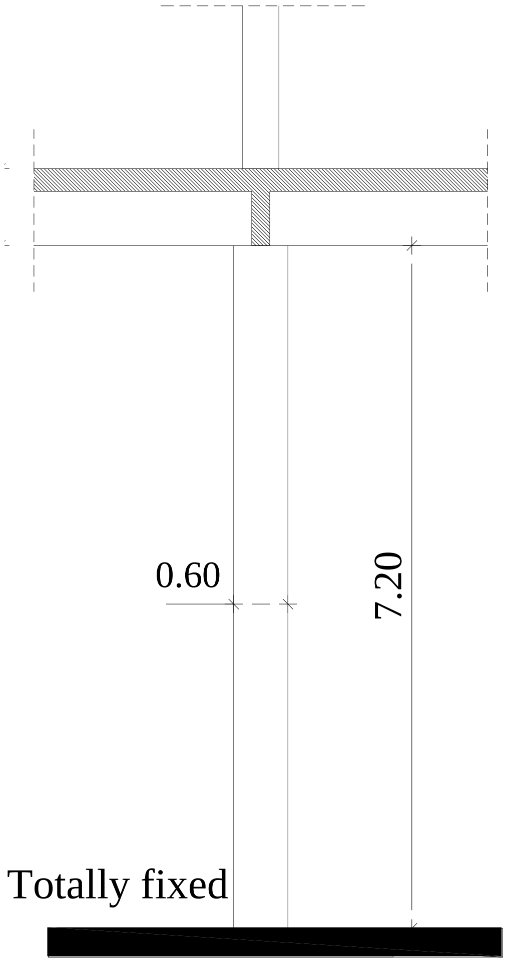
$$P_u \times 10^3 = 0.35 \times f_{cu} \times b^2 + 0.67 \times f_y \times A_{sc}$$

$$assume\ A_{sc} = \frac{1}{100} \times b^2$$

$$3298.37 \times 10^3 = 0.35 \times 25 \times b^2 + 0.67 \times 360 \times \frac{1}{100} \times b^2$$

$$b = 544 mm \quad \rightarrow \quad take\ b = 600 mm$$

3-Check buckling



A-In plan = Out of plan

H_o =7.20m

K=1.20 (fixed @ top, fixed @bottom, un braced building)

$$\lambda = \frac{KH_o}{D} = \frac{1.20 \times 7.20}{0.60} = 14.40 > 10$$

Long columnin two directions

$$\delta_{add.} = \frac{\lambda^2 \times b}{2000} = \frac{14.40^2 \times 0.60}{2000} = 0.06m$$

$$M_{uxadd.} = M_{uyadd.} = p_u \times \delta_{add.} = 3298.37 \times 0.06 = 197.90 kN.m$$

4-Design moment

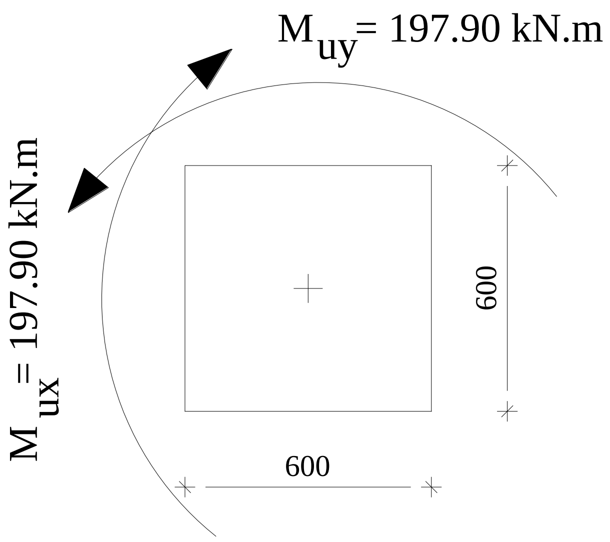
$$e_{\min} > 0.05b = 0.05 \times 600 = 30mm \;\; or \;\; 20mm$$

$$P_u \times e_{\min} = 3298.37 \times 0.03 = 98.95 kN.m$$

$$M_{udx} = M_{udy} = 197.90 kN.m$$

5-Design of section

The section subject to Bi-axial moment



$$R_b = \frac{N_u \times 10^3}{f_{cu} \times b \times t} = \frac{3298.37 \times 10^3}{25 \times 600 \times 600} = 0.37 \cong 0.40$$

$$\frac{M_{ux} \times 10^6}{f_{cu} \times b \times t^2} = \frac{197.90 \times 10^6}{25 \times 600 \times 600^2} = 0.04$$

$$\frac{M_{uy} \times 10^6}{f_{cu} \times t \times b^2} = \frac{197.90 \times 10^6}{25 \times 600 \times 600^2} = 0.04$$

$$f_y = 360 Mpa \qquad \qquad \xi = 0.90$$

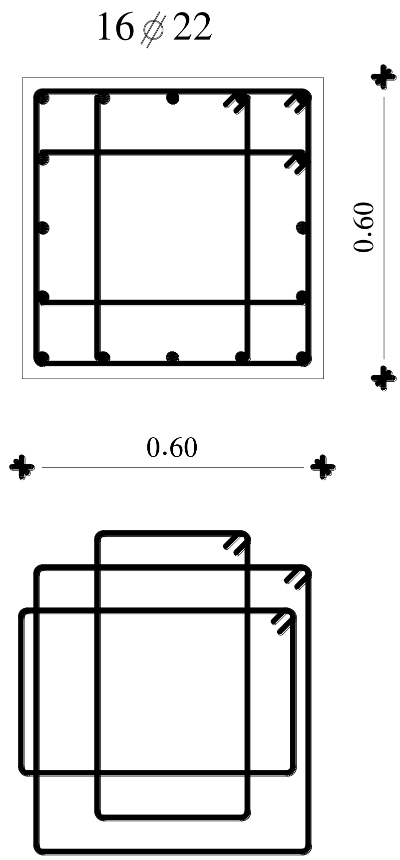
$$use \;\; Bi-axial \;\; I.D$$

$$\rho = 6.00 \qquad \mu = \rho \times f_{cu} \times 10^{-4} = 6 \times 25 \times 10^{-4} = 0.015$$

$$\mu_{\min} = 0.25 + 0.052 \lambda_b = 0.25 + 0.052 \times 10.95 = 0.82\%$$

$$A_s = \mu \times b \times t = 0.015 \times 600 \times 600 = 5400 mm^2 \;\; use 16\phi 22$$

6-Reinforcement detailing



Design of column (C3)

1-Loads

Slab loads

$$P_{slab} = \sum A_{slab} \times \left(t_s \times \gamma_{con.} + F.C + L.L\right)$$

$$P_{slab} = 2.50 \times 5 \times 4\left(0.15 \times 25 + 2.0 + 5.0\right) = 537.50 kN$$

Beam loads

$$P_{beam} = \sum L_{beam} \times b \times (t - t_s) \times \gamma_{con.}$$

$$P_{beam} = (5 \times 5 + 2.50 \times 4) \times 0.30 \times (0.80 - 0.15) \times 25 = 146.25 kN$$

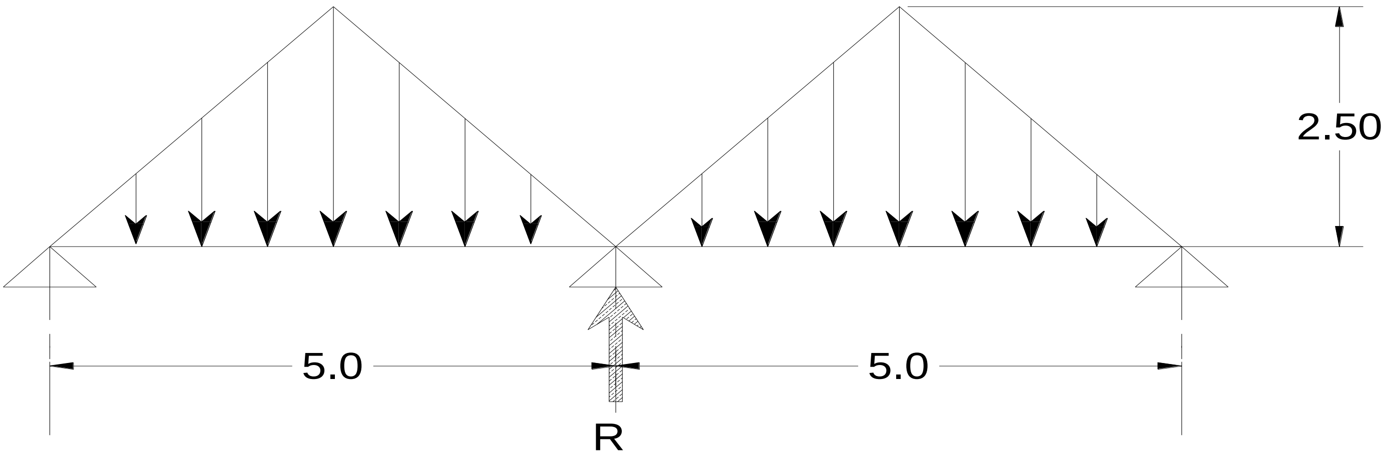
Wall loads

$$P_{wall} = \left(\sum L_{wall} \times h_{wall}\right) \times \text{int}\,ensity$$

$$P_{wall} = (5.0 \times 4 \times 3.20 + 1.25 \times 5.0) \times 5 = 351.25 kN$$

Cantilever loads

Load (for shear) on Beam at Axis (A~A):

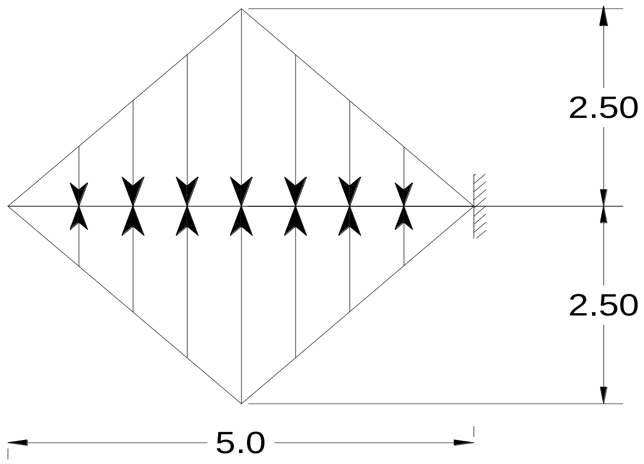


$$w_{sh} = b \times (t - t_s) \times \gamma_{con.} + \left(t_s \times \gamma_{con.} + F.C + L.L\right) X \beta$$

$$w_{sh} = 0.30 \times (0.80 - 0.15) \times 25 + \left(0.15 \times 25 + 2.0 + 5.0\right) \times 2.50 \times 0.50 = 18.31 kN/m$$

$$R = w_{sh} \times L = 18.31 \times 5 = 91.55 kN$$

Load cantilever beam:

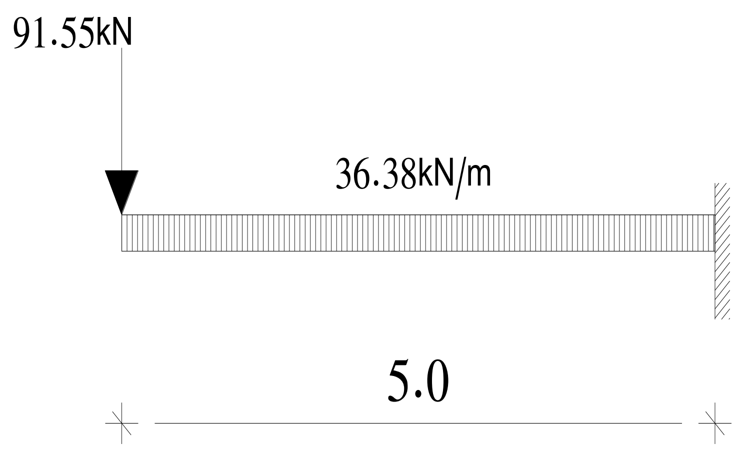


$assume\, b_{can.} = b_{col.} = 400mm$

$$t_{avr} = \frac{1.40 + 0.80}{2} = 1.10m$$

$$w_{sh} = b \times (t - t_s) \times \gamma_{con.} + (t_s \times \gamma_{con.} + F.C + L.L) X \beta$$

$$w_{sh} = 0.40 \times (1.10 - 0.15) \times 25 + (0.15 \times 25 + 2.0 + 5.0) \times 2.50 \times 0.50 \times 2 = 36.38 kN/m$$



$$reaction of\ cantiliver (R_{can.}) = 91.55 + 36.38 \times 5.00 = 273.45 kN$$

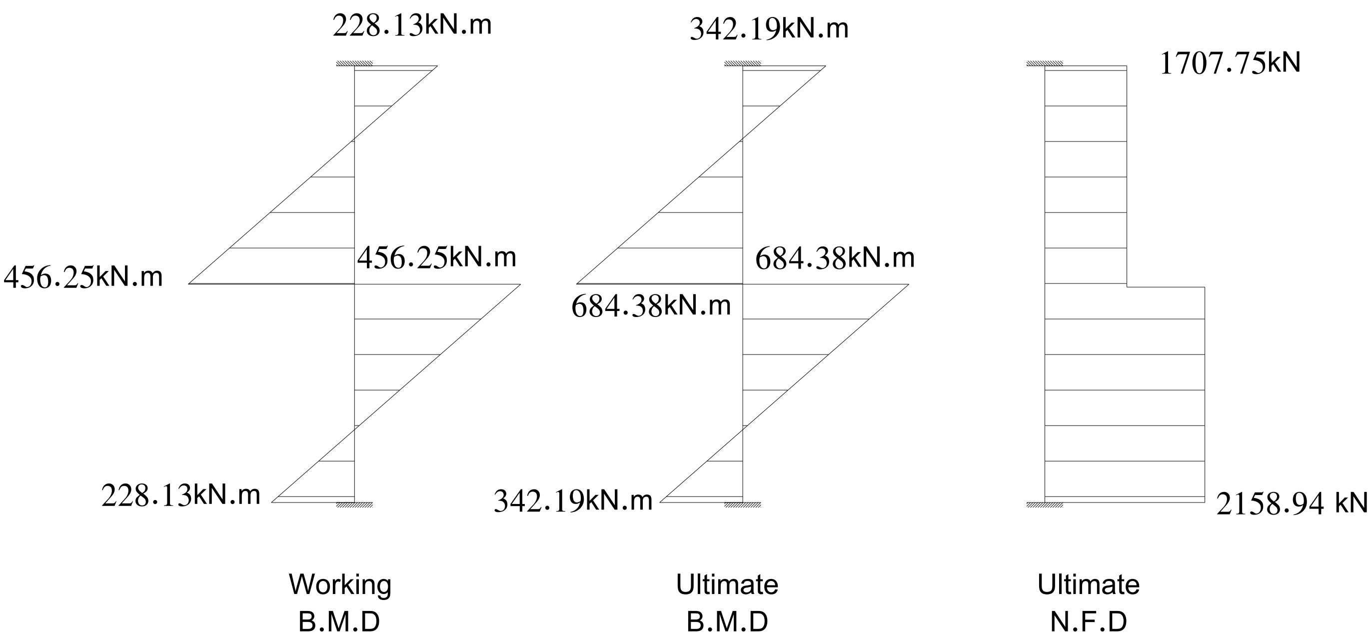
$$M_{can} = 91.55 \times 5.00 + \frac{36.38 \times 5.00^2}{2} = 912.50 kN.m$$

Total ultimate load

$$P_u = \left(P_{slab} + P_{beam} + P_{wall} + P_{cant.}\right) \times 1.10 \times 1.50$$

$$P_u = \left(537.50 + 146.25 + 351.25 + 273.45\right) \times 1.10 \times 1.50$$

$$P_u = 2158.94\,kN$$



Critical sections:-

Sec. No.	P_u (kN)	M_u (kN.m)
1	-2158.94	342.19
2	-2158.94	684.38
3	-1707.75	684.38
4	-1707.75	342.19

$b = 400mm\ Given$

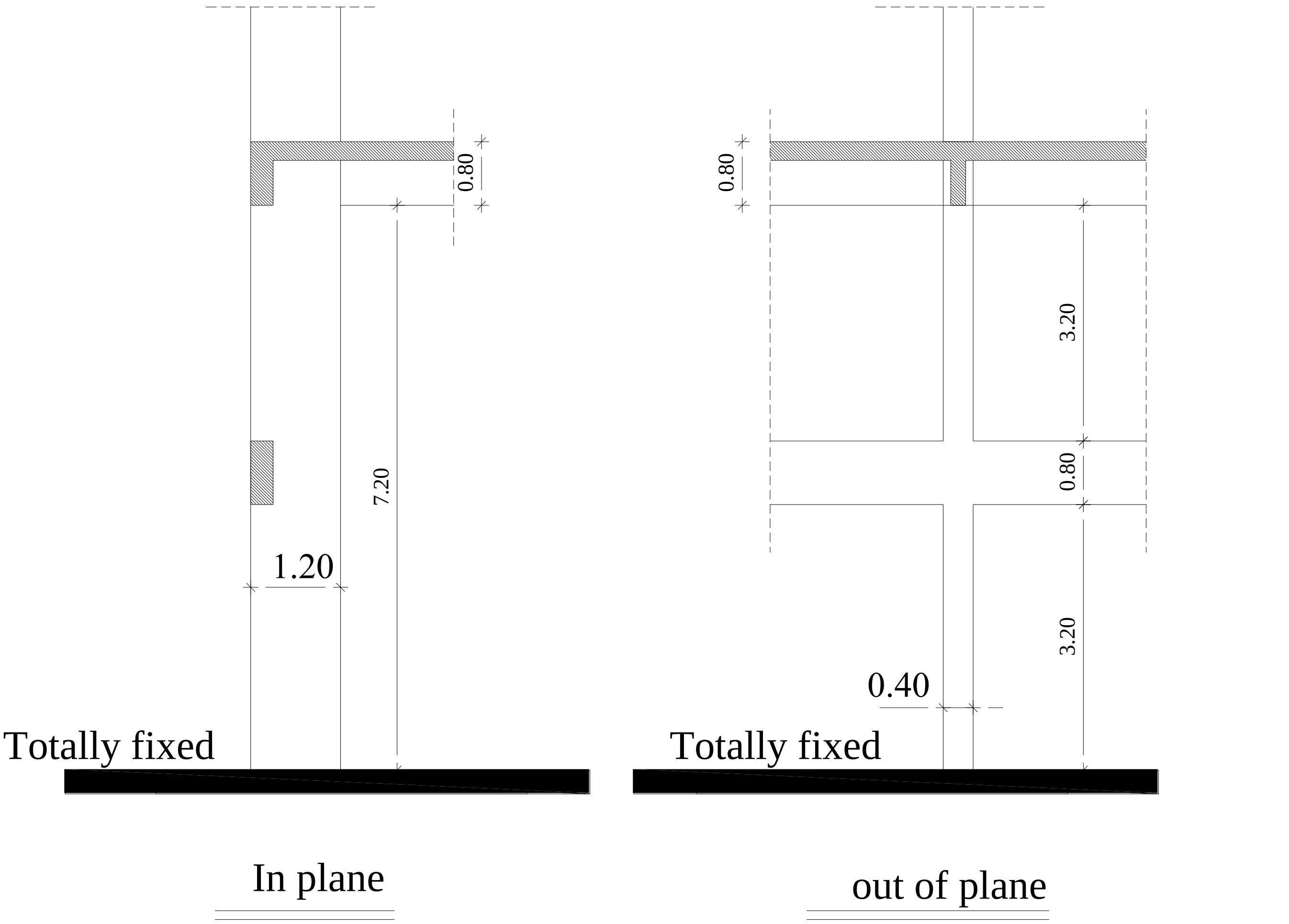
$P_u \times 10^3 = 0.35 \times f_{cu} \times b \times t + 0.67 \times f_y \times A_{sc}$

$assume\ A_{sc} = \frac{1}{100} \times b \times t$

$2158.94 \times 10^3 = 0.35 \times 25 \times 400 \times t + 0.67 \times 360 \times \frac{1}{100} \times 400 \times t$

$t = 484mm \quad \rightarrow \quad take\ t = 0.80 t_{cant.} = 0.80 \times 1400 = 1120mm \rightarrow t = 1200mm$

3-Check buckling



A-In plan

H_o =7.20m

K=1.30 (partially fixed @ top, totally fixed @bottom, un braced building)

$$\lambda_t = \frac{KH_o}{t} = \frac{1.30 \times 7.20}{1.20} = 7.80 < 10 \quad Short\,column$$

B-out of plan

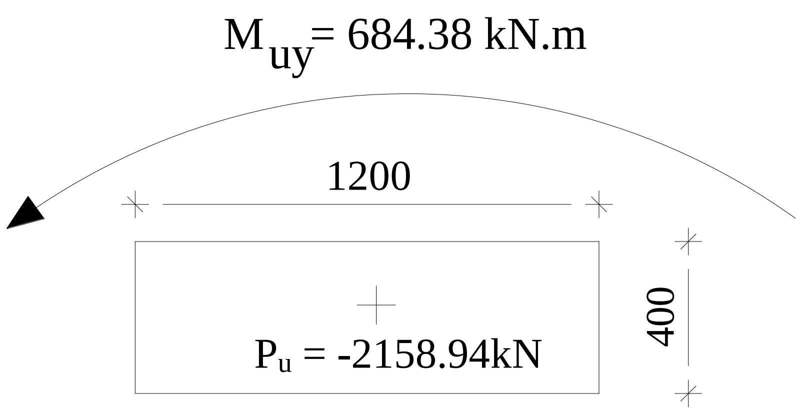
H_o =3.20m

K=1.20 (totally fixed @ top, totally fixed @bottom, unbraced building)

$$\lambda_b = \frac{KH_o}{b} = \frac{1.20 \times 3.20}{0.40} = 9.60 < 10 \quad Short\,column$$

4-Design of section

The section subject to Bi-axial moment



Tanta University | Department: **Civil Engineering** | Faculty of Engineering
Total Marks: **75 Marks**

Course Title:	Course Code:	2^{nd} year
Design of Reinforced Concrete Structures (1) b	**CSE2205**	
Date: **June 8th 2014 (Second term exam)**	Allowed time: **4 hrs**	**No. of Pages: (3)**

1- Eccentricity

$$e = \frac{M_u}{N_u} = \frac{684.38}{2158.94} = 0.32m$$

$$e/t = \frac{0.32}{1.20} = 0.26 > 0.05 \rightarrow Not\ Zone\ A$$

2-K

$$K = \frac{N_u \times 10^3}{f_{cu} \times b \times t} = \frac{2158.94 \times 10^3}{25 \times 400 \times 1200} = 0.18 > 0.04 \rightarrow Not\ Zone\ D$$

3- e/t

$$\because e/t = 0.26 < \frac{1}{3} \rightarrow Zone\ B\ (Compression\ failure)$$

$$\because e/t = 0.26 > 0.20 \rightarrow Double\ R.F.T.\ Interaction\ Diagram$$

4- Double R.F.T. Interaction Diagram

$$K = 0.18$$

$$K\frac{e}{t} = 0.18 \times 0.26 = 0.05$$

$$f_y = 360\ N/mm^2$$

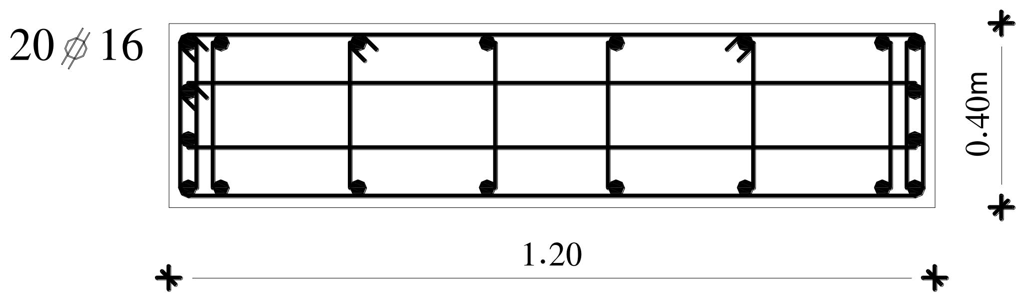
$$\xi = \frac{d - d'}{t} = \frac{1200 - 50}{1200} = 0.95 \approx 0.90$$

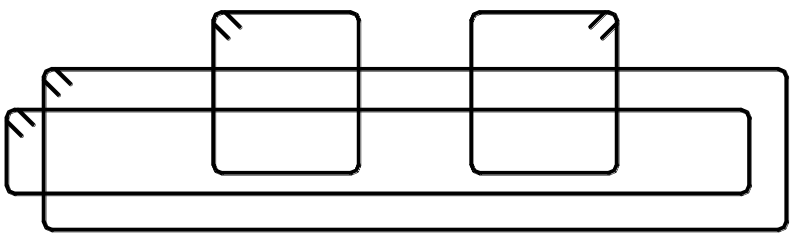
$$\alpha = \frac{A'_s}{A_s} = 1.0$$

$$From\ I..D \rightarrow \rho = 1.0 \rightarrow \mu = \rho \times f_{cu} \times 10^{-4} = 1.00 \times 25 \times 10^{-4} = 25 \times 10^{-4}$$

$$A_s = A'_s = \mu \times b \times t = 25 \times 10^{-4} \times 400 \times 1200 = 1200 mm^2 \rightarrow Use\ 6\phi 16$$

5-Reinforcement detailing





Design of Tie

1-Loads

Slab

$$P_{slab} = A_{slab} \times \left(t_s \times \gamma_{con.} + F.C + L.L\right)$$

$$P_{slab} = 2.50x5 \times \left(0.15 \times 25 + 2.00 + 5.00\right) = 134.375kN$$

Beam

$$P_{beam} = b \times \left(t - t_s\right) \times \sum L_b \times \gamma_{con.}$$

$$P_{beam} = 0.30 \times \left(0.80 - 0.15\right) \times 7.50 \times 25 = 36.56kN$$

Total load

$$T_u = \left(P_{slab} + P_{beam}\right) \times 1.10 \times 1.50$$

$$R_u = \left(134.375 + 36.56\right) \times 1.10 \times 1.50 = 282.05kN$$

2-Design of tie

$$A_s = \frac{T_u \times 10^3}{f_y / \gamma_s} = \frac{282.05 \times 10^3}{360 / 1.15} = 901mm^2 \quad use 8\phi 12$$

$$A_c = b^2 = 40A_s = 40 \times 8 \times 113 = 36160mm^2$$

$$b = 190mm \quad take \rightarrow b = 250mm$$

3 -Reinforcement detailing