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 – 2010/2011

Time Allowed: Three (03) Hours

Date: 2011 - 04 - 05 (Tuesday) Time: 1400 - 1700 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.) Using **Moment Area Method**, find the vertical displacement at mid span C of the cantilever beam shown in Fig. 1(a). (EI = constant).

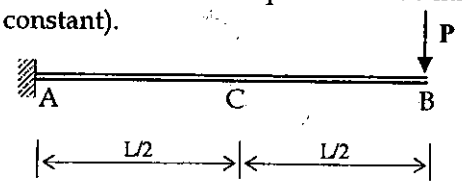


Fig. 1(a)

[05 marks]

b.) Analyse the continuous beam ABC shown in Fig. 1(b) using the **Theorem of Three Moments** and draw the Bending Moment diagram.

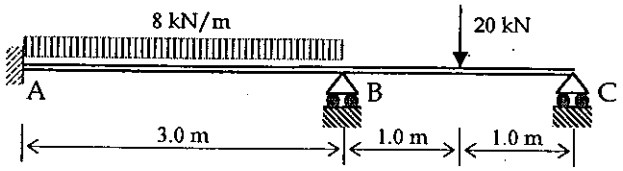


Fig. 1(b)

[15 marks]

Q2.

a.) Using the **Moment Area Method**, show that the maximum deflection in the simply supported beam shown in Fig. 2(a) is $5wL^4/384EI$. (EI = constant).

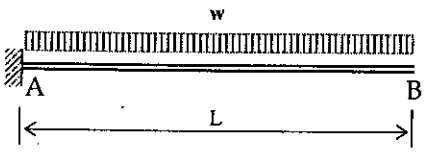


Fig. 2(a)

[04 marks]

b.) Analyse the portal frame shown in Fig. 2(b) using **Slope Deflection Equations** and sketch the Bending Moment diagram (**I** values are indicated near the members).

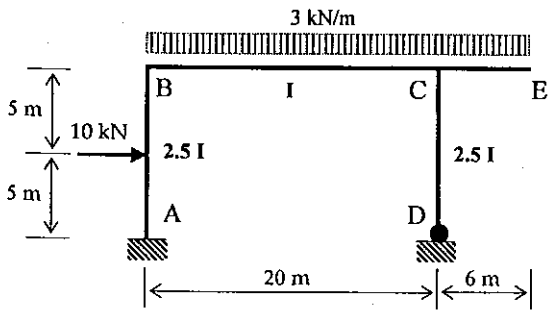


Fig. 2(b)

[16 marks]

Q3.

a.) Show that when moment M is applied at A for the beam shown in the Fig. 3(a), the mom induced at support B will be M/2.

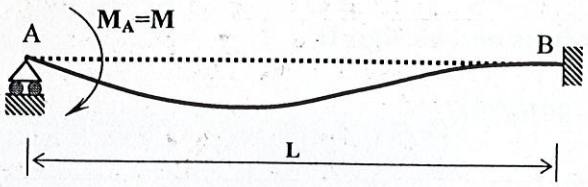


Fig. 3(a)

[04 mar

b.) Analyse the frame shown below using **Slope Deflection Method** and sketch the Bend Moment diagram (**EI = Constant**).

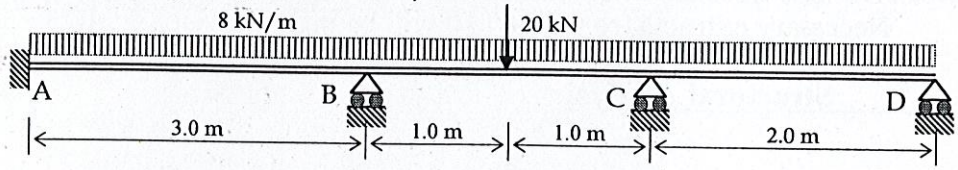


Fig. 3(b)

[16 mar

Q4.

a.) State **Castigliano's** two theorems on strain energy.

[04 mar

b.) Analyse the propped cantilever beam shown in Fig. 4, using **Castigliano's Theorems** a determine the reaction at support B. (EI = Constant).

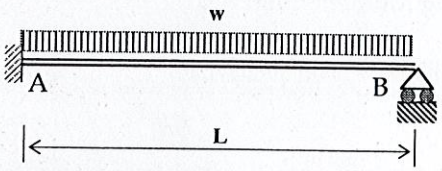
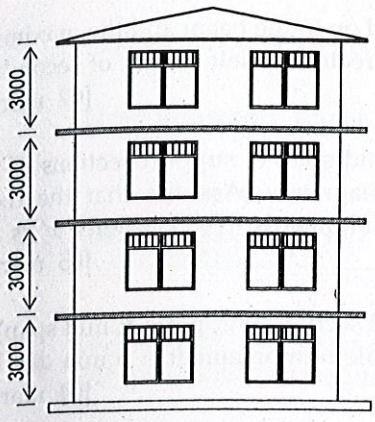


Fig. 4

[16 mar

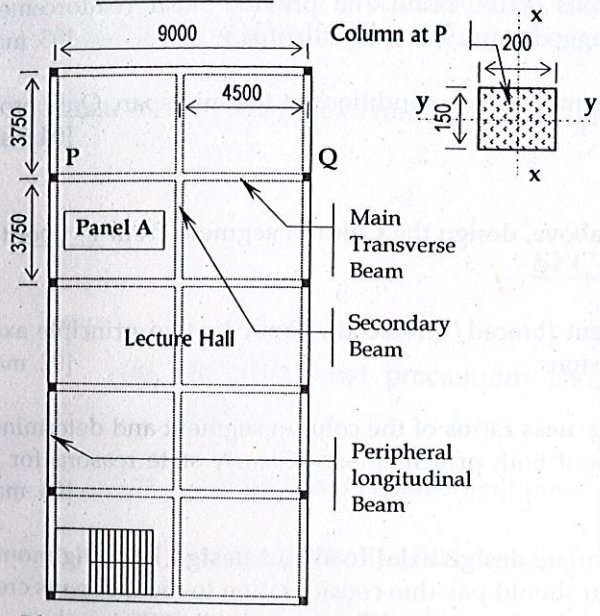
Section B - Design of Structures

All designs are to be done according to the recommendations of the Standard BS 8110. (Handout provided)
For questions Q5 Q6 & Q7 use the data and parameters pertaining to the following structure.



Side Elevation

A four storey large capacity lecture room building is needed for the central campus of the OUSL. The Engineer in charge of the project has decided on a reinforced concrete framed structure for the building. To maintain a clear line of sight from all locations within each hall, no internal columns should be placed. To reduce spans of the slab panels under this condition, secondary beams had to be provided between primary beams. The outside walls, capable of resisting lateral loads are to be made with masonry block work.



Plan of an upper floor slab

Material & Load Specifications:

Concrete grade	- C35
Grade of Steel fy HYS	- 460 N/mm²
MS	- 250 N/mm²
Unit weight of concrete	- 24 kN/m³
Unit weight of block Masonry	- 18 kN/m³
Dead load by roof (incl. ceiling)	- 1.2 kN/m²
Imposed load on roof	- 0.3 kN/m²
Weight of finishes on slab	- 1.0 kN/m²
Imposed load on slab	- 3.0 kN/m²
Nominal cover for reinforcement	- 20 mm

*** Use only necessary values ***

General Notes:

* Dotted lines indicate beams cast integral with slabs.
* Grids are spaced equally.
* Marked intersection points of beams are supported on 200 x 150 mm **RC columns**
* Transverse beams (ex. PQ) are of 500 x 300 mm & peripheral longitudinal beams and secondary beams are 300 x 200 mm cross-section
* Internal beams do not carry any walls on top
* Slabs are to be 125 mm thick
* Roof is entirely supported by the 12 columns.
* Block work peripheral walls are 100 mm thick
* All dimensions are to be in **'mm'**.

Q5. Using the given data, design the **'Panel A'** of the upper floor slab, assuming all loads to be uniformly distributed. Follow the steps below for the design.

i.) Decide on a nominal cover for reinforcement against **SLS Durability.** Calculate the **Characteristic** (dead load & imposed load due to normal loading) and the **Design** load on the panel as area loads. [02 marks]

ii.) Identify the spanning condition, end conditions of the slab and evaluate appropriate mid span and over the support moments for the **ULS of flexure.** You may use the factors from table in the handout. [05 marks]

iii.) Design reinforcement against **ULS of flexure** to resist bending at mid spans and over supports for the slab panel. (Assume 10 mm HYS for main reinforcement). [05 marks]

iv.) Check against the **SLS of deflection** for the slab panel and if necessary, propose suitable modifications. [04 marks]

v.) Sketch the reinforcement on a plan and one cross section of the slab panel using the **Standard Method of Detailing** (not necessary to indicate curtailment lengths). [04 marks]

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

i.) Evaluate the characteristic **dead and imposed** loads transferred on to the beam and the maximum **design** load as linear loads (You may neglect the point load created by self weight of secondary beams). [02 marks]

ii.) Calculate the design bending moments and shear forces at mid span & support sections of the beam and sketch the **Bending moment** and **Shear force** diagrams. (**Assume** that the fixity moment at the ends of the beam **PQ** due to connection to columns is $wl^2/30$, where 'w' is the design udl on the beam.) [05 marks]

iii.) Design the reinforcement against **ULS of flexure** at the critical sections (supports & mid span) of the beam. (You may assume 20 mm dia. HYS steel main tensile reinforcement & 6 mm dia. MS shear stirrups.) [04 marks]

iv.) Check for **ULS of shear** at critical sections of the beam and provide shear reinforcement if necessary. (You may assume <u>two or four</u> legged 6 mm MS shear stirrups.) [05 marks]

v.) Check against **SLS of deflection** of the beam based on conditions at the mid span. <u>Only</u> propose modifications if this check fails. [04 marks]

Q7. Using data pertaining to the structure given above, design the **Column segment** from <u>1st floor</u> to <u>2nd floor</u> at location **P**, along the following steps.

i.) Determine the **type** of the column segment (braced/unbraced), about its two principle axes of bending and state reasons for your conclusions. [02 marks]

ii.) Evaluate the **effective heights**, and **slenderness ratios** of the column segment and determine the slenderness condition (slender/short), about both principle axes. Clearly state reasons for your answers. [04 marks]

iii.) Evaluate the **characteristic loads** and calculate **design axial load** and **design 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. [06 marks]

iv.) Design the column <u>main reinforcement</u> against **ULSs of compression & flexure** and the <u>requirement</u> against **SLS of cracking**, assuming a symmetrical arrangement of reinforcement. (Assume 16 mm HYS for main steel & 6 mm MS for ties). [04 marks]

v.) Produce a detailed reinforcement **sketch** with column in elevation and required cross sections. You should adopt the standard method of detailing. [04 marks]