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

CEX 4231 - Structural Analysis and Design II

FINAL EXAMINATION - 2005

Time Allowed: Three (03) Hours

Date: 2006 - 03 - 19 Time: 0930 - 1230 hrs.

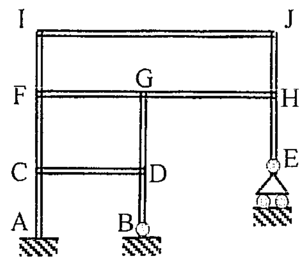
Answer Five (05) questions with at least Two (02) questions from each section.
Necessary extracts from BS 8110 will be provided separately.

Section A - Structural Analysis

Q1.

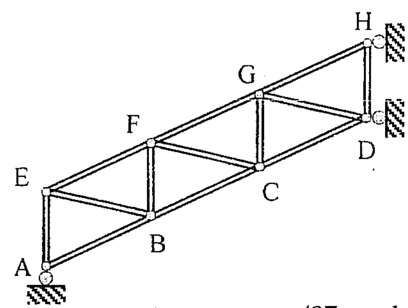
a.) Define; i.) **Statical Indeterminacy** & ii.) **Kinematic Indeterminacy** of a structure.
(06 marks)

b.) Determine the degree of **Statical Indeterminacy** and the **Kinematic Indeterminacy** of this planar framed structure.



(07 marks)

c.) Determine the degree of **Statical Indeterminacy** and the **Kinematic Indeterminacy** of this planar pin-jointed truss.

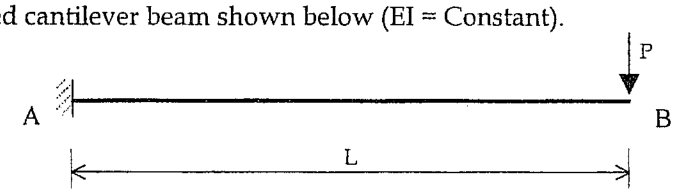


(07 marks)

Q2.

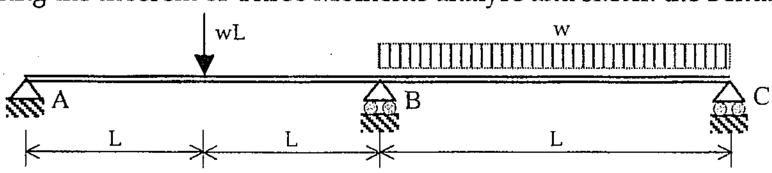
a.) State the two **Theorems** of the **Moment-Area Method** with the aid of sketches.
(04 marks)

b.) Use the **Moment-Area Method** to determine the rotation and the deflection at the end B of the loaded cantilever beam shown below (EI = Constant).



(06 marks)

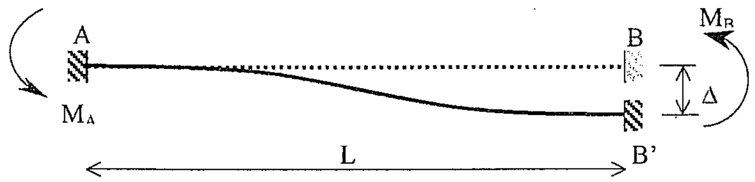
c.) A uniform cross-sectioned continuous beam ABC shown below, is loaded as shown. Using the **theorem of Three Moments** analyse and sketch the Bending Moment Diagram.



(10 marks)

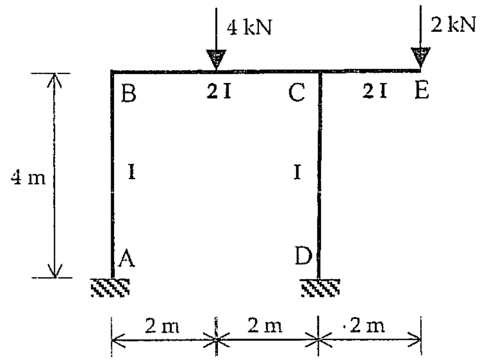
Q3.

a.) In the fixed beam AB shown in the figure below, 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.



(06 marks)

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



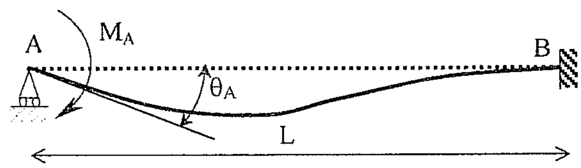
(14 marks)

Q4.

a.) The beam **AB** is fully fixed at **B** and freely supported at **A**. A moment M_A is applied at **A** without displacing **A**. Use the Moment Area Method to show that;

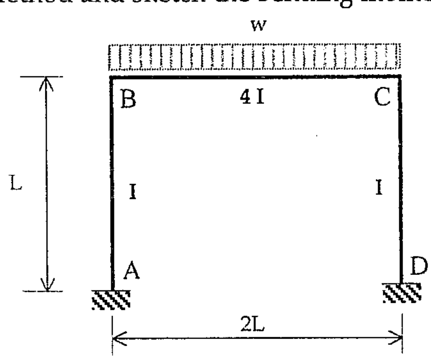
i.) The moment induced at B is equal to $\mathbf{M_A/2}$

ii.) $M_A = 4EI\theta_A/L$ where, θ_A is the rotation at **A**.



(08 marks)

b.) Determine the end moments for all members of the frame in the figure below, using Moment Distribution Method and sketch the bending moment diagram (take $I = (L/12)^4$).

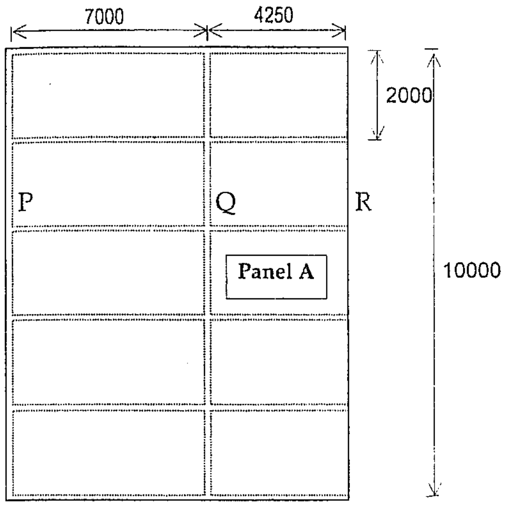


(12 marks)

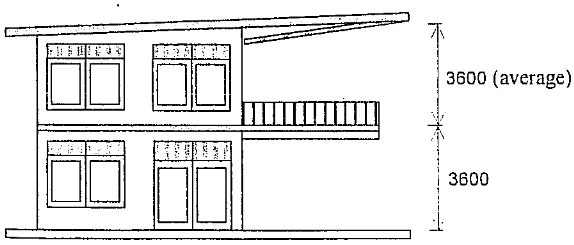
Section B - Design of Structures

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

A national school in Colombo suburbs requires a mini pavilion for its playground. The Chief Designs Engineer in charge of this project has decided on a two-storied pavilion building with inner space on the upper floor to be alternatively used for as an auditorium, after discussion with the school. The Engineer decided on reinforced concrete framed structure concept to be used for construction with peripheral walls made of masonry block work. An upper floor structural plan and the side elevation of the proposed building are given below.



Plan of the upper floor slab



Side Elevation

General Notes:
* Dotted lines indicate beams.
* Cross intersection points of all beams are supported on 225 mm square columns
* Transverse beams (PQR) are of 450 x 300 mm & longitudinal beams 300 x 225 cross-section
* Slabs are to be 100 mm thick
* Roof is entirely supported by the 12 columns.
* Roof eaves overhang is 1200 mm

All Dimensions are in 'mm'

Technical Specifications:

Concrete grade		- 30
Grade of Steel fy	HT 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		- 1.2 kN/m^2
Weight of finishes on slab		- 0.8 kN/m^2
Weight of partitions on slab		- 0.4 kN/m^2
Imposed load on slab		- 2.0 kN/m^2
Nominal cover for reinforcement (For Fire protection & exposure)		- 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.
(03 marks)

ii.) Identify the spanning condition of the slab and calculate appropriate mid span and over the support moments. (You may use the following table for one-way spanning slabs)

Location	Outer Support	mid of end span	1st interior support	mid of interior spans	Interior supports
Moment	$-0.04wl^2$	$+0.075wl^2$	$-0.086wl^2$	$+0.063wl^2$	$-0.063wl^2$

(05 marks)

iii.) Design reinforcement to resist bending at mid spans and over supports for the slab panel.
(05 marks)

iv.) Check for deflection of the slab panel and if necessary, <u>only propose</u> suitable modifications.
(03 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 segment QR, 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.)

(04 marks)

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

(04 marks)

iii.) Design the reinforcement to resist bending 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 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 deflection of the beam based on conditions at the mid span. Propose modifications if this check fails.

(04 marks)

Q7.

Using data pertaining to the structure given above, design the column segment at Q between <u>upper floor & roof</u>, along following steps;

i.) Determine the type of column (braced/unbraced), its effective height, and the slenderness ratio and determine the slenderness condition (slender/short). Clearly state reasons for your answers.

(06 marks)

ii.) Evaluate the design axial load and design bending moments (if any) acting on the column (Assume that no bending moments are transferred to the column from beams. You should pay due consideration to the moments created by eccentricity of loading and possibility of slenderness buckling in evaluating these values.

(07 marks)

iii.) Design the column main reinforcement and tie requirement for the column segment, assuming a symmetrical arrangement of reinforcement. (Assume 16 mm HTS type II bars for main reinforcement and 6 mm MS plain bars for ties. You could reduce the main bar size if found too high.)

(05 marks)

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

(02 marks)