UNIVERSITY OF RUHUNA

Faculty of Engineering

Mid-Semester 4 Examination in Engineering: November 2014

Module Number: CE4310 **Module Name:** Design of Concrete Structures I

[Two Hours]

[Answer **both questions**, question 1 carries 6 marks and question 2 carries 14 marks]

BS 8110 is provided

Q1. a) Explain the two terms under-reinforced and over-reinforced sections and derive appropriate relationship for the x/d (neutral axis depth /effective depth) ratio that will ensure under reinforced section of a singly reinforced flexural element. Assume $E_s = 200\ GPa$, $f_y = 460\ N/mm^2$ $\varepsilon_c = 0.0035$ (Ultimate strain at which concrete crushes due to compression), $\varepsilon_s = 0.002$ (Strain at which steel yields)

[1 Mark]

b) Explain by deriving the equation, how $k = 0.156$ in the equation $M = kf_{cu}bd^2$ can ensure under-reinforced section for the singly reinforced beam elements.

[2 Marks]

c) Rectangular beam 200 mm × 400 mm (see Fig. Q1) has a cover of 25mm. Diameter of the shear links used is 6 mm. The beam is reinforced with 06 Nos. of 25mm tore steel bars at the tension phase and no reinforcement is provided in the compression face. Assume $f_{cu} = 25\ N/mm^2$, $f_y = 500\ N/mm^2$, $E_s = 200\ kN/mm^2$. Where f_{cu} , f_y and E_s have their usual meaning

i) Considering that the section is over reinforced, calculate the moment capacity of the section using the first principals.

ii) Calculate the amount of compression reinforcement required to transform the above section back to an under-reinforced section.

iii) Calculate the new moment capacity of the doubly reinforced section proposed in Q1. c) ii).

[3 Marks]

Q2. a) Interior beam of a reinforced concrete frame and its cross section is shown in Fig. Q2. Take dead load of the structure including self weight is 25 kN/m and imposed load is 15 kN/m. Using moment-distribution method, draw bending moment and shear force envelopes for the idealized continuous beam considering all the possible load combinations at the ultimate limit state.
Consider constant EI values along the member.
(Plot the bending moment and shear force envelops in a graph sheet provided)

[4 Marks]

b) Assuming that the 250 mm×500 mm section is used for the continuous beam, determine the reinforcement steel required at the two intermediate supports. Consider the cover to all reinforcement is 25 mm and shear links are provided with 8 mm diameter mild steel bars. Take $f_{cu} = 25\ N/mm^2$, $f_y = 460\ N/mm^2$ $f_{yv} = 250\ N/mm^2$. Where f_{cu} , f_y and f_{yv} have their usual meaning

[2 Marks]

c) Calculate the reinforcement requirement at the middles of the three bea. Consider that the beam has a monolithically cast 125 mm thick slab at the top an that the slab spans 6 m either side of the beam before it finds next frame.

[2 Marks]

d) Based on the answers to Q2 b) and c) draw the reinforcement detail of the beam to scale clearly identifying all the bars. Assume that all the tor steel bars used for main reinforcement are 6 m long. Drawing should clearly identify all the lap length and anchorages provided and should be according to the detailing recommendations given in BS8110.

[2 Marks]

e) Calculate the maximum shear reinforcement requirement of the beam (in terms of spacing between links) assuming that only 8 mm mild steel are allowed as shear reinforcement. Take $f_{yv} = 250\ N/mm^2$

[2 Marks]

f) Based on the maximum and minimum shear reinforcement requirement propose a shear reinforcement detail for the above continuous beam.
(Include the shear reinforcement detail of the beam in the same drawing produced in Q2 (d))

[2 Marks]

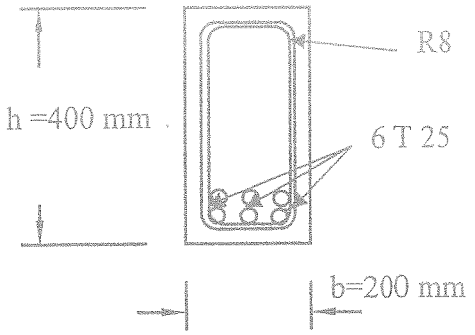
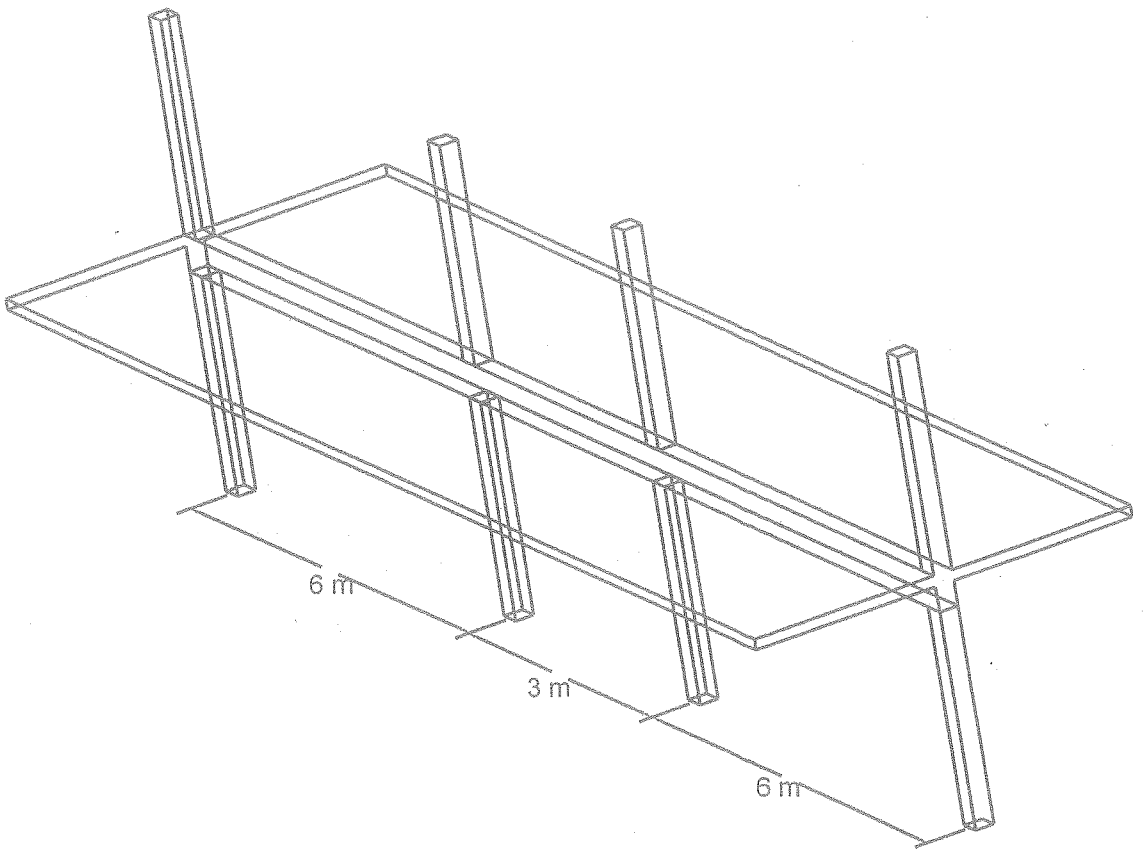
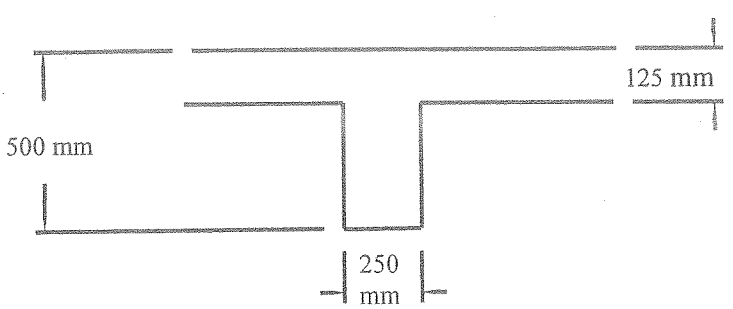


Fig. Q1



(a) Isometric view of the continuous beam



(b) Cross section of the beam slab connection

Fig. Q2