City & Guilds

9210-111
Level 6 Graduate Diploma in Engineering
Structural analysis

Sample Paper

You should have the following for this examination • one answer book • non-programmable calculator • pen, pencil, ruler, drawing instruments	**A reference booklet is attached**

General instructions
- This examination paper is of **three hours** duration.
- This examination paper contains **seven** questions.
- Answer any **five** questions.
- All questions carry equal marks. The maximum marks for each section within a question are given against that section.
- An electronic, non-programmable calculator may be used, but the candidate **must** show clearly the steps prior to obtaining final numerical values.
- Drawings should be clear, in good proportion and in pencil. Do **not** use red ink.

1 Figure Q.1 shows the loads that are acting on a steel frame. The flexural rigidity of vertical members is 2EI and the horizontal member is EI.

a) Calculate the stiffness coefficients for the members AB, BC and CD. (3 marks)

b) Calculate the moment distribution factors at joints B and C. (2 marks)

c) Calculate the fixed end moments at joints A, B, C and D. (3 marks)

d) Using the moment distribution method, determine the bending moment diagram annotating prominent values for the frame shown in Figure Q.1. Consider that there is a bracing system to resist the lateral loading. (12 marks)

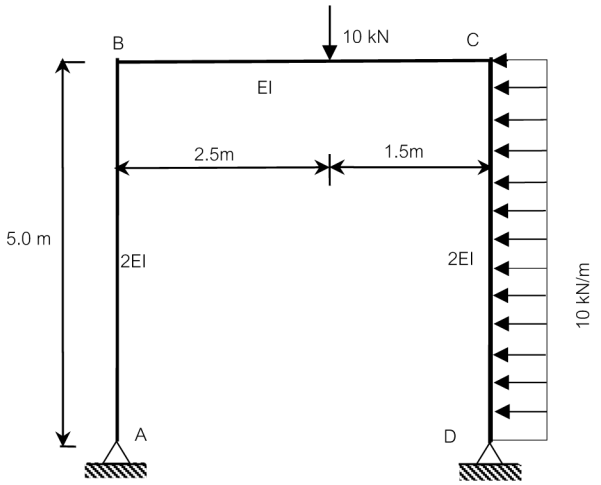

Figure Q.1

2 A horizontal reinforced concrete slab of 6 m x 3 m has fixed support along the long edges and pinned support along the short edges as shown in Figure Q.2. The slab is subjected to a uniformly distributed load **q** kN/m^2. Plastic moment capacity in x and **y** directions is 5 kNm (i.e. $M_x^+ = M_y^+ = M_x^- = M_y^- = 5$ kNm).

a) Sketch the possible yield pattern (8 marks)

b) Using the energy theorem, calculate the collapse load q_c kN/m^2. (12 marks)

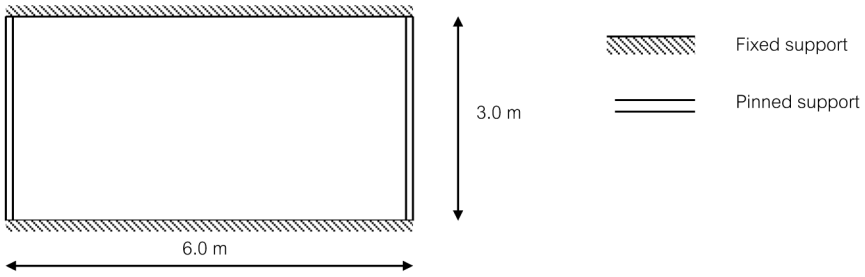

Figure Q.2

3 The continuous beam shown in Figure Q.3 has four equal spans. The plastic moment capacity of the beam is Mp.

a) Sketch the possible collapse mechanisms. (6 marks)

b) Calculate the collapse loads corresponding to all the possible mechanisms stated in part a). (11 marks)

c) Hence, determine the true collapse load. (3 marks)

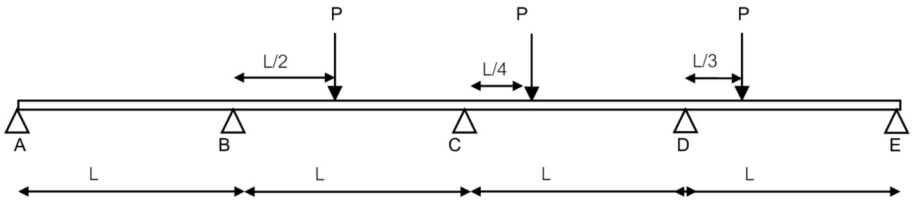

Figure Q.3

4 Analyze the rigid frame shown in Figure Q.4 by the direct stiffness matrix method. Given that the Elastic modulus (E) = 200 GPa, Cross sectional area (A) = 4 x 10^{-2} m^2 and the second moment of inertia (I) = 1.33 x 10^{-4} m^4.

a) Derive the element stiffness matrix for members AB and BC with respect to the local coordinate system. (16marks)

b) Hence, derive the global stiffness matrix for the frame. (4 marks)

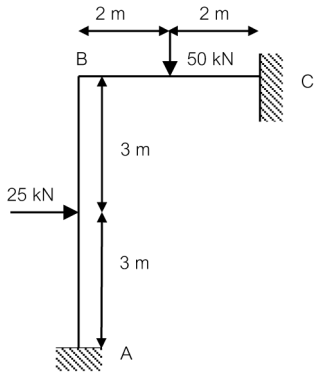

Figure Q.4

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5 It is proposed to construct a three-storey building with a roof slab. The grid arrangement has been selected as shown in Figure Q.5 for all floors. The floor slabs will be designed as one way since only the main beams are provided as indicated in Figure Q.5. The slab thickness is 150 mm. The live load is considered as 2.5 kN/m^2. The allowance for the finishes and services is 1.0 kN/m^2. An additional allowance of 1.0 kN/m^2 has been allocated for lightweight partitions that will be completed depending on the requirements. The sizes of 6.5 m long spanned beams have been selected as 600 mm x 300 mm (depth x width). The column size is 300 mm x 300 mm. Unit weight of concrete is 24 kN/m^3.

a) Calculate the dead load on Beam B2 (Grid B/1-4) (5 marks)

b) Calculate the imposed load on Beam B2 (Grid B/1-4) (2 marks)

c) Draw a typical frame along Grid B of this three-storey building. (2 marks)

d) Sketch/Explain the vertical load path of the building. (2 marks)

e) Considering the Ultimate Limit State load combination as 1.4 g_k + 1.6 q, calculate the load transfer to the foundation of column B/3 as shown in Figure Q.5. Floor to floor height is 3.15 m. (9 marks)

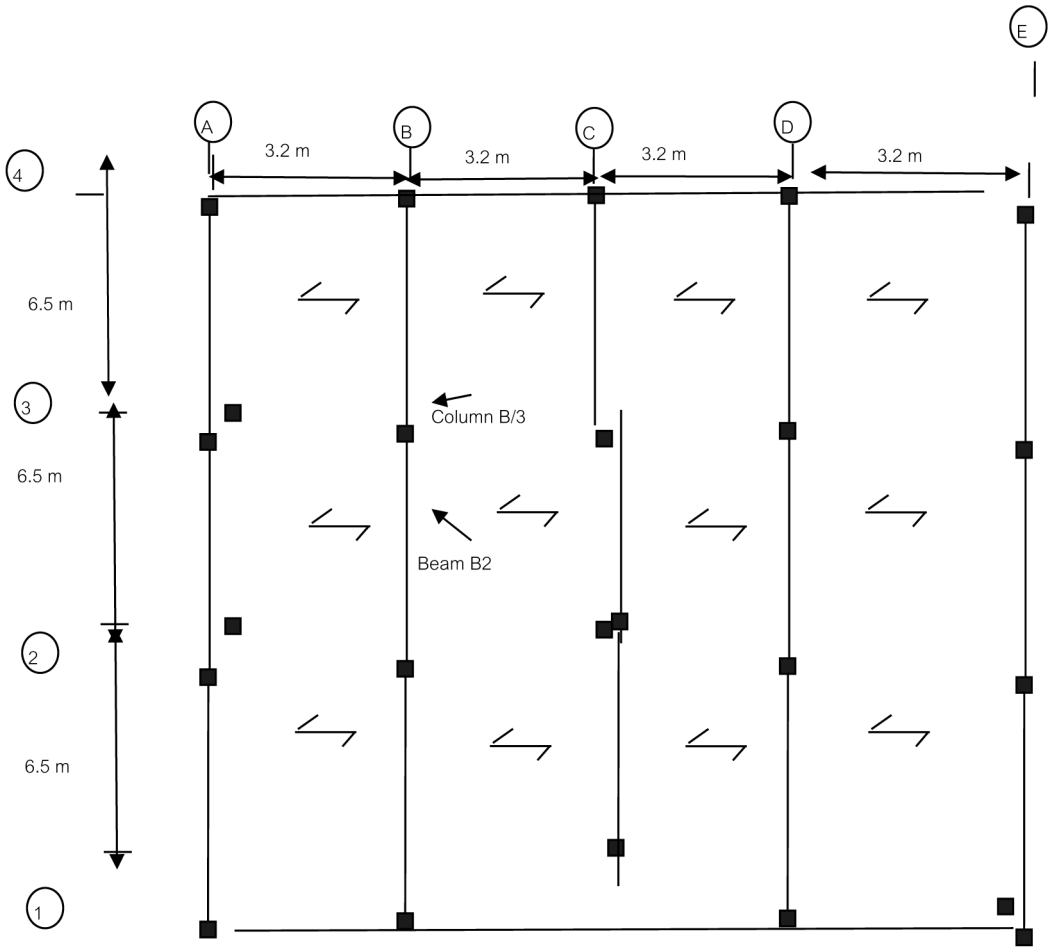

Figure Q.5

6 A hollow cast iron cylinder is 3.8 m long and outer diameter is 310 mm. The thickness of metal is 40 mm. The cylinder is subjected to a central load on the top when the cylinder is standing in a vertical position as shown in Figure Q.6. The Young's modulus of cast iron can be assumed as 1.5×10^8 kN/m^2.

a) If the stress induced on the cylinder due to applied axial compressive load (at the centre) is 74000 kN/m^2, calculate the magnitude of the applied load. (6 marks)

b) Determine the longitudinal strain produced in the cylinder due to applied load found in part a) (5 marks)

c) Hence, calculate the total decrease in length of the cylinder. (5 marks)

d) If the yield load of this cylinder is 2250 kN, find the yield stress. (4 marks)

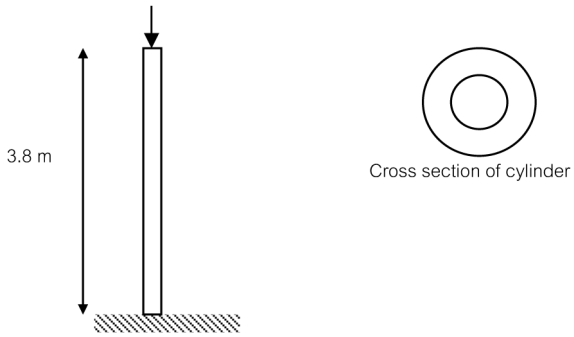

Figure Q.6

7 A rigid plate is attached using four wires as shown in Figure Q.7. Material of wires is steel with an elastic-perfectly plastic stress strain behaviour. The cross sectional area of each wire is 25 mm^2. Where L = 1200 mm, E = 200,000 MPa, f_y = 600 N/mm^2.

a) Which wire will yield first? Provide reasons for your answer. (4 marks)

b) Calculate the deflection of the plate at first yield. (5 marks)

c) Hence, calculate the corresponding forces in the wires at first yield. (8 marks)

d) Determine the value of P at first yield of wire. (3 marks)

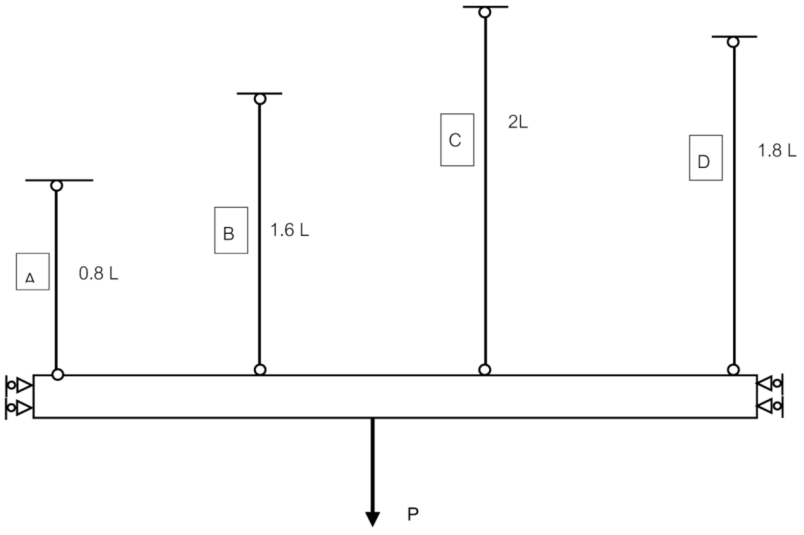

Figure Q.7