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 – 2012/2013

Time Allowed: Three (03) Hours

Date: 2013 - 08 - 09 (Friday) 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.) Draw a small sketch and explain what is stated by the **First Theorem of Moment Area Method.** (04 marks)

b.) Analyse the continuous beam shown in the Figure 1(b) below using Theorem of Three Moments and draw the Bending Moment diagram. (Support B sinks by 6.35 mm below the level of A & C, 'EI' is constant, E = 20 kN/mm², I = 33,200 cm⁴).

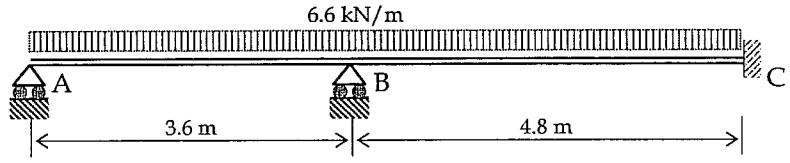


Fig. 1(b)

(16 marks)

Q2.

a.) Describe briefly how you would use Slope Deflection Method to analyse an unbraced statically indeterminate frame that is subjected to sway displacements. (05 marks)

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

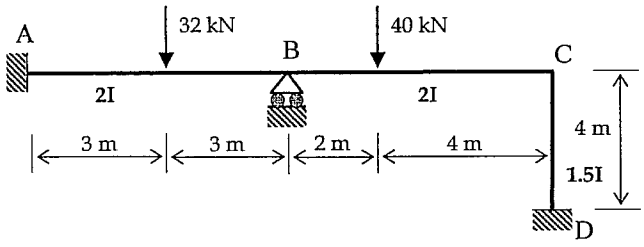
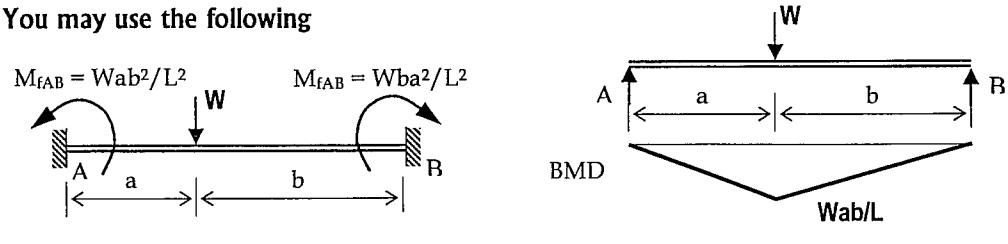


Fig. 2(b)

You may use the following



(15 marks)

Q3.

a.) In the fixed beam AB shown in the Figure 3(a), the support B settles by 'Δ'. Using Moment Area Method show that the support moments $M_A = - M_B = - 6EI\Delta/L^2$, where EI is the flexural rigidity of the beam.

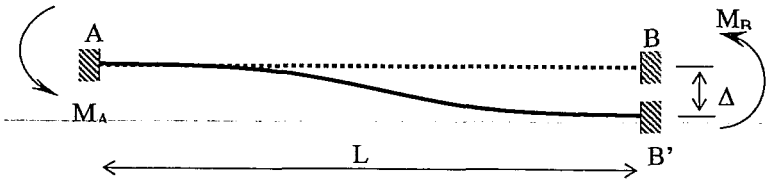


Fig. 3(a)

(06 marks)

b.) Analyse the frame shown in the Figure 3(b) using **Slope Deflection Equations** and determine the rotations at B & C and the sway displacement 'Δ'.

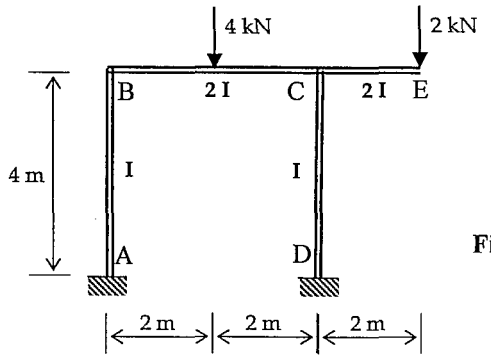


Fig. 3(b)

(14 marks)

Q4.

a.) State the Principle of Superposition.

(02 marks)

b.) State Betti's theorem.

(02 marks)

c.) State Castigliano's two theorems on strain energy.

(04 marks)

d.) Using Castigliano's theorems, determine the maximum vertical displacement of the simply supported beam shown below. Also determine the rotation at support B.

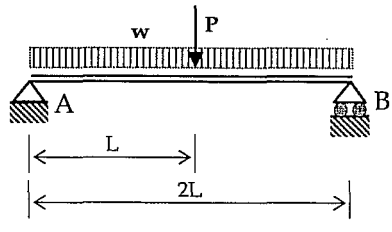


Fig. 4(d)

(12 marks)

Section B - Structural Design

Do all designs according to the recommendations of the Standard BS 8110. (Use provided Handout)
Use the data and parameters pertaining to the following structure for questions Q5 Q6 & Q7.

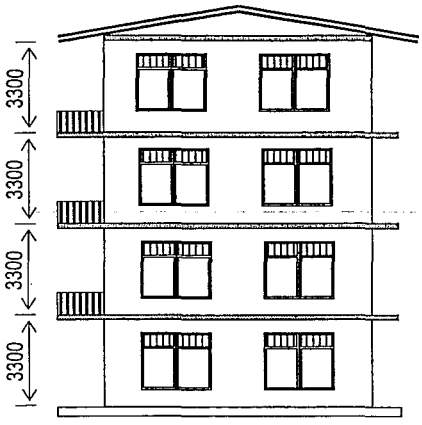
In order to accommodate higher student numbers nearing 50, over the sanctioned 35 for a class, in National Schools, the size of the classroom has to be increased in new buildings so that about 1 m^2 could be allocated per student. Further, land limitations compel the buildings to be constructed up to four stories, which is the maximum allowed without elevators.

Type drawings for such a four storied building is depicted here in side elevation and plan. The Design Engineer in charge of school buildings has decided on a reinforced concrete framed structure for the

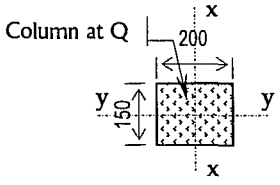
building. Sidewalks (balconies) are to be placed on one side of the building for movement. The outside walls, capable of resisting lateral loads are to be made with masonry cellular block work.

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. PQR) are of 500 x 300 mm & longitudinal beams are 300 x 300 mm cross-section
* Transverse beam PQR does not carry any walls on top
* Slabs are to be 125 mm thick
* Roof is entirely supported by the 12 columns.
* Block work on peripheral walls are 100 mm thick
* All dimensions are in 'mm'.



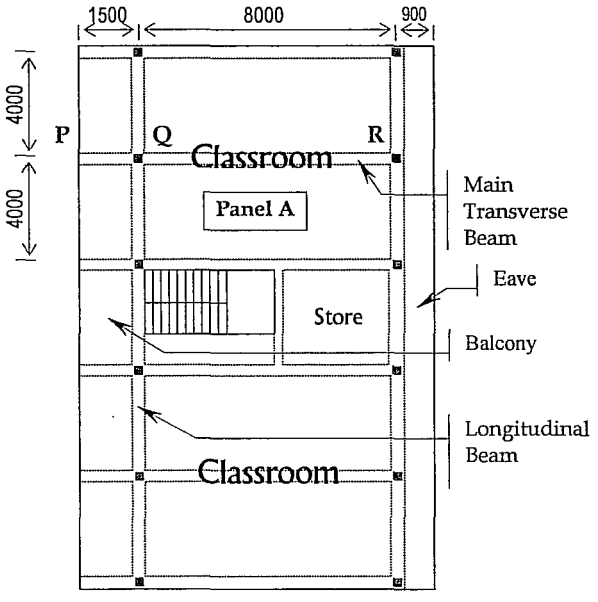
Side Elevation



Material & Load Specifications:

Concrete grade	- C25
Grade of Steel fy HYS	- 460 N/mm^2
MS	- 250 N/mm^2
Unit weight of concrete	- 24 kN/m^3
Unit weight of block Masonry	- 12 kN/m^3
Dead load by roof (incl. ceiling)	- 1.0 kN/m^2
Weight of finishes on slab	- 1.0 kN/m^2
Imposed load on slab	- 3.0 kN/m^2
Nominal cover for reinforcement	- 20 mm

*** Use necessary values only ***



Plan of an upper floor slab

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 **PQR** (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 assume that balconies carry the same imposed load as the classrooms). [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. [05 marks]

iii.) Design the reinforcement against **ULS of flexure** at the critical sections (support & 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 two or four legged 6 mm MS shear stirrups.) [05 marks]

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

Q7. Using data pertaining to the structure given above, design the **Column segment** from 1st floor to 2nd floor at location Q, 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 main reinforcement against **ULSs of compression & flexure** and the tie requirement against **SLS of cracking**, assuming a symmetrical arrangement of reinforcement. (Assume 16 mm HYS bars for main steel & 6 mm MS bars 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]