UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: December 2018

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

[Three Hours]

[Answer **all questions.** Each questions carry twelve 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 with different partial safety factors for materials and loads adopted by BS8110:1997 ensure safer and more economical means of designing compared to other design philosophies.

[2.5 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.

[2.5 Marks]

c) Fig Q1.(c) show cross section detail of a reinforced concrete beam. Taking into account the reinforcement in both top and bottom, calculate required minimum flange thickness to make this section unreinforced section. Also calculate the moment carrying capacity of this section. Take f_{cu} of concrete is 30 N/mm^2, yield strength of QST bar is 500 N/mm^2, cover to all reinforcement is 50mm and that QST bars are used for both main reinforcements and shear reinforcement.

[7 Marks]

Q2 a) Fig. Q2 a) shows plan view of a slab with of 6 m X 6 m slab panels. Slab is subjected to a uniformly distributed imposed load of 5 kN/m^2. Take density of the 150 mm thick reinforced concrete slab as 24 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 C as shown in Fig. Q2 a). Taking initial fixed end moments based on moment coefficients found in Table 14 of the BS8110:1997, calculate the final design bending moments for the slab panel C.

[4 Marks]

b) Calculate the reinforcement requirement to satisfy bending moments calculated for the slab panel C of Q2 a) above. 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.

[2Marks]

c) Calculate reinforcement requirement for crack control and deflection of the slab panel C.

[3 Marks]

d) Provide final reinforcement detail of the slab panel C with due consideration to; bending, torsion reinforcement requirement at the corners, deflection, reinforcement

requirement for crack control and minimum reinforcement requirement for rectangular sections. (Use the graph paper provided)

[3 Marks]

Q3 Bending moment and shear force diagrams 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 10 mm diameter QST steel having same yield strength as above.

a) Calculate the reinforcement requirement of the beam at supports and at the middle between beam supports. Consider 150 mm thick monolithically cast slab spanning 5m in either side of the beam is available.

[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 and 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. (Use the graph sheets provided)

[4 Marks]

Q4 Dimensions of ground floor and first floor columns of a four story brazed 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 7.5 m, whilst, rest of the floor to floor height is 3.5m. All columns are founded on individual pad foundation of the type specifically design to take moment.

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 having 300mm square section. Take concrete grade as C35 (35 N/mm^2), reinforcement grade 460. Assume d/h=0.9. The intersection curves for the column are given as Fig. Q4 (a).

Table Q4(a)

Axial Load (Ultimate)	Moment about major and minor axis (kNm)	
	X-X Axis	
	Top	Bottom
1800 KN	64	-31

[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 (Ultimate)	Moment about major and minor axis (kNm)	
	X-X Axis	
	Top	Bottom
1300 KN	54	-28

[4 Marks]

Q5. An internal column 300 mm x 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. Applied

bending moment on the foundation is 31 kNm (Bending moment is applied about a single plane of bending). The allowable bearing capacity of the soil on the site is estimated to be 150 kN/m^2.

a) Punching shear at the connection between the column and pad connection is an important additional design consideration for individual footings. Explain this statement and how the punching shear capacity can be enhanced in pad column connection.

[2.0 Mark]

b) Design a rectangular individual footing to transmit the above loads to the ground. Take the longer dimension of the footing in the plane of bending. Ratio between the longer and shorter dimension 2:1. Assume grade 35 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 $d = 11.5\,N^{0.5}$ where d is in mm N (axial load) is in kN. The footing has to be designed to resist both the axial load and moment.

[10 Marks]

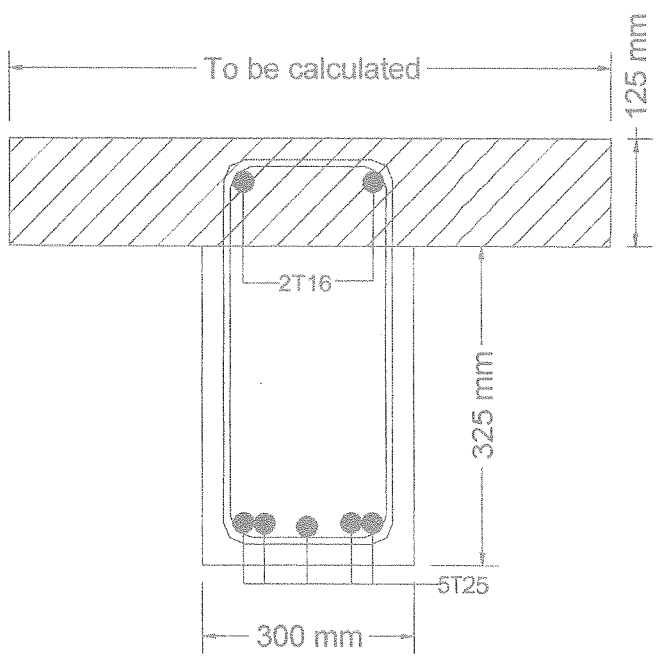


Fig. Q1(c) Beam Cross section

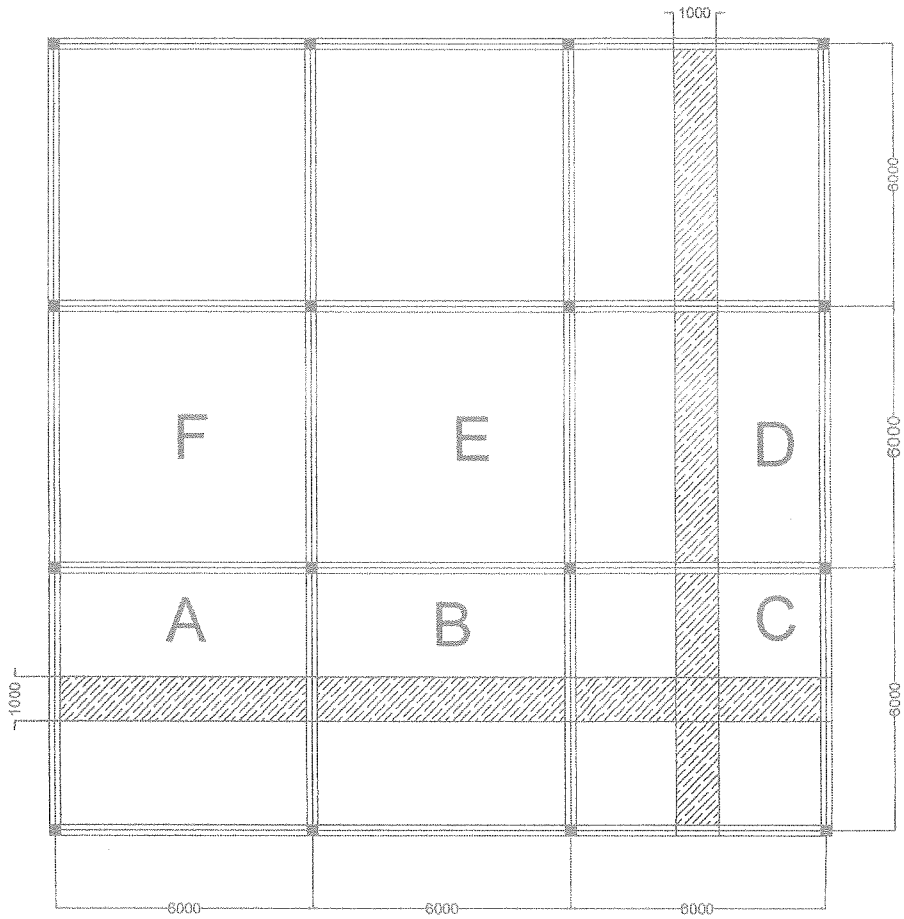
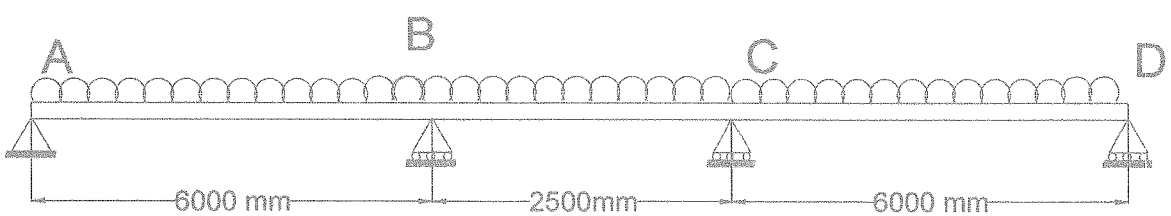
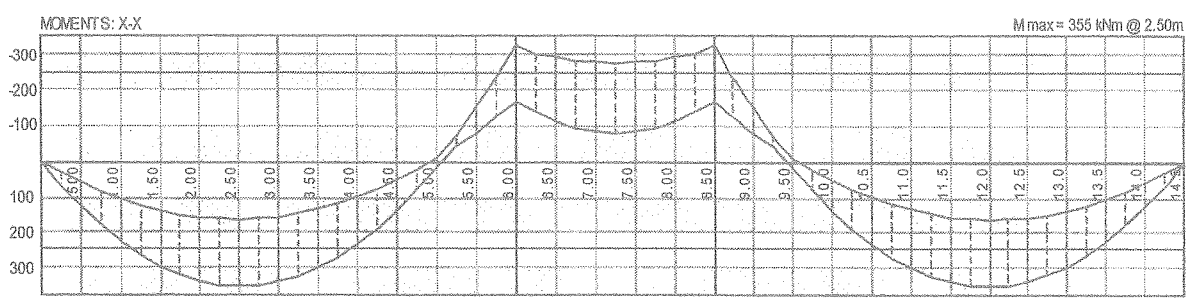
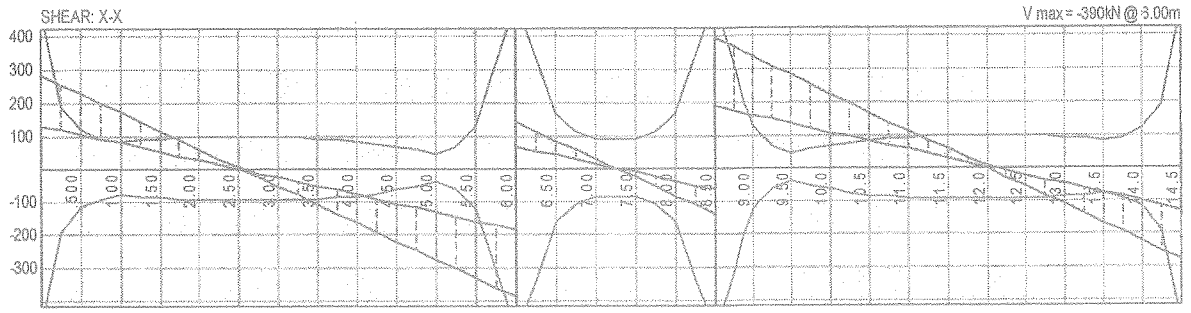


Fig. Q2 (a) Plane view of the slab panel and 1m width strips to be considered for moment distribution



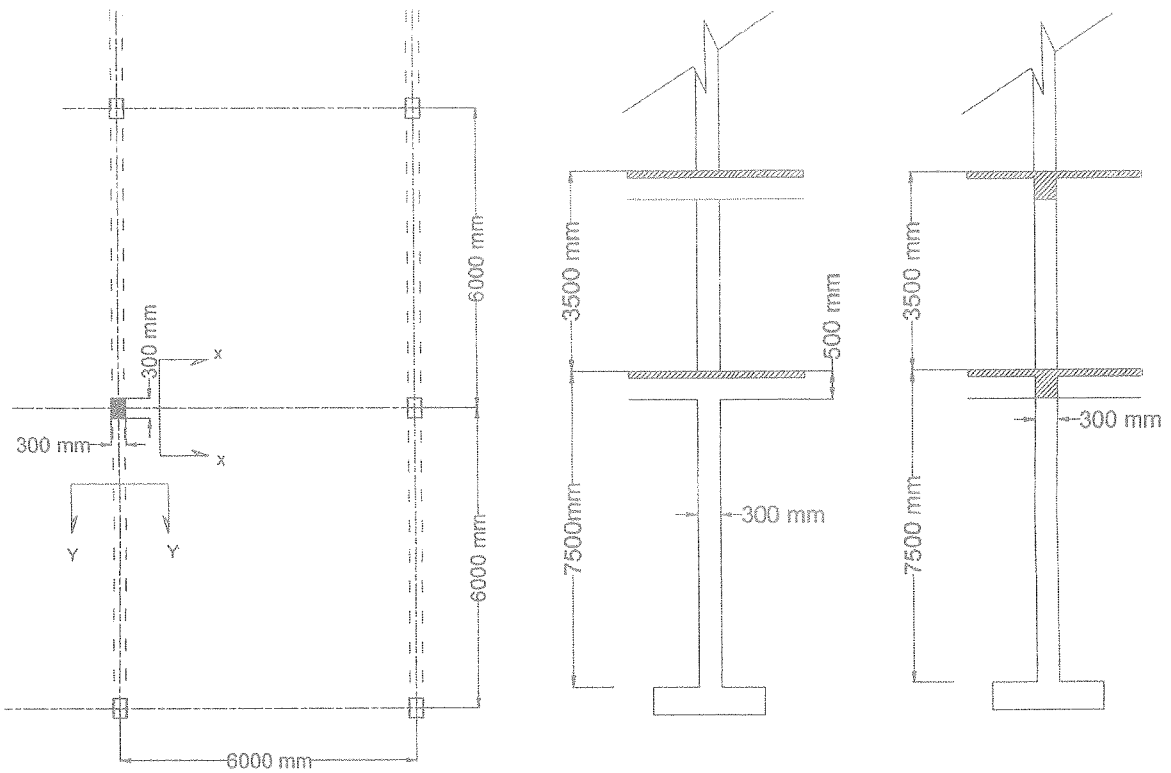


Bending moment envelop



Shear force envelop

Fig. Q3 Bending moment and shear force envelops of the beam ABCD



(a) Plan view (b) Cross Section X-X (c) Cross Section Y-Y

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

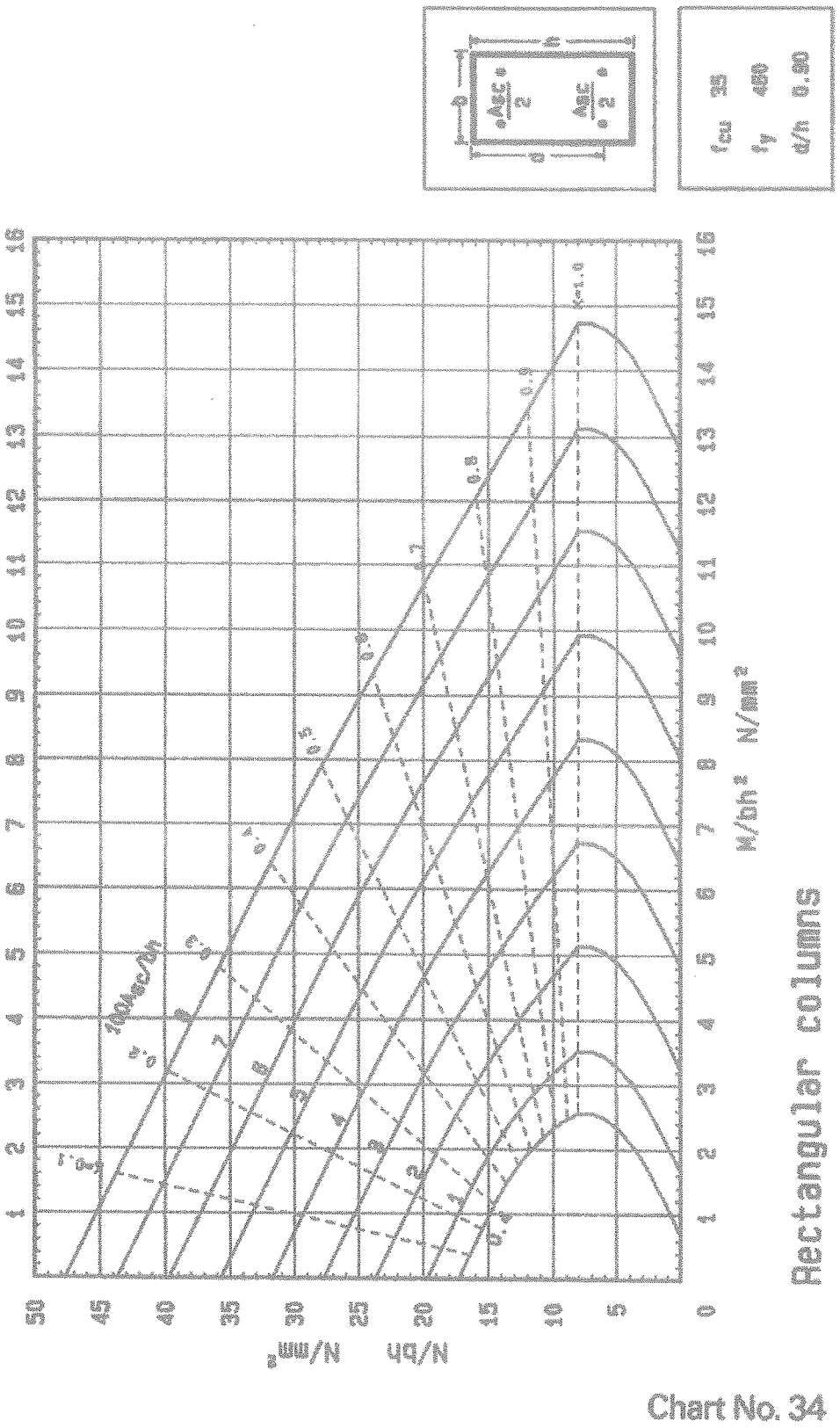


Fig. Q 4(a) Intersection diagram for column