UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: November 2016

Module Number: CE4301 **Module Name: Design of concrete structures I**

[Three Hours]

[Answer **all questions.** All questions carry equal marks]

BS8110 Part I: 1997 is provided. Graph sheets provided shall be used for Q2.(d) and Q3.(c)

Q1 a) Among the different design philosophies like working stress method and load factor method, explain how the limit state approach coupled with different partial safety factors for materials and loads adopted by BS8110:1997 ensure safer and more economical reinforced concrete design.

[4 Marks]

b) Explain how the design provisions under BS8110:1997 have ensured yielding of tensile reinforcement before concrete crushing (under reinforced section) and prevented the occurrence of premature shear failure in reinforced concrete flexural elements.

[4 Marks]

c) Fig. Q1.(c) shows cross section detail of a reinforced concrete beam. Taking into account the reinforcement in both top and bottom, calculate sagging moment capacity of the section under the current orientation. Take f_{cu} of concrete is 40 N/mm^2, yield strength of QST bar is 500 N/mm^2, cover to all reinforcement is 50mm and shear links used is of 8mm diameter.

[4 Marks]

Q2 a) Fig. Q2 a) shows slab with panel dimensions of 6 m X 6 m. Slab is subjected to a uniformly distributed imposed load of 4 kN/m^2. Take density of the 175 mm thick reinforced concrete slab as 25 kN/m^3 and load from slab finishes as 1 kN/m^2. Considering 1 m wide strips across two perpendicular direction of the panel E and carrying out moment distribution based on moment coefficients in Table 14 of the BS8110:1997, calculate the final design bending moments for the internal slab panel E.

[4 Marks]

b) Calculate the reinforcement requirement for bending at all phases of the slab panel E. Cover to reinforcement shall be taken as 25 mm. All reinforcement requirements shall be provided using 10 mm diameter QST steel bars conforming to SLS 375 and BS 4449. Take the strength of concrete as 30 N/mm^2 and design strength of QST bars as 500 N/mm^2.

[3 Marks]

c) Check for reinforcement requirement for crack control and deflection of the slab panel E above.

[2 Marks]

d) Provide final reinforcement detail of the slab panel E with due consideration to bending, torsion reinforcement requirement at the corners, deflection, reinforcement requirement for crack control and minimum reinforcement requirement for rectangular sections.

[3 Marks]

Q3 Bending moment diagram and shear force diagram of a continuous beam ABCD is shown in the Fig. Q3. Assume the cross section dimension for the beam as 300x500 mm and cover to all reinforcement as 25 mm. Take the strength of concrete as 35 N/mm^2 and design strength of QST bars as 500 N/mm^2. All the requirement of shear reinforcement is provided through diameter 8 mm mild steel having yield strength of f_{yv} -250 N/mm^2.

a) Calculate the reinforcement requirement of the beam at supports and at the middle between beam supports. Consider 150 mm thic slab spanning 5m is available at either side of the beam in designing the beam sections for sagging moment.

[4 Marks]

b) With due consideration the shear force distribution along the beam and shear capacity enhancement close to the support, calculate the shear reinforcement requirement at critical sections to suggest a scheme for providing shear reinforcement for the beam ABCD .

[4 Marks]

c) Based on the answer to Q3. a), Q3. b) and due consideration for detailing rules (i.e. anchorage, lap length and curtailment of reinforcement) draw the reinforcement detail of the beam ABCD.

[4 Marks]

Q4 Details of a ground floor and a first floor column of a four story brazed frame with individual footing connected at the ground level and beams having 500 mm X 300 mm cross section connected at floor levels are shown in Fig. Q4. The height of the column in the ground floor, from the top of foundation to top of the first floor is 6 m, whilst, rest of the floor to floor height is 3.5m. The foundation is an individual pad footing of the type whilst not specifically design to take moment will nevertheless provide some restraint against bending.

a) Find the longitudinal reinforcement requirement for the Ground floor column under the ultimate limit state loading given in the Table Q4 (a). Consider column of 300mm square section. Take concrete Grade as C40 (40 N/mm^2), Reinforcement Grade 500 (500 N/mm^2). Assume d/h=0.9. The intersection curves for the column are given as Annex -1.

Table Q4(a)

Axial Load	Moment about major and minor axis (kNm)	
	X-X Axis	Y-Y Axis
	Top	Top
1800 KN	76	68

[8 Marks]

b) Find the reinforcement detail of a column located between the 1st and 2nd floors of which loading at ultimate limit state are given in the Table Q4.(b). Assume same design data specified for the ground floor column in Q4.(a) for Q4.(b).

Table Q4(b)

Axial Load	Moment about major and minor axis (kNm)			
	X-X Axis		Y-Y Axis	
	Top	Bottom	Top	Bottom
1300 KN	54	-28	44	-24

[4 Marks]

Q5. An internal column 300 mm × 300 mm carrying un-factored dead load of 750 kN and an un-factored imposed load of 450 kN is founded on an individual footing. The allowable bearing capacity of the soil in the site is estimated to be 150 kN/m^2.

a) Punching shear at the column and pad connection is an important additional design consideration for individual footings. Explain this statement in the light of the traditional slab beam column connection and how the punching shear capacity can be enhanced in pad column connection if it is found to be inadequate.

[2.0 Mark]

b) Design a square base individual footing to transmit the above loads to the ground. Assume Grade 30 concrete and Grade 500 QST steel reinforcement for the design. Use single diameter to provide reinforcement requirement at the base. Cover to all reinforcement shall be maintained at 50mm.
(Hint: line bending, line shear and punching shear have to be checked before deciding the final reinforcement requirement. Initial trail depth (d) for the footing shall be based on $d = 10\,N^{0.5}$ where d is in mm N (axial load) is in kN. The footing has to be designed to resist only axial loads)

[10 Marks]

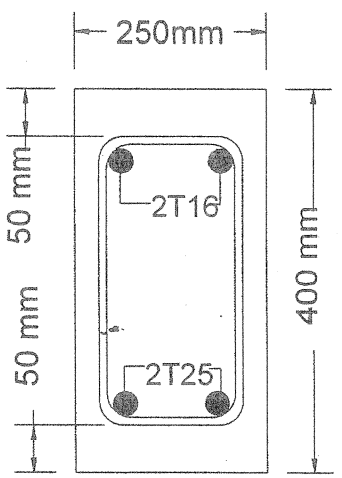
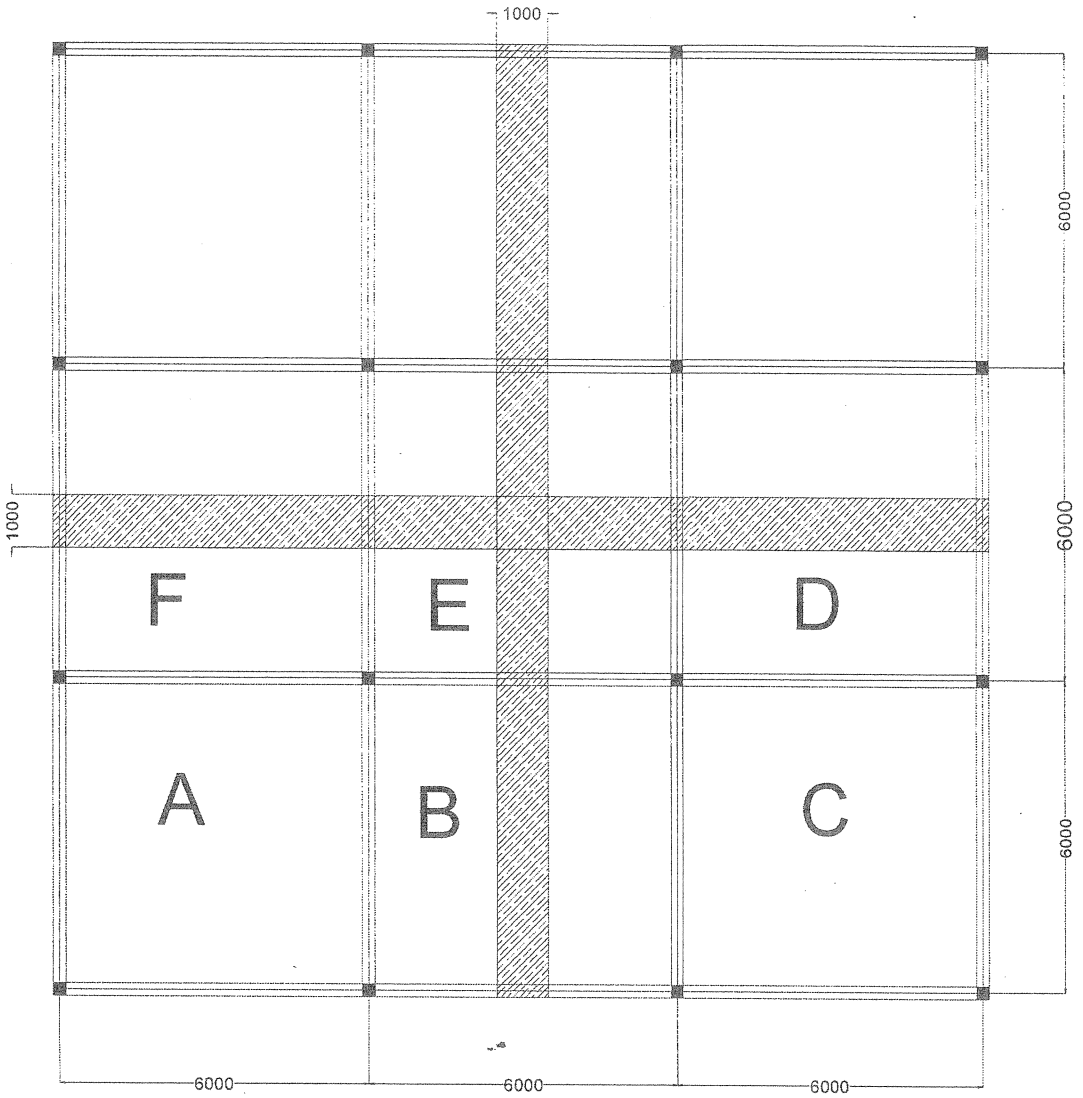
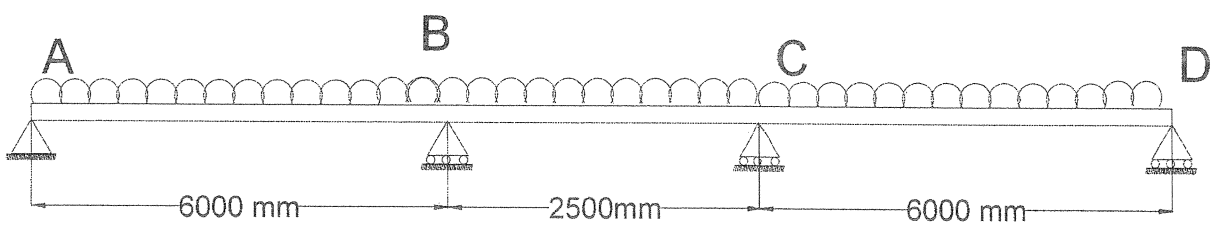
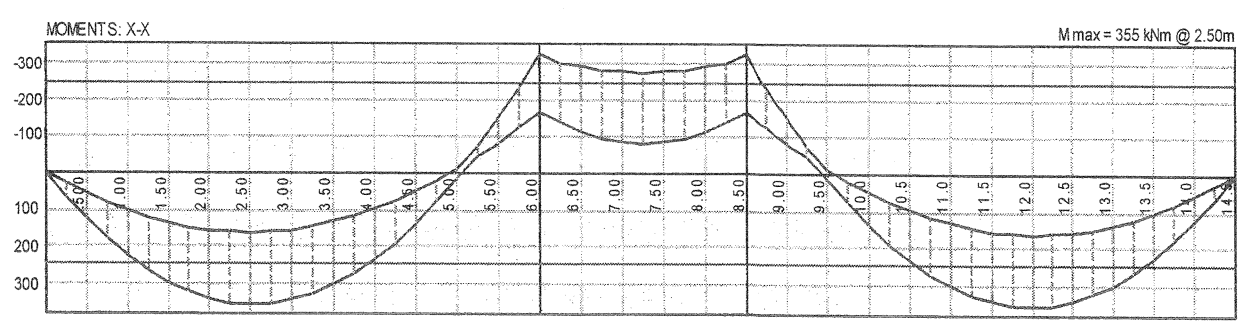


Fig. Q1(c) Beam Cross section

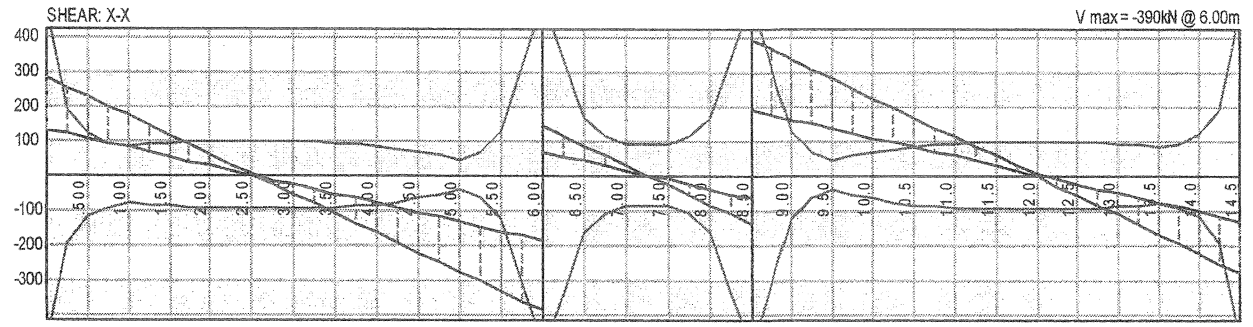


Font type? → **Fig. Q2 (a) Plane view of the slab panel and 1m width strips to be considered for moment distribution**



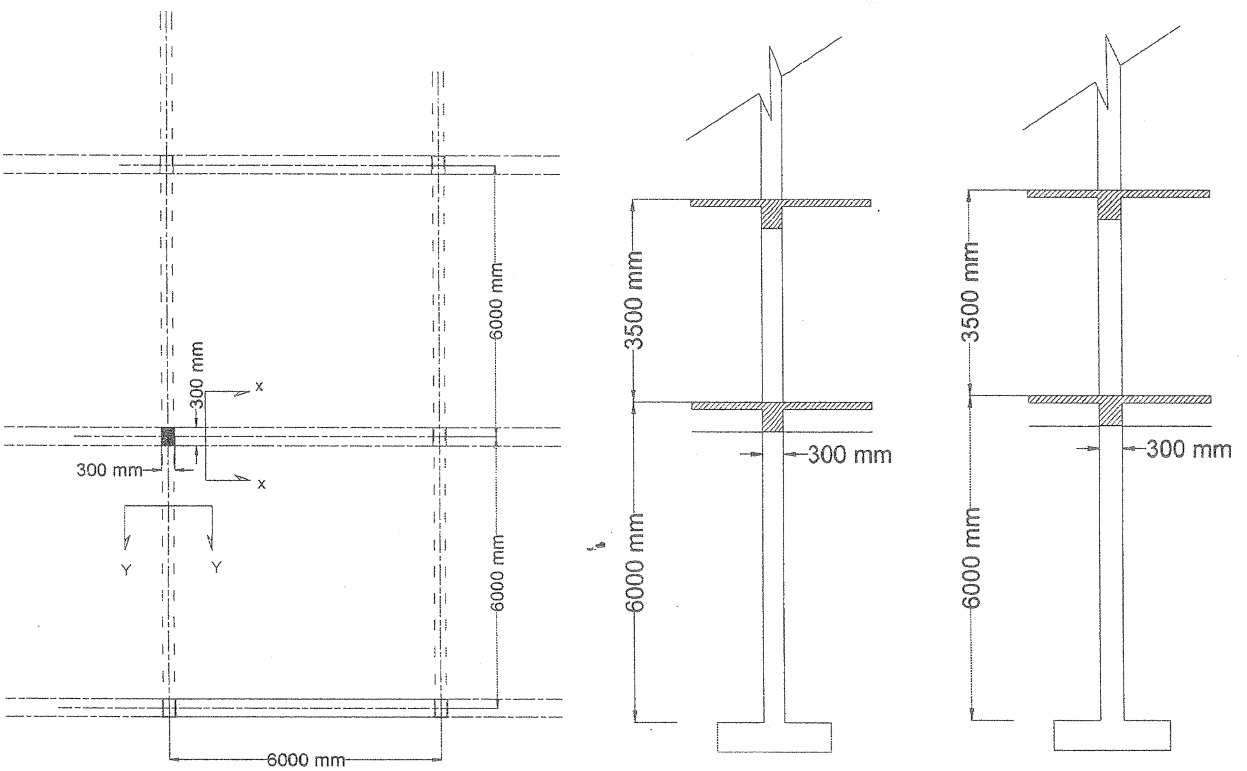


Bending moment envelop



Shear force envelop

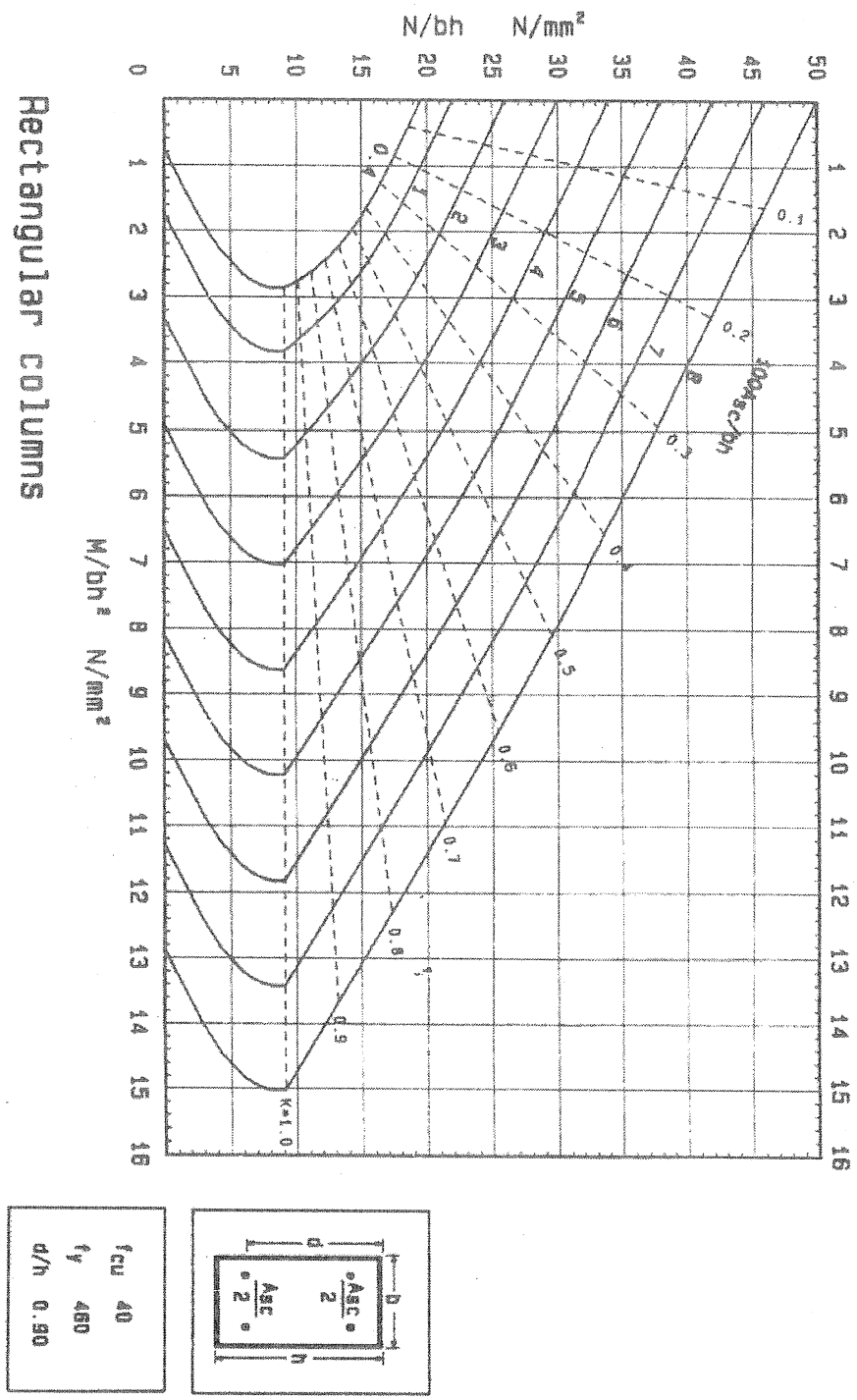
Fig. Q3 Bending moment and shear force evelops



(i) Plan view (ii) Section X-X (iii) Section Y-Y

Fig. Q4 Plan view and cross sections of the ground floor and first floor column

Annex 1



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