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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

**FINAL EXAMINATION
SEMESTER I
SESSION 2021/2022**

COURSE NAME : FINITE ELEMENT ANALYSIS
COURSE CODE : BFS 41003
PROGRAMME CODE : BFF
EXAMINATION DATE : JANUARY / FEBRUARY 2022
DURATION : 3 HOURS
INSTRUCTION : 1. ANSWER **ALL** QUESTIONS.
2. THIS FINAL EXAMINATION IS
AN **ONLINE** ASSESSMENT AND
CONDUCTED VIA **OPEN BOOK**.

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES



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- Q1** (a) A steel bar is subjected to an axial force at the free end, while the other side is fixed. Given the guessed solution of the steel bar as:

$$u = a_1x^3 + a_2x^2 + a_3x + a_4$$

Identify the boundary conditions and form the residual function of the steel bar. (7 marks)

- (b) **Figure Q1** shows two rods that are welded together. The left rod is solid stainless steel with a diameter of 21 mm. Meanwhile, the right rod is a high-carbon tube with inner and outer radii of 9 mm and 15 mm, respectively.
- (i) Discretize the rods into three uniform elements and determine the maximum deformation. Take the elastic modulus for the solid stainless steel as 193 GPa and high-carbon tube as 207 GPa. (14 marks)
- (ii) Describe **TWO (2)** consequences that may appear if the mesh element is refined to a smaller size. (4 marks)

- Q2** (a) Unlike the moment distribution method, the stiffness method is rarely implemented in the manual analysis and design of statically indeterminate structures. However, the stiffness method is mostly associated with many computer programs. Clarify this situation concerning the real engineering practices. (6 marks)
- (b) **Figure Q2** shows a cantilever truss with a total span of 1040 mm. The top and bottom chords are designed with SHS 60×60×5.0, while the web and vertical members use SHS 60×60×2.5. The cantilever truss is horizontally restrained at A and pinned at B. A nodal load of 25 kN is imposed at D.
- (i) Derive the element stiffness matrix for the diagonal member AC. (6 marks)
- (ii) Develop the structure stiffness matrix of the cantilever truss. (13 marks)

Q3 In **Figure Q3**, a long-galvanized pipe is subjected to an internal pressure of 5 MPa. The pipe has inside and outside diameters of 250 mm and 290 mm, respectively. Given the following material properties:

Elastic modulus, E = 210 GPa
 Poisson's ratio, ν = 0.3
 Yield strength, σ_y = 345 MPa
 Ultimate strength, σ_u = 448 MPa

- (a) By using two elements across the thickness with 10 mm length, construct the connectivity and coordinate of all nodes. (4 marks)
- (b) Check the displacement at the inner radius of the pipe. (15 marks)
- (c) Discuss the procedure to evaluate the external stress of the pipe. (6 marks)

Q4 **Figure Q4** shows a stress-strain curve of cold-formed steel. The stress-strain curve is obtained directly from the tensile test using coupon specimens. Given the following material properties:

Elastic modulus, E = 186 GPa
 Poisson's ratio, ν = 0.29
 Bulk modulus, G = 148 GPa
 Shear modulus, S_τ = 72 GPa

- (a) Determine the hardening properties of cold-formed steel. Use five to seven data only. (5 marks)
- (b) Based on the hardening properties in **Q4(a)**, propose a suitable material model and describe its yield surface characteristics. (8 marks)
- (c) For a single LC 88×40×1.2 stub column under a compression force of 0.45 mm/minute speed rate, execute the numerical modelling procedure to simulate the buckling. (12 marks)

– END OF QUESTIONS –

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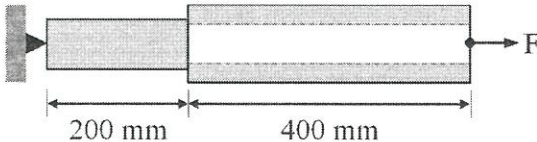


FIGURE Q1

$$\sigma_F = 5.5 \text{ N/mm}^2$$

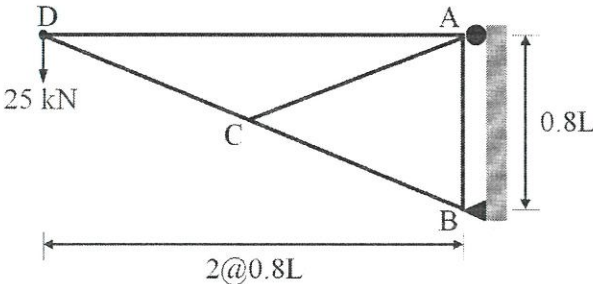


FIGURE Q2



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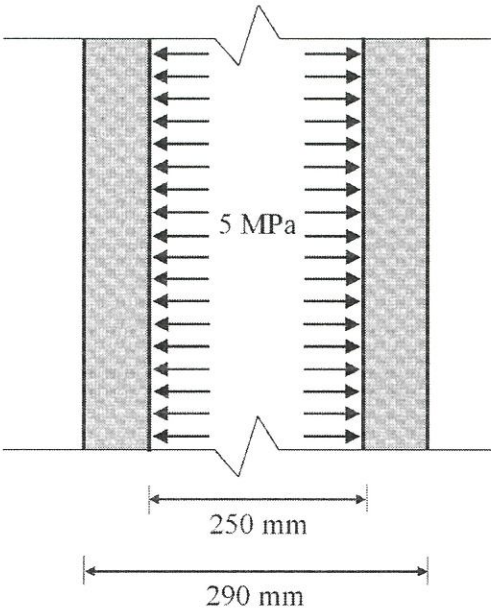


FIGURE Q3

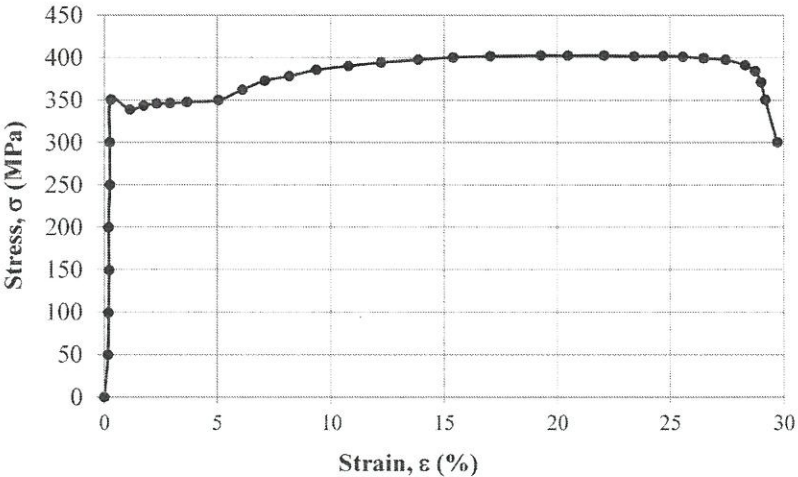


FIGURE Q4

