UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: December 2015

Module Number: CE4301 **Module Name: Design of Concrete Structures I**

[Three Hours]

[Answer **all questions**, all questions carry twelve marks each]
BS 8110 is provided

Q1. a) Rectangular beam 300 mm × 450 mm (see Fig. Q1 (a)) with an effective depth *(d)* of 402.5 mm is reinforced with 04 Nos. of 25mm diameter tore steel bars at the bottom and 02 Nos. of 16 mm diameter tore steel bars at the top. Take $f_{cu} = 30\ N/mm^2$, $f_y = 460\ N/mm^2$, $E_s = 200\ kN/mm^2$ and effective depth to top reinforcement *(d')* as 47.5 mm. Calculate the sagging moment carrying capacity of the section. Ignore the effect of the top reinforcement in the calculation.

[6 Marks]

b) Consider that composite concrete slab of 90mm is available at the top of the beam described in the Q1.a) and that 600mm width of the slab is effectively contributing to the beam flange action when the beam is subjected to sagging moment (see Fig. Q1 (b)). Calculate the new sagging moment capacity of the section considering the flange action of the slab. Ignore the effect of the top reinforcement in the calculation.

[4 Marks]

c) Discuss the advantages of considering the flange action in the beam design and requirements to consider the existing slab in beam design.

[2 Marks]

Q2. a) Two adjacent edges discontinuous 5m x 6m slab panel extracted from a sufficiently large slab is shown in the Fig. Q2. Slab is expected to support 4 kN/m^2 imposed load, self-weight of the deck (need to be calculated based on the density of concrete) and the loads from finishes amounting to 1 kN/m^2 (consider this as dead load). Take density of concrete as 24 kN/m^3 and calculate the critical moments at the continuous and discontinuous edges and in the mid-way of the slab panel. Take the thickness of the slab as 150 mm.

[4 Marks]

b) Calculate the critical reinforcement requirement at the beam supports and at the middle of the slab panel based on requirement to resist applied bending moment, control crack width and deflection criteria, and the minimum reinforcement requirement. Take cover to all reinforcement in the major direction of bending as 20 mm, $f_{cu} = 30\ N/mm^2$, $f_y = 500\ N/mm^2$, and the slab is reinforced with 10 mm diameter tore steel bars.

[4 Marks]

c) Calculate and check whether the adequate shear resistance is provided by the selected slab thickness.

[2 Marks]

d) Draw the reinforcement details of the slab panel showing all the necessary details for construction. This should include plan views and two orthogonal cross section views.

[2 Marks]

Q3 a) Fig. Q3 show continuous beam of equal span lengths located in a brazed frame, loaded uniformly with sufficient floor area that qualify the calculation of bending moment shear forces in accordance with clause 3.4.3 (Table 3.5) of BS8110. Total dead load including the self-weight of the beam is estimated to be 40 kN/m, whilst imposed load is 25 kN/m. Calculate the bending moment and shear forces according to the recommended coefficient available in Table 3.5 of BS8110.

[3 Marks]

b) Considering the cross sectional dimension of the beam as 300mm x500mm, and the effective depth to tension reinforcement *(d)* and compression reinforcement *(d')* as 452.5mm and 47.5 mm respectively, calculate the main reinforcement requirement of the beam at the two supports and the three mid span sections. Consider that 6 m wide slab 150mm thick is available either side of the beam. Take $f_{cu} = 35\ N/mm^2$, $f_y = 500\ N/mm^2$.

[4 Marks]

c) Assuming that all shear reinforcement is provided using 10 mm diameter tore steel; calculate the required minimum spacing of shear reinforcement at critical sections of the beam. Take yield strength of shear links $f_{yv} = 500\ N/mm^2$

[3 Marks]

d) Based on your calculation in part b) and c) complete the reinforcement detail of the beam ABCD and suggest improvements to design if any.

[2 Marks]

Q4 Plan view, and two cross sections of a ground floor column located in a brazed structure is shown in Fig Q4 (a). Column is connected to a moment carrying based at the bottom and monolithically cast beams in orthogonal directions at the first floor level (see Fig Q4 (a)). The two connecting beams have 300 mm x500 mm cross sectional dimensions. Based on results of a frame analysis, table below show bending moment of the column about minor and major axis. Column is square section with dimensions of 300 mm x300 mm. The height of the column from top of foundation to the top of the first floor level is 7.5m.

<table>
<tr><td>Axial Load</td><td colspan="2">Moment about major and minor axis of bending (kNm)</td></tr>
<tr><td rowspan="5">1800 KN</td><td colspan="2">X-X Axis (Major axis of bending)</td></tr>
<tr><td>Top</td><td>Bottom</td></tr>
<tr><td>78</td><td>-39</td></tr>
<tr><td colspan="2">Y-Y Axis (Minor Axis of bending)</td></tr>
<tr><td>68</td><td>-34</td></tr>
</table>

a) Calculate the effective length of the column about the major and minor axis and classify the column.

[2 Marks]

b) Based on above classification of the column, applied axial load and initial bending moment, calculate the reinforcement detail for the above column located in the ground floor level. Take concrete grade as G40 (40 N/mm^2), reinforcement grade as 460 (460 N/mm^2) and assume d/h of the column as 0.9. The relevant column interaction curve is given in the Fig. Q4 (b).

[6 Marks]

c) Explain how this calculation would change had the frame been considered was un brazed.

[4 Marks]

Q5. An internal column 300 mm×300 mm carries un-factored dead load of 900 kN and un-factored imposed load of 450 kN. The column is connected to simple pad footing not specifically designed to take bending moment. Bearing capacity of the soil is expected to be 150 kN/m^2.

a) Select suitable dimension (Length and breadth of the foundation (LxB)) and thickness for the pad foundation.
(Hint: 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.)

[2.0 Mark]

b) Based on the above description and selected foundation dimensions calculate the reinforcement detail for the critical section of the foundation. Consider grade 35 concrete and grade 500 Tore steel for the construction of the foundation. Cover to all reinforcement shall be 50mm.

[4Marks]

c) Calculate the line shear and punching shear and check whether the required resistances are provided by the selected cross sectional dimension and the thickness of the foundation considered in the Q5 a) above.

[6 Marks]

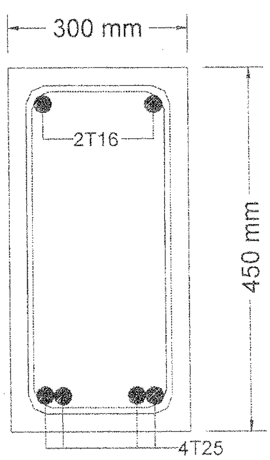

Fig. Q1 a) Rectangular section

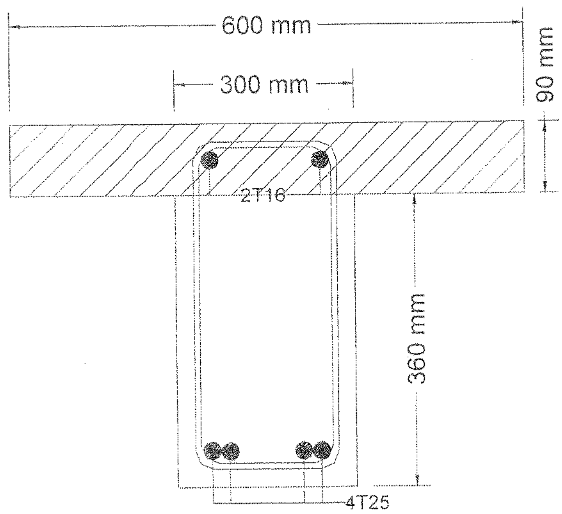

Fig. Q1 b) Flange section

Fig. Q1 Rectangular and flage beam section

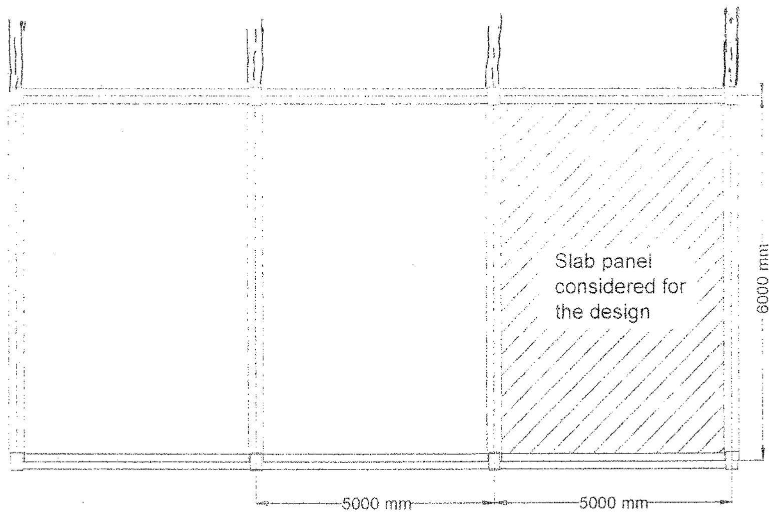

Fig. Q2 Corner slab panel with two adjacent edges discontinuous.

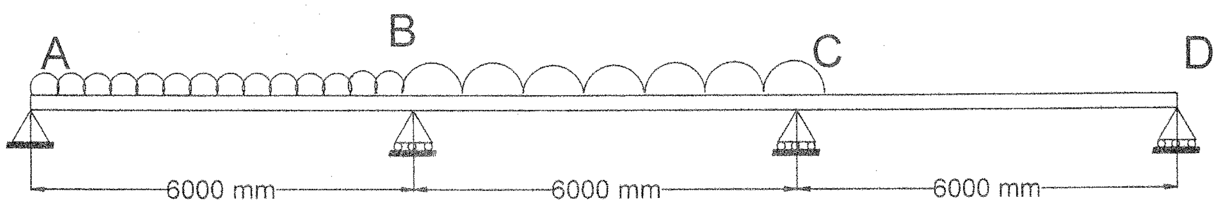

Fig. Q3 Continuous beam with 3 equal spans of 6000mm each

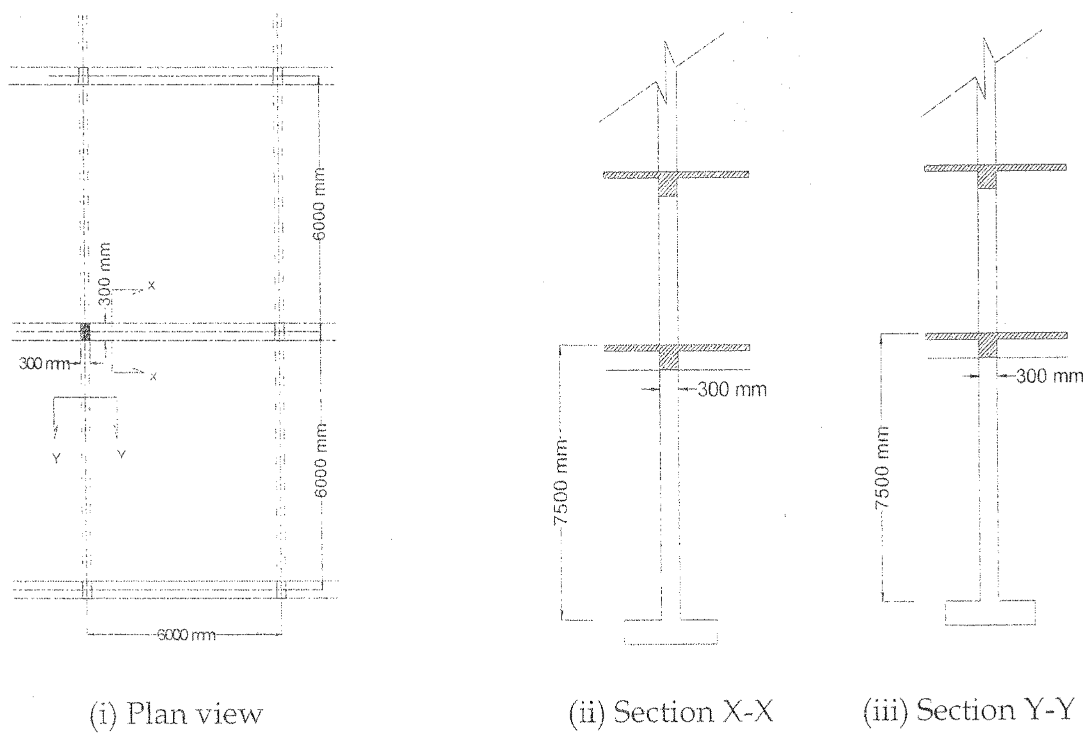

Fig. Q4 (a) Plan view and cross sections of the ground floor column

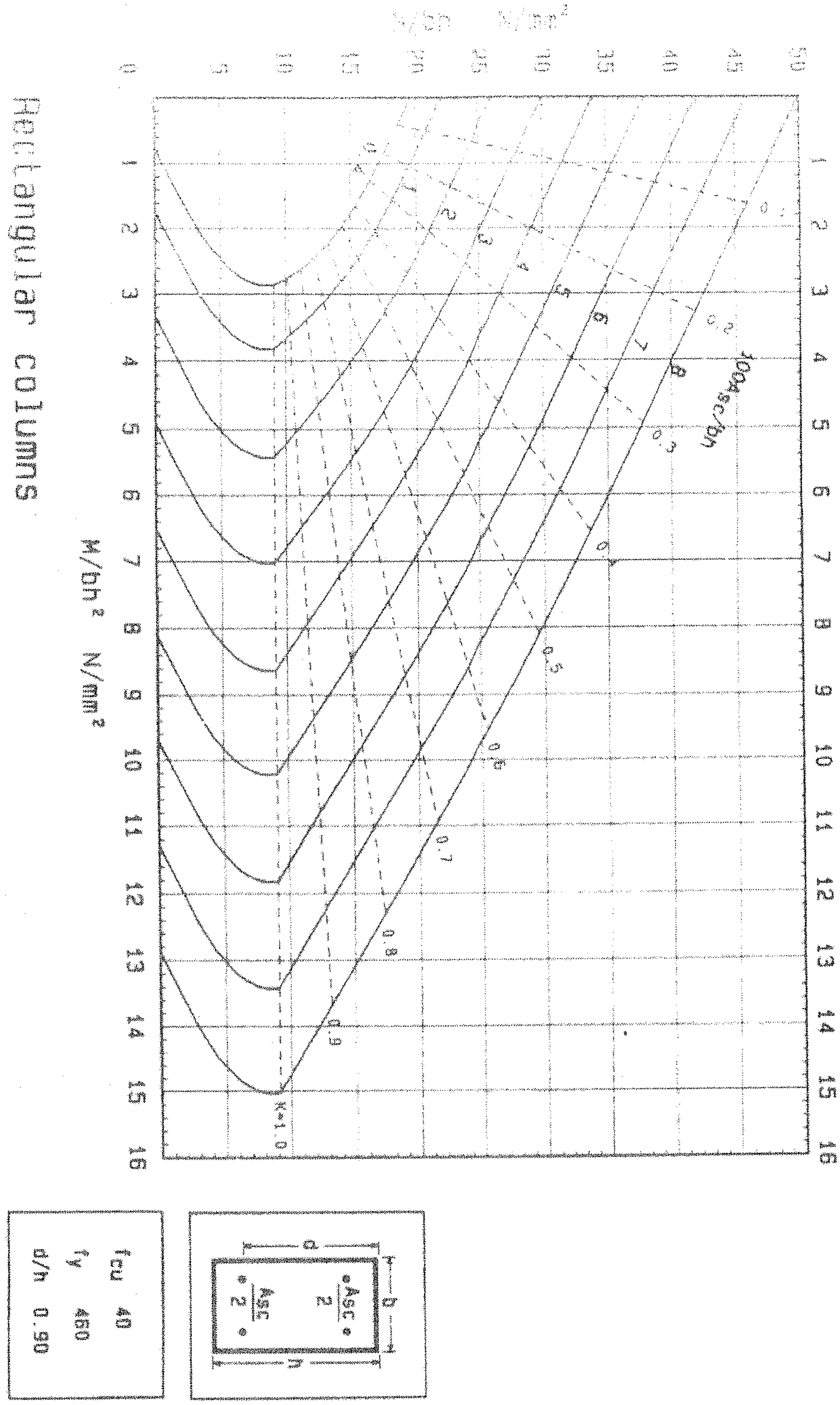

Fig. Q4 (b) Extract of the column interaction diagram for Grade 40 concrete