00102

THE OPEN UNIVERSITY OF SRI LANKA
Department of Civil Engineering/ Faculty of Engineering Technology

Diploma in Technology (Civil)/ Bachelor of Technology (Civil) - LEVEL 4

CEX4231 STRUCTURAL ANALYSIS AND DESIGN II

FINAL EXAMINATION - 2014/2015
Time allowed: **Three (03) hours**

Date: **2015 – 09 – 04 (Friday)** Time: **09.30 – 12.30hrs**

Answer **Any 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 the first theorem of **Moment Area Method** using a neat sketch. **(4 Marks)**

(b) A cantilevered beam (AB) is loaded with a point load P at the free end as shown in Figure 1(a). Using **Moment Area Method**, determine the rotation and vertical deflection at free end B of the beam. (EI is constant) **(6 Marks)**

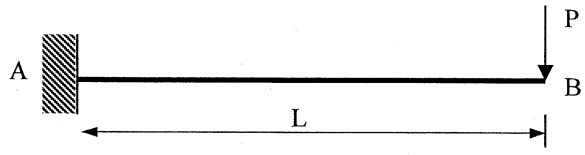

Figure 1(a)

(c) Using the **Theorem of Three Moments**, analyse the continuous beam shown in Figure 1(b) and draw the bending moment diagram. (EI is constant) **(10 Marks)**

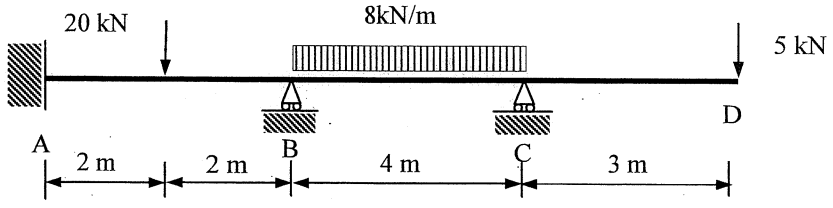

Figure 1(b)

Q2.

(a) A beam (AB) of length L is simply supported at A and fixed at B as shown in Figure 2(a). When a moment M is applied at A, the rotation at A is Θ_A. Using Moment Area Method, show that $M = \frac{4EI\theta_A}{L}$ where EI is the flexural rigidity of the beam. **(5 Marks)**

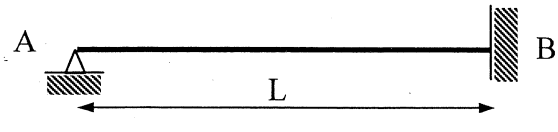

Figure 2(a)

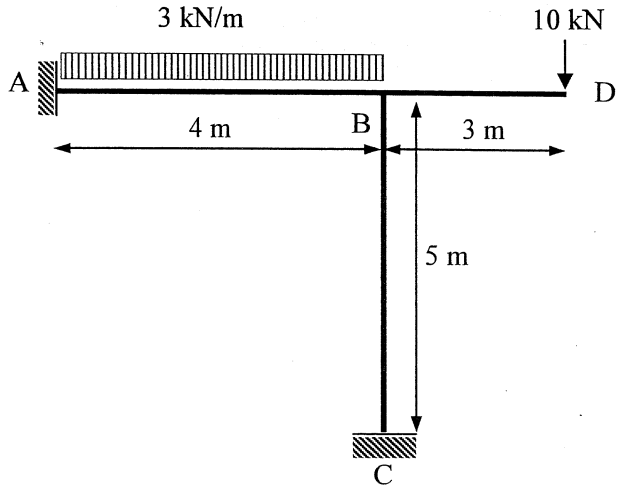

Figure 2(b)

(b) A non-sway frame is shown in Figure 2(b). Using **Slope Deflection Equations**, analyse the frame and draw the bending moment diagram. (EI = Constant) **(15 Marks)**

Q3.

(a) A beam AB of length L is simply supported at A and fixed at B. If a moment M is applied at A, show that the moment carried over to the fixed support B is M/2. Flexural rigidity of the beam is EI. (Hint: You may use **Moment Area Method**). **(5 Marks)**

(b) Analyse the continuous beam shown in Figure 3 below using **Moment Distribution Method** and draw the bending moment diagram. (EI=Constant). **(15 Marks)**

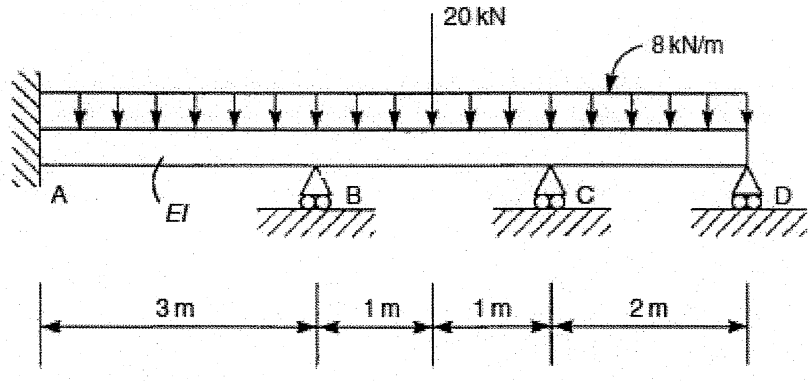

Figure 3

Q4.

(a) Derive the expression for strain energy for an element subjected to pure bending

$$U = \int_0^L \frac{M^2}{2EI} dx$$

(4 Marks)

(b) A cantilevered beam is loaded with a **uniformly distributed load w** per unit length and a **point load P** at the free end as shown in Figure 4(a). Using **Castigliano's second theorem**, determine the vertical deflection at free end B of the beam. **(8 Marks)**

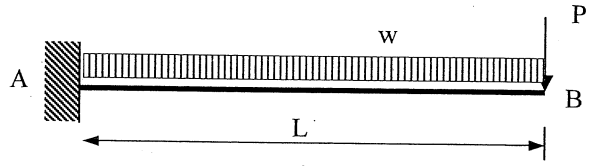

Figure 4(a)

(c) A propped cantilever beam AB is loaded with a **uniformly distributed load w** per unit length as shown in Figure 4(b). Using **Castigliano's second theorem**, determine the vertical reaction at support B. **(8 Marks)**

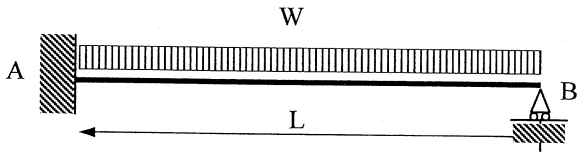

Figure 4(b)

Section B –Design of Structures

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

A two storey canteen building is proposed to be constructed in one of the regional centres of the Open University of Sri Lanka. The structural design 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. Column and beam arrangement at the first floor level is shown in Figure 5(a). Side elevation of the building is shown in Figure 5(b).

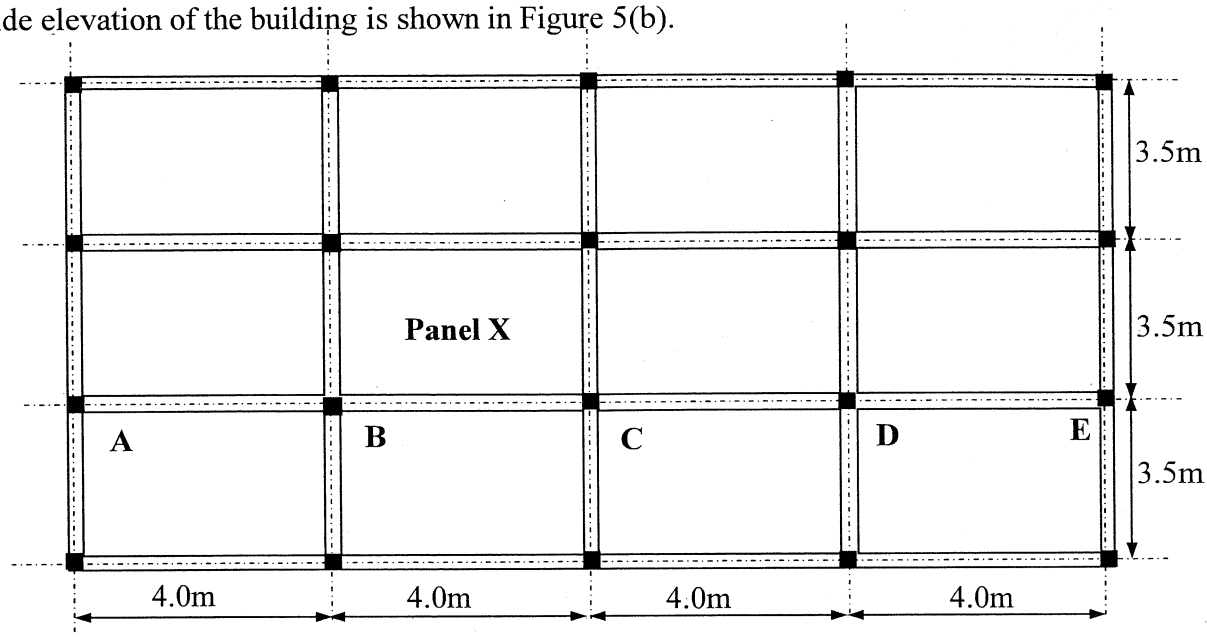

Figure 5(a) Plan (Column and beam layout)

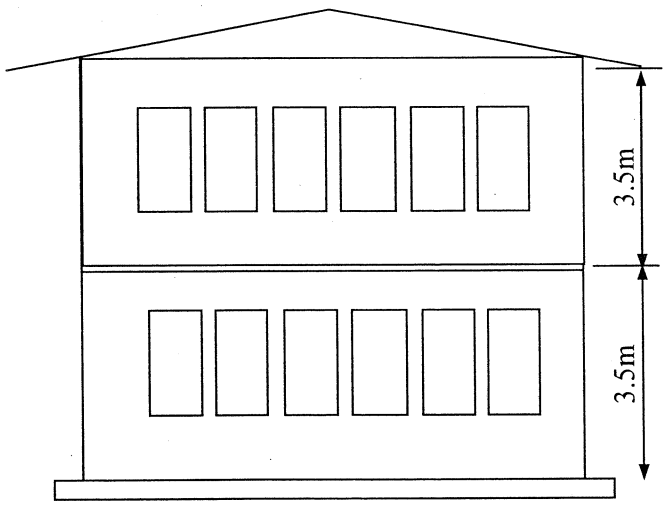

Figure 5(b) Side elevation

Material and Load Properties:

Concrete grade	- C30	
Grade of Steel f_y	HT steel	- 460 N/mm^2
	MS	- 250 N/mm^2

Unit weight of concrete - 24 kN/m^3
Unit weight of block masonry – 18 kN/m^3
Dead load by floor finishes - 0.5 kN/m^2
Dead load by the roof - 1.0 kN/m^2
Imposed load on floors- 2.5 kN/m^2
Exposure condition - mild
Fire protection required - 1 hr

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 225 x 225.
* Column positions are as indicated in the plan.
* Columns are to be 150 mm square.
* Beams monolithic with the upper floor slab are to be cast over all walls.

Q5. Using given data, design the **Panel X**, 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 span 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 HYS 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 ABCDE** (there are no walls along the beam in the first floor level). Follow the design steps given below.

(a) Evaluate the **characteristic dead and imposed loads** transferred on to the beam and the maximum **design load** as a uniformly distributed load. **(2 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**. **(5 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 design required shear reinforcements. (You may assume two or four legged 6mm MS shear stirrups) **(5 Marks)**

(e) Check against **SLS of deflection** of the beam based on conditions at the mid spans. Only propose modifications only if this check fails. **(4 Marks)**

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

(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 tie arrangement. **(6 Marks)**

(e) Produce a sketch of proposed reinforcement detail showing the column in elevation and required cross sections, using the standard method of detailing. **(4 Marks)**