THE OPEN UNIVERSITY OF SRI LANKA
Department of Civil Engineering
Diploma in Technology (Civil)/Bachelor of Technology (Civil) - Level 4

CEX4231 – Structural Analysis and Design II

FINAL EXAMINATION – 2015/2016

Time Allowed: Three (03) Hours

Date: 2016 - 12 - 03 (Saturday) Time: 0930 - 1230 hrs.

Answer Five (05) questions with at least Two (02) questions from each section.
Necessary extracts from BS 8110 will be provided separately.

Section A - Structural Analysis

Q1.

(a) State two theorems of **Moment Area Method** using neat sketches. **(4 Marks)**

(b) A simply supported beam (PQ) is uniformly loaded as shown in Figure Q1(b). Using **Moment Area Method**, determine the vertical deflection at the point **R** of the beam. (EI is constant)

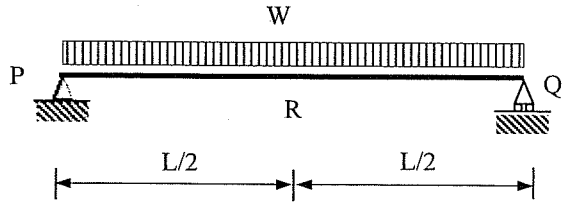

Figure Q1(b)

(6 Marks)

(c) Using the **Theorem of Three Moments Equation**, analyse the continuous beam (ABCD) shown in Figure Q1(c) and draw the bending moment diagram. (EI is constant)

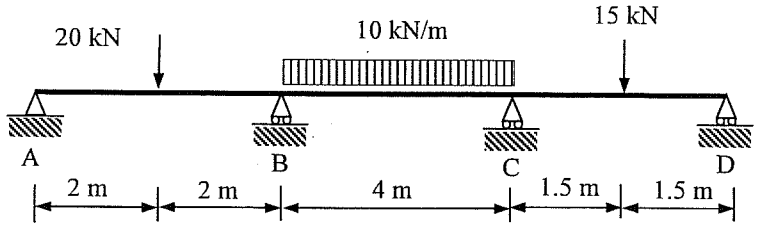

Figure Q1(c)

(10 Marks)

Q2.

(a) A fixed end beam (AB) is shown in Figure Q2(a). If the support A rotates by θ_A, obtain the resulting bending moments at both ends. Flexural rigidity of the beam is EI. (Hint: You may use Moment Area Method).

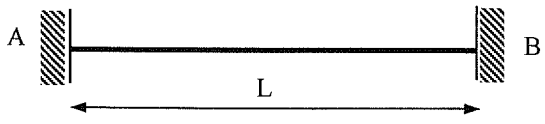

Figure Q2(a)

(8 Marks)

(b) A continuous beam (ABCD) is loaded as shown in Figure Q2(b). Second moment of area of the members AB and BC are same and it is twice than that of the member CD. Using **Slope Deflection Equations**, analyse the frame and draw the bending moment diagram.

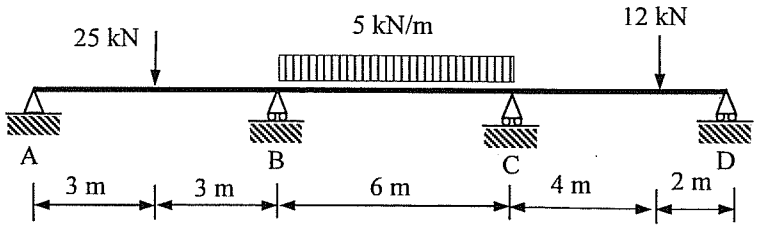

Figure Q2(b)

(12 Marks)

Q3.

(a) Describe following terms used in the **Moment Distribution Method**.

(i) Stiffness factor

(ii) Distribution factor

(iii) Carry over factor **(6 Marks)**

(b) A non-sway frame is shown in Figure Q3. Analyse the structure using **Moment Distribution Method** and draw the bending moment diagram. Second moments of area of members are shown close to respective members in the figure.

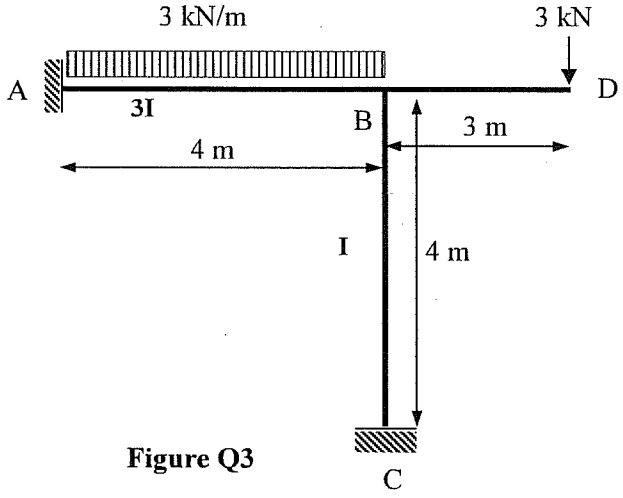

Figure Q3

(14 Marks)

Q4.

(a) Briefly explain following energy theorems.

(i) Principle of superposition

(ii) Reciprocal deflection theorem

(iii) Muller – Breslau principle **(6 Marks)**

(b) A cantilevered beam is loaded with end **point load P** as shown in Figure Q4. Using **Castigliano's second theorem**, determine the rotation and vertical deflection at end B of the beam.

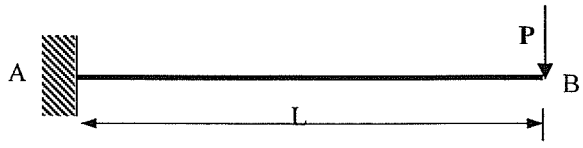

Figure Q4

(14 Marks)

Section B - Structural Design

All designs are to be done according to the recommendations of the Standard BS8110. For Questions 5, 6, 7 and 8 use data and parameters pertaining to the following structure.

A two storey power generation house is proposed to be constructed in a certain water tank in North Central Province. The structural engineer has decided on a framed reinforced concrete building. Exterior walls which are capable of resisting lateral loads are to be made with masonry block walls. Side elevation of the building is shown in Figure 5(a). Column and beam arrangement at the first floor level is shown in Figure 5(b).

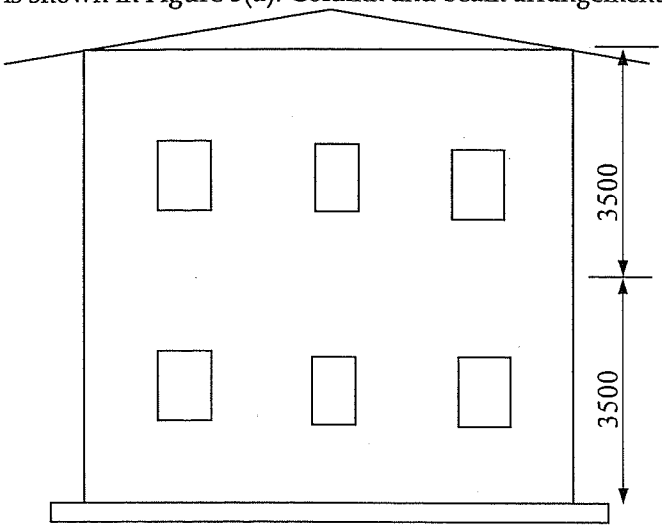

Figure 5(a) Side elevation

Notes:
* All walls are to be of 150 mm thick hollow block masonry.
* Slab is to be 125 mm thick.
* All longitudinal beams are to be 350 x 225, while transverse beams are to be 400 x 225.
* Column positions are as indicated in the plan.
* Columns are to be 225 mm square.
* Beams monolithic cast with the upper floor slab
* Wall loads may be assumed to be transferred directly down.
* Foundations are 1m below the ground surface.

All Dimensions are in 'mm'

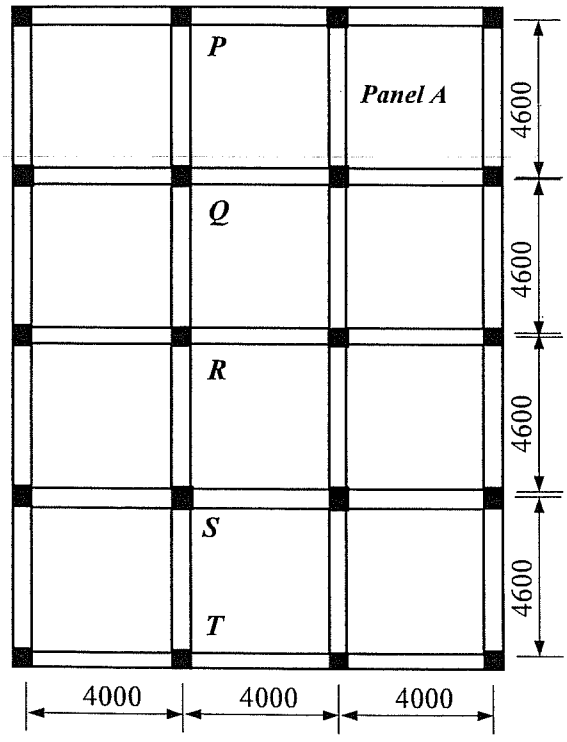

Figure 5(b) Column and beam layout

Material and Load Properties:

Concrete grade - C30
Grade of Steel fy-HT steel - 460 N/mm²
MS - 250 N/mm²

Unit weight of concrete - 24 kN/m³
Dead load by floor finishes - 0.5 kN/m²
Dead load by the roof - 1.0 kN/m²
Imposed load on floors - 3.5 kN/m²
Exposure condition - mild
Fire protection required - 1 hr
Allowable bearing pressure- 250 kN/m²

Q5. Using given data, design the **Panel A**, of the first floor assuming all loads are uniformly distributed. Follow the design steps given below.

(a) Decide on **nominal cover** for SLS durability and SLS fire resistance, calculate **characteristic** (dead and imposed loads due to nominal loads) and **design load** on the panel as area loads. **(2 Marks)**

(b) Identify the span conditions, end conditions and evaluate appropriate mid pan and over the support

moments for **ULS of flexure**. You may use the factors from Table given in the handout. **(5 Marks)**

(c) Design reinforcement against **ULS of flexure** to resist the bending moments at mid spans and over supports for the slab panel. (You may use 10 mm HTS for main reinforcements). **(5 Marks)**

(d) Check against **SLS of deflection** for the slab panel and if necessary, propose suitable modifications. **(4 Marks)**

(e) Sketch the reinforcement arrangement on a plan and one cross section of the slab panel using the **standard method of detailing**. (Not necessary to indicate curtailment lengths) **(4 Marks)**

Q6. Using data given pertaining to the structure given above, design the **Beam PQRST** (there are no walls along the beam), and following the steps (assume that effective beam section is rectangular and all loads are transferred to the beam uniformly distributed).

(a) Evaluate the **characteristic dead and imposed loads** transferred on to the beam and the **ultimate design load** as linear loads. **(3 Marks)**

(b) Calculate design bending moments and shear forces at the mid spans and support sections of the beam and sketch **bending moment** and **shear force diagrams**. **(4 Marks)**

(c) Design reinforcement for **ULS of flexure** at the critical sections (support and mid spans) of the beam. **(4 Marks)**

(d) Check for **ULS of shear** at critical sections of the beam and provide shear reinforcements required. (You may assume two or four legged 6mm MS shear stirrups) **(4 Marks)**

(e) Check against **SLS of deflection** of the beam based on conditions at the mid spans. Propose modifications only if this check fails. **(3 Marks)**

(f) Sketch the reinforcement arrangement of the beam at critical locations. **(2 Marks)**

Q7. Using the data pertaining to the structure given above, design the **Column Segment** from ground floor to 1st floor **at location R**, along the following steps,

(a) Determine the **type** of the column segment (braced/unbraced) about its two principal axes of the bending and state your reasons for such selection. **(2 Marks)**

(b) Evaluate the **effective heights** and the **slenderness ratios** of the column segment and determine the slenderness condition (short/slender), about both principal axes. Give logical reasons. **(4 Marks)**

(c) Evaluate the **characteristic loads** and calculate **design axial loads** and **design axial bending moments** (If any) acting on the column segment. You should pay due consideration to the moments created by eccentricity of loading and possibility of slenderness buckling in evaluating these values. **(4 Marks)**

(d) Determine the column reinforcement against **ULS of Compression and flexure** and shear links arrangement. **(6 Marks)**

(e) Produce a detailed reinforcement **sketch** with column in elevation and required cross sections, usingthe standard method of detailing. **(4 Marks)**

Q8. It has been decided to have a pad foundation for **column location at R**. Design the pad foundation using following steps.

(a) Decide on the preliminary size of a square footing based on axial load and soil bearing capacity. **(3 Marks)**

(b) Check soil bearing for supporting axial load and bending moments transferred by column. **(4 Marks)**

(c) Design the footing reinforcement against **ULS** flexure considering bending at the critical section of the footing. **(5 Marks)**

(d) Check the footing against **ULS direct shear** and propose any modifications if any. **(4 Marks)**

(e) Check the footing against **ULS punching shear** and propose any modifications if any. **(4 Marks)**