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

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CEX4231 – Structural Analysis and Design II

FINAL EXAMINATION - 2009

Time Allowed: Three (03) Hours

Date: 2010 - 03 - 19 (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.

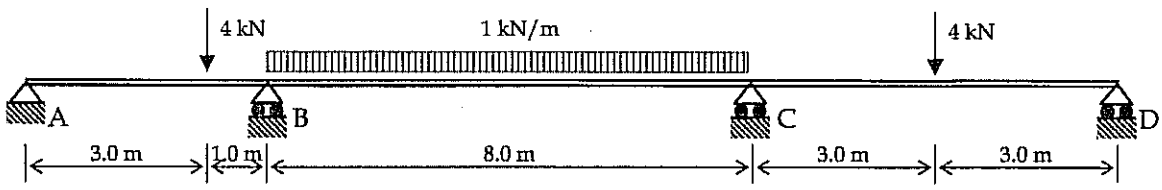
Section A - Structural Analysis

Q1.

a.) Draw a sketch and state the First Theorem of Moment Area Method.

(04 marks)

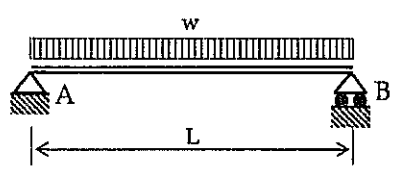
b.) A continuous beam ABCD is loaded as shown in figure below. During loading, support B sinks by 1cm.Using Three Moment Theorem find support moments and plot the Bending Moment diagram. ($E=2x10^5 N/mm^2$, $I=8x10^6 mm^4$)



(16 marks)

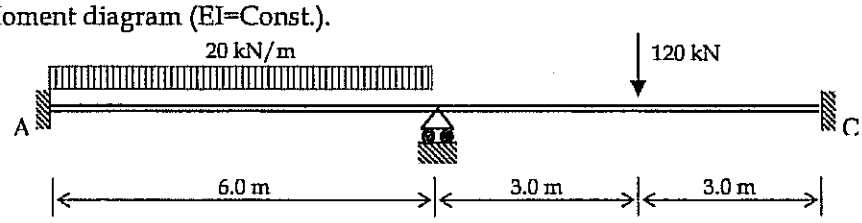
Q2.

a.) Using Moment Area Method, find the deflection at the centre of the simply supported beam shown in the figure below.



(05 marks)

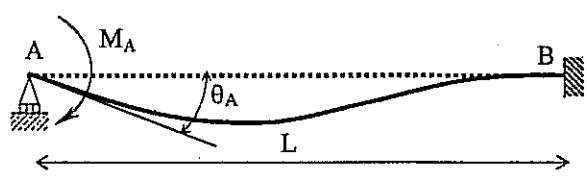
b.) Analyse the continuous beam shown in figure below, using Slope Deflection Method and draw the Bending.Moment diagram (EI=Const.).



(15 marks)

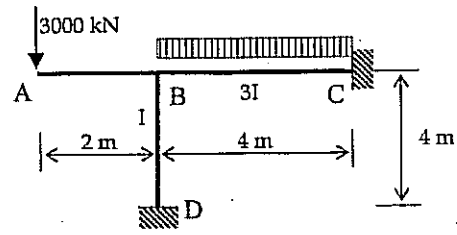
Q3.

a.) Beam AB is fully fixed at B and freely supported at A. If a moment M_A is applied at A, show that the moment induced at B is $0.5M_A$. Also show that $M_A=4EK\theta_A$, where θ_A is the slope at A and K is the stiffness factor.



(06 marks)

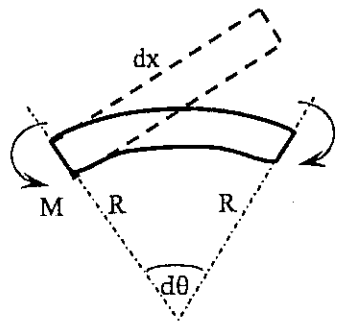
b.) Analyse the frame shown in the figure below, using **Moment Distribution Method** and draw the bending Moment diagram.



(14 marks)

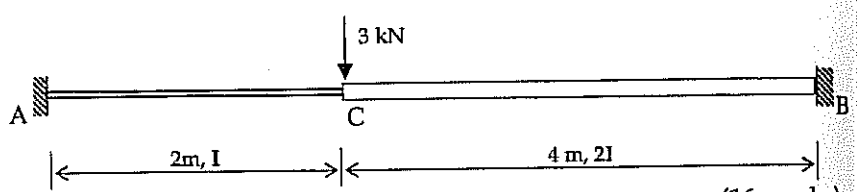
Q4.

a.) A small element of a bar of length dx is subject to a constant bending moment M, causing it to bend into an arc of radius R subtending an angle dθ at the center. Show that the strain energy resulting from bending is given by $\delta U_B = M^2 dx/(2EI)$.



(04 marks)

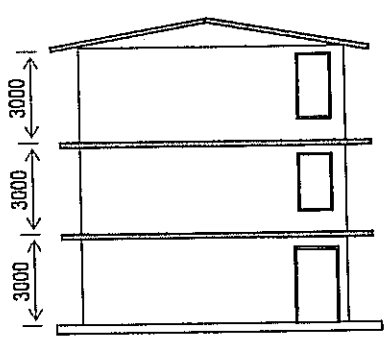
b.) Determine the Support Moments for the fixed beam loaded as shown in the figure below using Castigliano's Theorems.



(16 marks)

Section B - Design of Structures

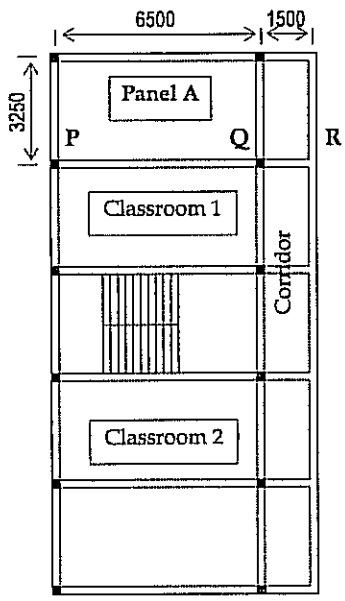
All designs are to be done according to the recommendations of the Standard BS 8110. (Handout provided) For questions Q5, Q6 & Q7 use the data and parameters pertaining to the following structure.



Side Elevation

Post conflict Sri Lanka is in need for rapid installation of infrastructure facilities for the more severely affected areas during the war. One of such infrastructure requirements are buildings for national schools. Design of the facilities of this nature is entrusted to the Buildings Department of the Ministry of Education. Efficient utilization of land area as well as economical and stable structure were the main considertations for the Chief Designs Engineer in charge of this project.

For durability and structural integrity under diverse conditions prevalent in northern and eastern areas of the country, the Engineer decided on reinforced concrete framed structure concept to be used for construction of school buildings with peripheral walls made of cellular masonry block work. An upper floor structural plan and the side elevation of a proposed six-classroom building are given here.



General Notes:

* Dotted lines in the plan indicate beams
* grids are spaced equally.
* Floor to floor height and floor to roof eaves level heights are uniform **3000 mm**, each.
* Intersection points of beams marked with a dark square are supported on **200 x 150 mm** columns
* Transverse beams (example PQR) are of **450 x 300 mm** & longitudinal beams are **300 x 225 mm** in cross-section
* Corridor is cantilevering by 1500 mm as shown in the plan
* Slabs are to be **125 mm** thick
* Roof is entirely supported by the 12 columns.
* Block work walls are 100 mm thick

All Dimensions are in 'mm'

Technical Specifications:

Concrete grade		- C30
Grade of Steel fy	HY steel	- 460 N/mm^2
	MS	- 250 N/mm^2
Unit weight of concrete		- 24 kN/m^3
Unit weight of Masonry		- 18 kN/m^3
Dead load by roof		- 1.0 kN/m^2
Weight of finishes on slab		- 1.0 kN/m^2
Imposed load on slab		- 2.5 kN/m^2
Nominal cover for reinforcement		- 20 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.) Evaluate 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 of the slab and calculate appropriate mid span and over the support moments. (You may use the factors from table in the handout)

(05 marks)

iii.) Design reinforcement against ULS of flexure at mid spans and over supports for the slab panel.

(05 marks)

iv.) Check for SLS of deflection at appropriate location of 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 school building structure above, design the beam **PQR** (there are no walls on the beam), along following steps assuming the effective beam section to be rectangular;

i.) Evaluate the characteristic dead and imposed loads transferred on to the beam and calculate the maximum design load. (You may assume that loads on the beam are uniformly distributed and neglect the point load by half-wall at the end of the cantilever R)

(04 marks)

ii.) Calculate the design bending moments and shear forces at critical sections of the beam PQR and sketch the Bending moment and Shear force diagrams.

(04 marks)

iii.) Design the reinforcement to resist ULS of flexure at the critical sections of the beam. (You may assume 20 mm dia. tor steel 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.)

(04 marks)

v.) Check for SLS of deflection of the beam based on conditions at the mid span and the end of the cantilever. Propose modifications if this check fails.

(04 marks)

Q7.

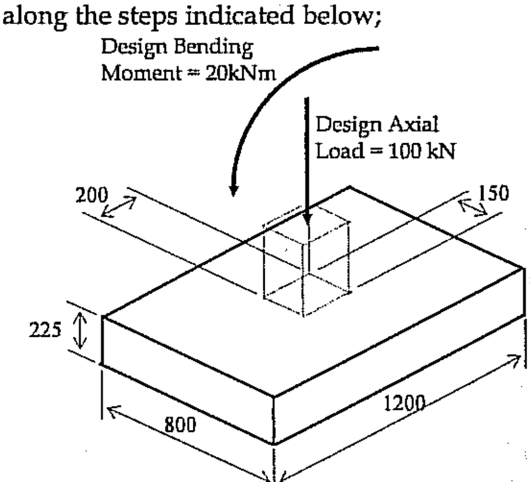
Isometric view of a rectangular pad footing supporting a central column of the school building is shown below. Through analysis of the Reinforced Concrete frame, the design axial load (excluding the self weight of the footing) and design bending moment about the major axis of the footing have been found as indicated. Using the given parameters, design this footing along the steps indicated below;

Design axial load on footing	- 100 kN
Design moment on footing	- 20 kNm
Soil bearing capacity (service)	- 150 kN/m^2
Nominal cover for reinforcement	- 40 mm

Service load = Design load / 1.5

Notes:
* Assume 10 mm dia. for main r/f
* Neglect the weight of soil above footing

All dimensions are in "mm"



i.) Check for soil bearing and possibility of lifting of the footing, under service loads and propose modifications if necessary,

(06 marks)

ii.) Design the reinforcement against the ULS of flexure for the critical section of the footing,

(05 marks)

iii.) Check for the ULS of punching shear at the critical periphery and propose modifications if necessary,

(05 marks)

iv.) Produce a sketch of the reinforcement drawing, in the form of a plan and a cross section of the footing, using the standard method of detailing.

(04 marks)