[ENG05]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

BEng (HONS) CIVIL ENGINEERING

SEMESTER ONE EXAMINATION 2024/2025

STRUCTURAL ANALYSIS & DETAILED DESIGN

MODULE NO: CIE5016

Date: Thursday 9th January 2025 **Time: 10:00am – 12:00pm**

INSTRUCTIONS TO CANDIDATES:

There are FOUR Questions.

Answer ANY THREE questions from FOUR.

Marks for parts of questions are shown in brackets.

This examination paper carries a total of 75 marks.

All working must be shown. A numerical solution to a question obtained by programming an electronic calculator will not be accepted.

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Question 1

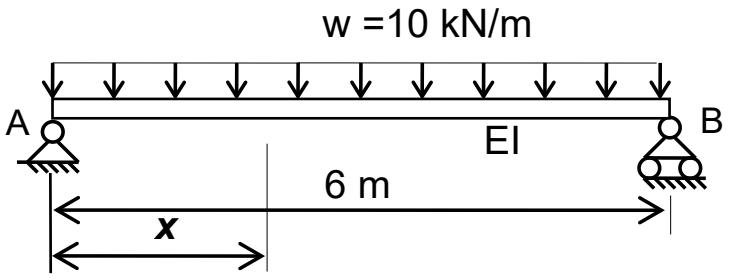

Figure Q1

Figure Q1 shows a simply supported beam AB with a span of **6m**. The beam carries a uniform distributed load of ***w* = 10 kN/m** as shown. The beam has uniform rigidity *EI*.

a) Find the vertical reaction at support A. **(2 marks)**
b) Write the bending moment ***M*** in terms of *x*. **(3 marks)**
c) Use the method of MaCaulay to write, in terms of x and *EI*:

i. The equation of the rotation (slope) **(7 marks)**

ii. The equation of the vertical deflection **(7 marks)**

d) Calculate the values of the rotation and vertical deflection at x = 3 m for the following data:

$E = 25\ kN/mm^2$
$I = 120000\ cm^4$

(6 marks)

Formula for the deflection of a beam: $\frac{d^2v}{dx^2} = -\frac{M}{EI}$

(Total 25 marks)

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Question 2

The three-pin frame shown in Figure Q2 (i) is pinned to supports at A and E, with a third pin at D. The frame is subjected to a horizontal point load of 20 kN applied at B and a vertical point load of 40kN at position C.

a) Calculate the value of the support reactions at A and E. **(5 marks)**

b) Draw the axial force diagram (AFD) **(5 marks)**

c) Draw the shear force diagram (SFD) **(5 marks)**

d) Draw the bending moment diagram (BMD) **(5 marks)**

For b), c) and d) show all important values on the diagrams and produce accompanying calculations to show how these values have been derived.

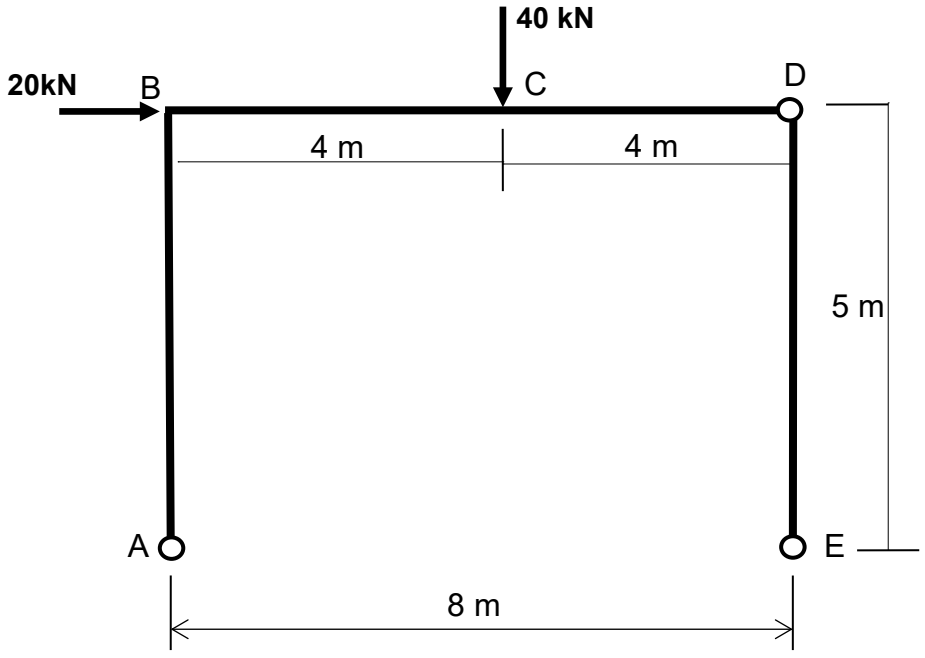

FIGURE Q2 (i)

Question 2 continued next page …
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Question 2 continued

Figure Q2 (ii) shows a very similar three pin frame, pinned to supports at A and E, with the third pin at B (no longer at D). The applied loads remain the same as Figure Q2 (i).

e) Without doing any further calculations, sketch the Bending Moment Diagram (BMD) for the three pin frame shown in Figure Q2 (ii). Do not attempt to calculate the values of the bending moments in the frame.

(5 marks)

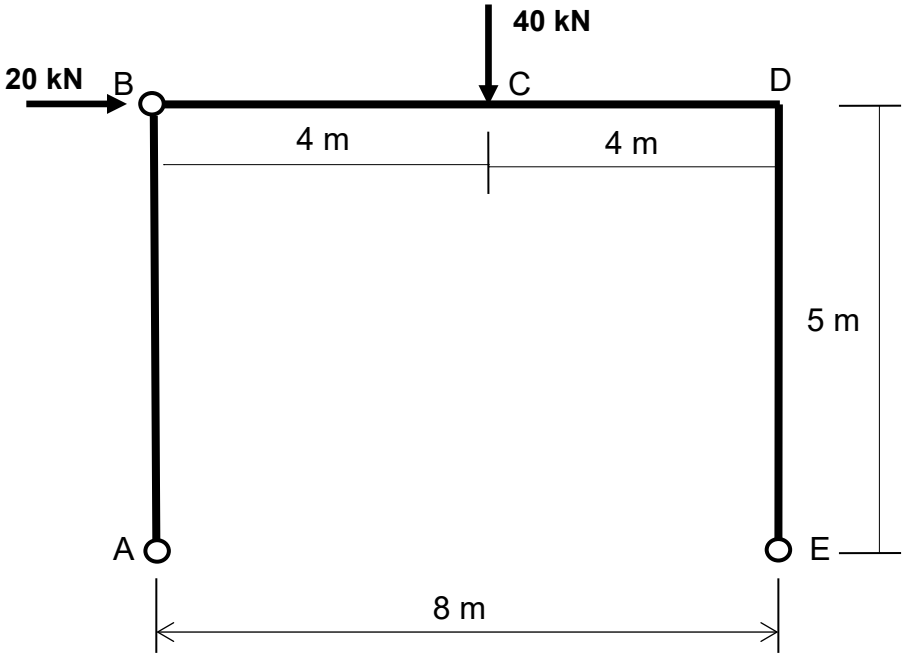

FIGURE Q2 (ii)

(Total 25 marks)

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Question 3

Figure Q3 shows a reinforced concrete frame structure that includes slabs, beams, columns and pad footings.

Calculate the mass of carbon emissions for the whole structure including the footings.

If you know:

Total volume of the concrete used in slabs is **85m^3**

Total volume of the concrete used in beams is **5m^3**

Total volume of the concrete used in columns is **4m^3**

Total volume of the concrete used in footings is **30m^3**

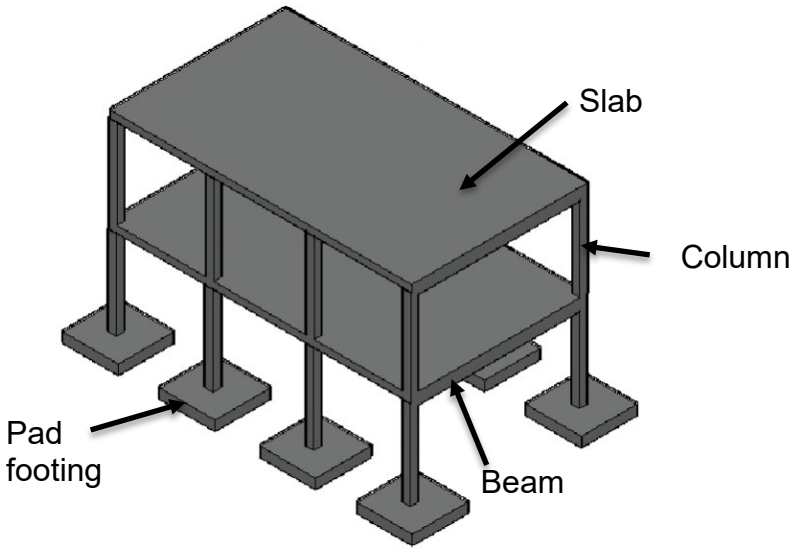

Figure Q3

Use the following data:

Density of concrete is 2400 kg/m^3

Estimated amount of reinforcement for slabs is: 75 kg/m^3 of concrete
Estimated amount of reinforcement for beams is: 120 kg/m^3 of concrete
Estimated amount of reinforcement for columns is: 200 kg/m^3 of concrete
Estimated amount of reinforcement for footings is: 90 kg/m^3 of concrete

Apply the wastage rate as 5%

Rate of embodied carbon for concrete is 0.126 kg CO2e/kg
Rate of embodied carbon for steel is 1.4 kg CO2e/kg

(Total 25 marks)

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Question 4 – Moment Distribution Method

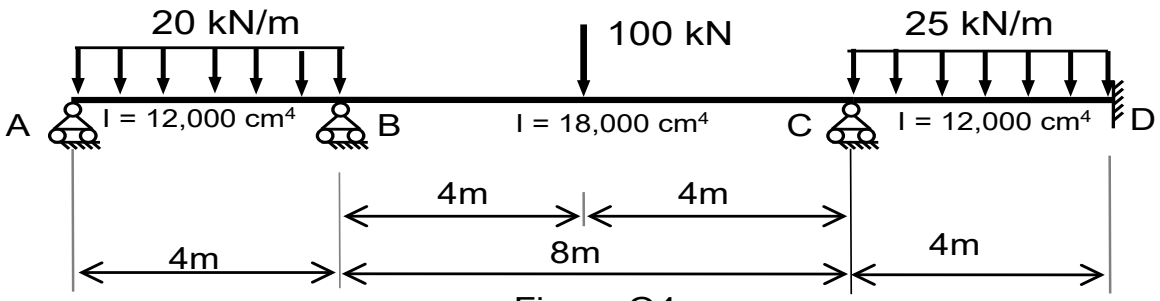

Figure Q4

Figure Q4 shows a 3-span continuous beam ABCD which is simply supported at A, B and C and fixed to a support at D. The members are steel (E = 210 kN/mm^2) and have second moment of areas as follows:

Spans AB and CD: I = 12,000 cm^4 Span BC: I = 18,000 cm^4

a. Using Moment Distribution method, calculate the bending moments at A, B, C and D.

Flexural stiffnesses of beams: Opposite end fixed: K = EI / L

Opposite end pinned: K = 0.75EI / L

(17 marks)

b. Sketch the bending moment diagram for the whole beam, showing values at supports and mid-spans. Indicate on your diagram where the beam is in hogging.

The maximum bending moment for a simply supported beam carrying a full length **UDL** is **wL^2 / 8**

The approximate maximum bending moment for a simply supported beam carrying an **off-set point** load is **Pab / L**

The approximate maximum bending moment for a simply supported beam carrying **mid-point** load is **PL / 4**

(8 marks)

Table of Fixed-End Moments is shown in **Table 1** in page 7.

(**Total 25 marks)**

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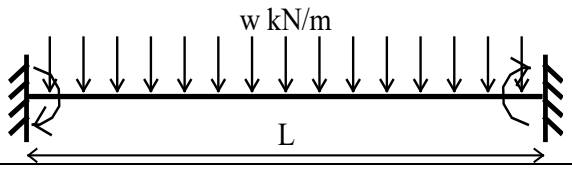
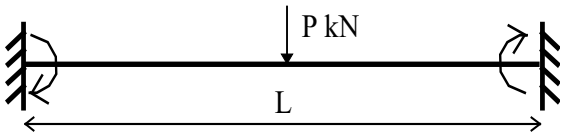
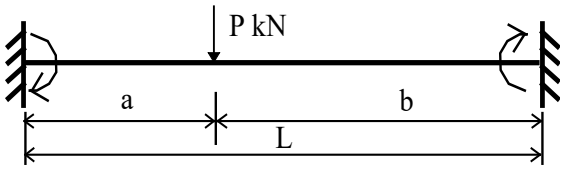
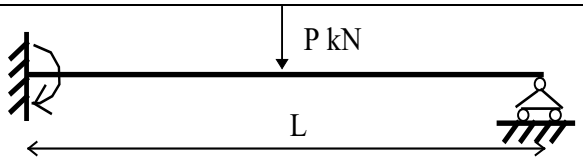
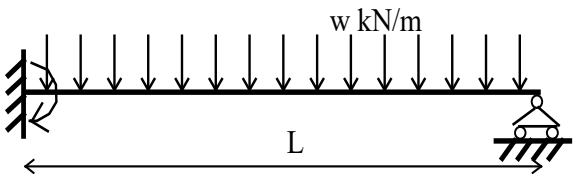
Table 1: Fixed End Moments to be used with Question 4

FIXED-END MOMENTS		
FEM_{AB}	**A** **B**	FEM_{BA}
$-\frac{wL^2}{12}$		$\frac{wL^2}{12}$
$-\frac{PL}{8}$		$\frac{PL}{8}$
$-\frac{Pab^2}{L^2}$		$\frac{Pa^2b}{L^2}$
$-\frac{3PL}{16}$ $\text{Reaction} = \frac{11P}{16}$		**0** $\text{Reaction} = \frac{5P}{16}$
$-\frac{wL^2}{8}$ $\text{Reaction} = \frac{5wL}{8}$		**0** $\text{Reaction} = \frac{3wL}{8}$

END OF QUESTIONS

END OF PAPER