The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Civil Engineering

Study Programme	: Bachelor of Science Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: CVX 4545 Structural Analysis and Design II**
Academic Year	: 2024/25
Date	: 17th February 2026
Time	: 13:30-16:30 hrs
Duration	: **3 hours**

General Instructions

1. Read all the instructions carefully before answering the questions.
2. This question paper consists of **SEVEN (7)** questions on **SEVEN (7)** pages.
3. Answer **ANY FIVE (05)** questions with **at least Two (2)** questions from each section (from Section A and Section B). Each question carries **20 Marks**.
4. **Relevant Charts** or **"Extract from BS8110" are provided**. See **ANNEX** for additional information.
5. This is a **Closed Book Examination**.
6. Answer for each question should commence from a **new page**.
7. **Clearly mention any assumptions** made for calculations.
8. An electronic non-programmable calculator may be used.

Section A – Structural Analysis

[Q1]

Analyze the frame shown in **Figure Q1** using the **Moment Distribution method** and **find the moments at *A, B, C, and D* joints**. Flexural rigidity of all members is *EI*. (***You may use the details given in the ANNEX.***) **[20 *Marks*]**

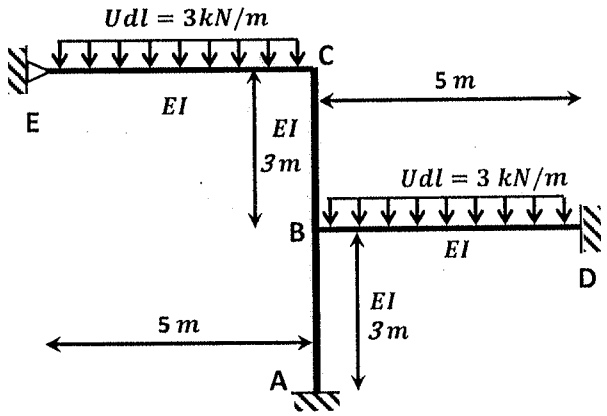


Figure Q1

[Q2]

(i) As shown in **Figure Q2a**, Beam AB is subjected to a uniformly distributed load (w) along the beam, and at the midspan a point load (P) is applied. Flexural rigidity of the beam is *EI*. Using **Mohr's 2nd theorem**, determine the **deflection at beam's mid-point C.** **[10 Marks]**

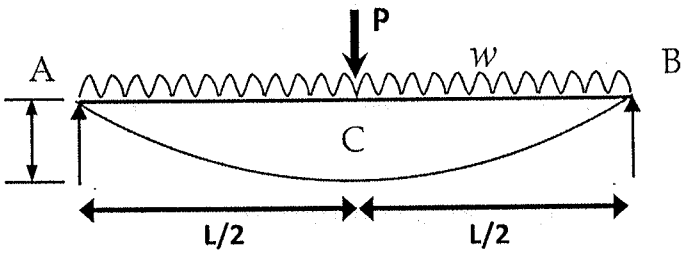


Figure Q2a

(ii) Using the **Theorem of Three Moments**, analyse the continuous beam shown in **Figure Q2b** and draw the bending moment diagram. (*EI* is constant) **[10 Marks]**

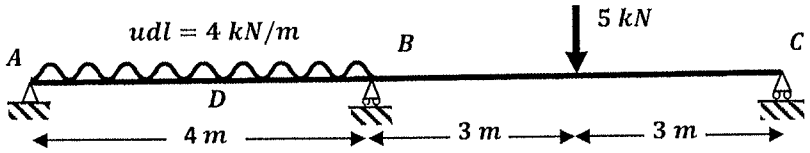


Figure Q2b

[Q3]

Figure Q3 shows the loading arrangement in ABCD frame. Point A, Point C, and Point D of the frame are pinned supported.

a) Using the **slope deflection method**, find the moments at all joints in the frame. **(Flexural rigidity of AB and BC is 2EI and that of BD is EI.)** **[13 Marks]**

b) Draw the **bending moment diagram** for the frame. **[7 Marks]**

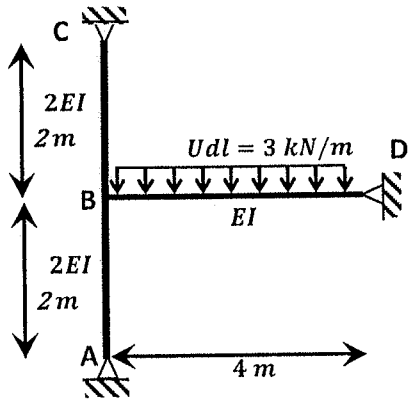


Figure Q3

[Q4]

(i) State two Castigliano's Theorems. **[6 Marks]**

(ii) As shown in **Figure Q4**, AB beam is loaded with a point load $(2P)$ at midspan. **Using Castigliano's theorems,**

a) Determine the rotation (angle) from the horizontal at **Point *A***. **[7 Marks]**

b) Determine the vertical deflection at midspan. **[7 Marks]**

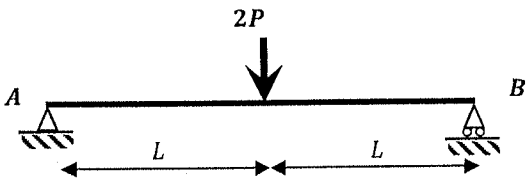
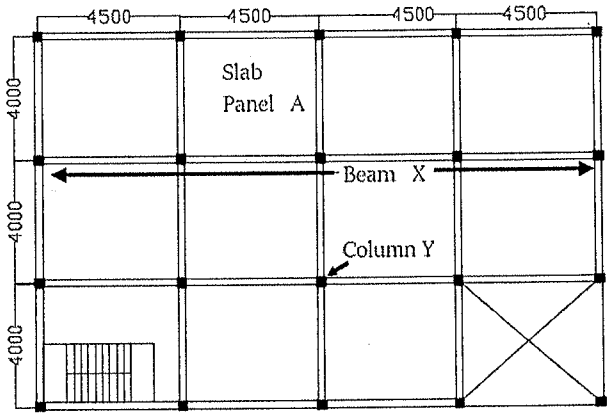


Figure Q4

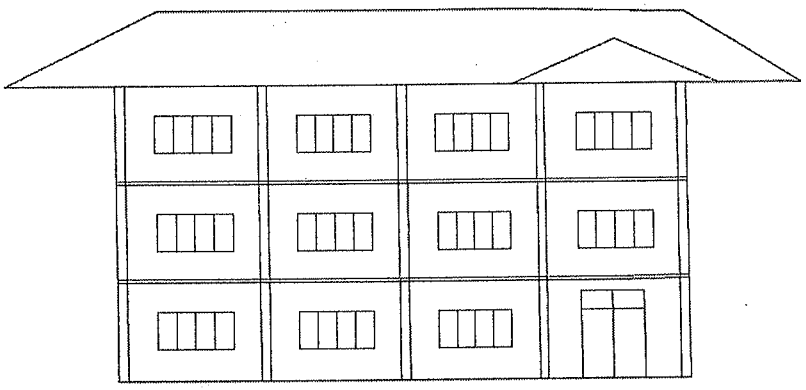
Section B – Design of Structures

All designs shall be carried out as per recommendations of BS 8110. You are allowed to use Design extract provided at the examination hall. **Any assumptions that you will be making (if any) shall be clearly stated.**

Question 5, 6 and 7 shall be based on the building project details described below.



PLAN



FRONT ELEVATION

Above Figures show a proposed three storey building of an office building at the OUSL. This building will be designed and constructed as a framed reinforced concrete building. Layout of all floors are same. The front right corner panel of the building does not have a slab panel at 1st and 2nd floor levels as it will be kept as the entrance lobby of the building.

Material properties and load parameters

Concrete grade	- Grade 25
Grade of steel HS steel	- 460 N/mm^2
MS	- 250 N/mm^2
Unit weight of concrete	- 24 kN/m^3
Unit weight of masonry walls	- 18 kN/m^3
Dead load on floors due to finishes and partitions	- 2.5 kN/m^2
Imposed load on floors	- 3.5 kN/m^2
Dead load of roof	- 0.8kN/m^2
Imposed load on the roof	- 0.5 kN/m^2
Exposure condition of slabs/ beams/columns	- Mild
Exposure condition for foundation	– Very severe
Fire protection required	– 1 hr

Notes:

- All perimeter walls shall be brick masonry walls having thickness of 225 mm
- Thickness of slabs shall be 125 mm
- All beams parallel to longer direction of the building shall be 225 $mm \times 400$ mm and beams parallel to shorter direction shall be 225 $mm \times 350$ mm. Beam heights include thickness of slab as well
- All beams and slabs shall be cast together ensuring monolithic connection
- All columns shall be $275mm \times 275mm$

Floor to floor height of each floor (height from top of floor slab to top level next floor slab) is 3.2 m. The height from top of 2nd floor slab to ceiling level of roof is also 3.2m.

[Q5] It is required to carry out design of slab **Panel *A*** of the first-floor slab of the given building.

(i) Decide the nominal cover for the slab considering durability and fire resistance requirements under SLS conditions. Also, calculate the ultimate limit state (ULS) design load for the slab panel as uniformly distributed area load. **[3 Marks]**

(ii) Based on the span condition and end conditions of the slab **Panel A**, calculate mid span moment and moments over continues supports under ULS conditions. You may use the relevant chart of the provided design extracts. **[4 Marks]**

(iii) Calculate reinforcement requirements to resist ULS flexural moments at all critical locations calculated in part (ii). You may use 10 mm HS as reinforcements. **[4 Marks]**

(iv) Check the serviceability limit state (SLS) deflection control requirement of the **slab Panel A** and if necessary, propose suitable modification to comply with the deflection control requirement. **[5 Marks]**

(v) Draw a neat Sketch of the reinforcement arrangement of the slab panel considering standard detailing rules as BS8110. **[4 Marks]**

[Q6] It is required to carry out design of the **Beam *X***. There is no brick wall along this beam. Carry out below steps for the purpose of designing this beam. You may use 6 mm or 10 mm MS stirrups as shear links and appropriate HS rebars as the main reinforcements.

(i) (a) Calculate ULS design loading on each span of beam X and mark them in a neat sketch of the beam. **[3 Marks]**

(b) Select the ULS design load that shall be used to calculate Design bending moments and shear forces of beam X. **[2 Marks]**

(ii) Calculate the design bending moments and shear force values at mid spans and over the supports using the relevant table of provided design extract and present it in a table. **[5 Marks]**

(iii) Calculate the required amount of reinforcements for ULS flexure at critical locations (at Mid spans and over the supports). **[6 Marks]**

(iv) Carry out the ULS shear checks **considering maximum shear forced reported in beam X** as a conservative approach and propose a shear link spacing for the beam. **[4 Marks]**

[Q7] It is required to design **Column Y** and foundation of **Column Y**. It has been decided to place column footing at a depth of 900 mm from the formation level of the ground floor level. The allowable bearing pressure of the soil at that level is 120 kN/m^2. Carry out the specified steps below relevant to design of **Column Y** and **footing of Y**.

(i) From the initial design checks, it has been found that **Column Y** can be designed as a short-braced column **(no need to prove it)**. Calculate the ULS axial load that has to be considered when designing the column exists from the foundation level to first floor level. **[4 Marks]**

(ii) Calculate the amount of reinforcement required for **Column Y** using a standard design approach of a short-braced column. **[3 Marks]**

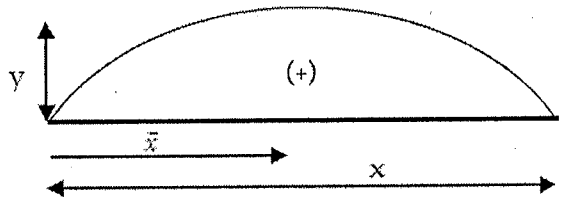
(iii) Calculate suitable size for a square shape symmetrical individual footing for the **Column Y** (no need to consider any eccentric moment for the calculation). **[4 Marks]**

(iv) Carry out flexural design of the footing by calculating critical bending moments in the footing. **[4 Marks]**

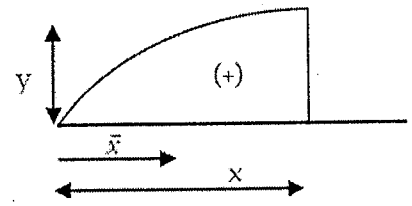
(v) Carry out the necessary shear design checks for the footing to complete the reinforcement design of the footing. **[5 Marks]**

ANNEX

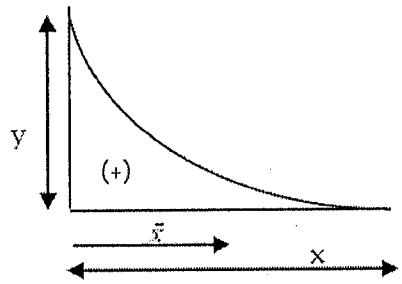
Area and centroid for some common shapes



$$Area = \frac{2}{3}xy; \qquad Centroid\bar{x} = \frac{x}{2}$$



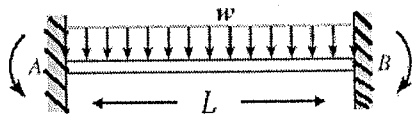
$$Area = \frac{2}{3}xy; \qquad Centroid\bar{x} = \frac{5x}{8}$$



$$Area = \frac{1}{3}xy; \qquad Centroid\bar{x} = \frac{x}{4}$$

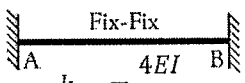
Fixed End Moments (FEM):

$$(FEM)_{AB} = \frac{wL^2}{12}$$

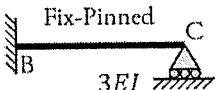


$$(FEM)_{BA} = \frac{wL^2}{12}$$

Member Stiffness:

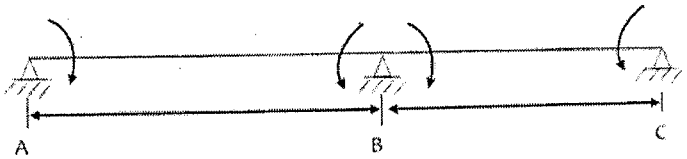


$$k_{BA} = \frac{4EI}{L}$$



$$k_{BC} = \frac{3EI}{L}$$

Three moments theorem:



$$\frac{M_1 l_1}{E_1 I_1} + 2M_2\left[\frac{l_1}{E_1 I_1} + \frac{l_2}{E_2 I_2}\right] + \frac{M_3 l_2}{E_2 I_2} = -6\left[\frac{A_1 a_1}{E_1 I_1 l_1} + \frac{A_2 a_2}{E_2 I_2 l_2}\right] + 6\left[\frac{\Delta_B - \Delta_A}{l_1} + \frac{\Delta_B - \Delta_C}{l_2}\right]$$

*All parameters have their respective meanings.

– End of Paper –