UNIVERSITI SAINS MALAYSIA

2nd. Semester Examination
2002/2003 Academic Session

February / March 2003

EAS 454/3 -

Duration : 3 hours

Instructions to candidates:

1. Ensure that this paper contains **SEVEN (7)** printed pages include appendices.

2. This paper contains **SEVEN (7)** questions. Answer **FIVE (5)** questions only. Marks will be given to the **FIRST FIVE (5)** questions put in order on the answer script and **NOT** the **BEST FIVE (5)**.

3. All questions carry the equal marks.

4. All questions **MUST BE** answered in Bahasa Malaysia.

5. Write answered question numbers on the cover sheet of the answer script.

1. (a) By using the three basic equations in structural mechanics, derive the following element stiffness equation for the case of an axially loaded element as shown in Fig.Q1-1 :

$$\begin{Bmatrix} f^i \\ f^j \end{Bmatrix} = \frac{EA}{L}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}\begin{Bmatrix} u^i \\ u^j \end{Bmatrix}$$

where f^i, f^j : nodal forces at node i and node j, respectively, E : modulus of elasticity of the bar material, A : cross-sectional area of the bar, L : original length of the bar and u^i, u^j : nodal displacement of node i and node j, respectively.

(8 marks)

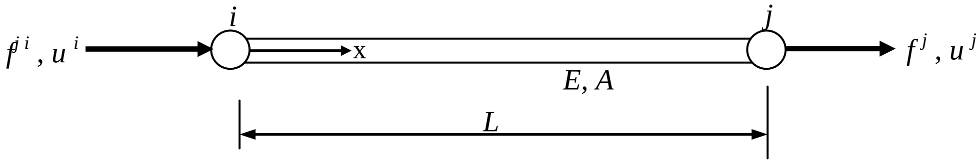

Fig.Q1-1

(b) Fig.Q2-1 shows a step beam with different moment of inertias in member 1 and 2. Assemble the structure stiffness matrix $\boldsymbol{K_B}$. Then, calculate the reactions at both supports by using matrix stiffness method.

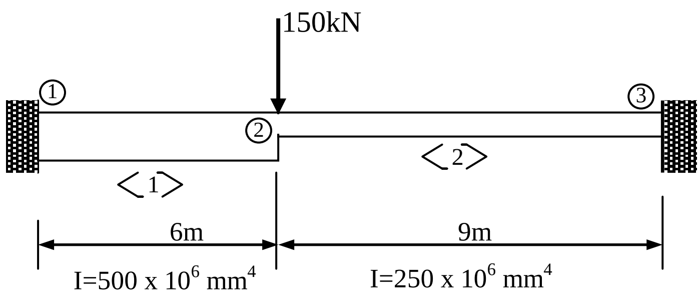

Fig.Q2-1

If the beam is modified as shown in Fig.Q2-2, show how the modification is taken into consideration into the structure stiffness matrix $\boldsymbol{K_{BT}}$.

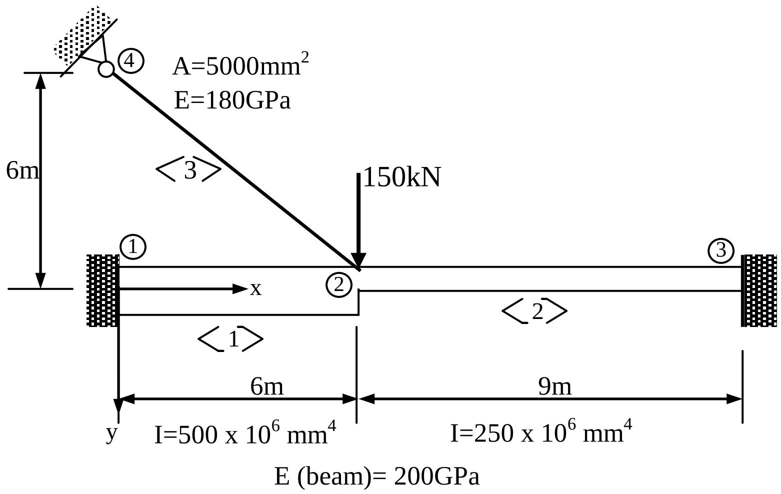

Fig.Q2-2

2. (a) By using the mass spring model shown in Fig.Q2-1, explain the meaning of D'Alembert force.

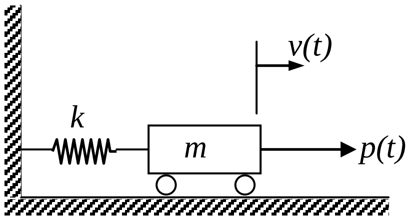

Fig.Q2-1

(6 marks)

(b) Fig.Q2-2 shows the idealization of the frame for a one-storey building which can be modeled as a single degree-of-freedom system . Show that the total stiffness of the system can be represented as the sum of lateral stiffness of the two columns.

A free vibration test has been carried out on the frame. An initial lateral displacement of 5mm has been forced on the girder by using hydraulic jack. It is observed the corresponding jack force required is 90kN. When the girder is instantaneously released from this initial position, it is observed that the time recorded for the frame to swing back is 1.30s. The maximum displacement on the return swing in only 4mm. Using this data , compute :

i. Effective weight *W* of the girder
ii. Frequency of vibration *f* in Hertz
iii. Damping ratio ζ
iv. Amplitude of vibration of the system after 5 cycles

(14 marks)

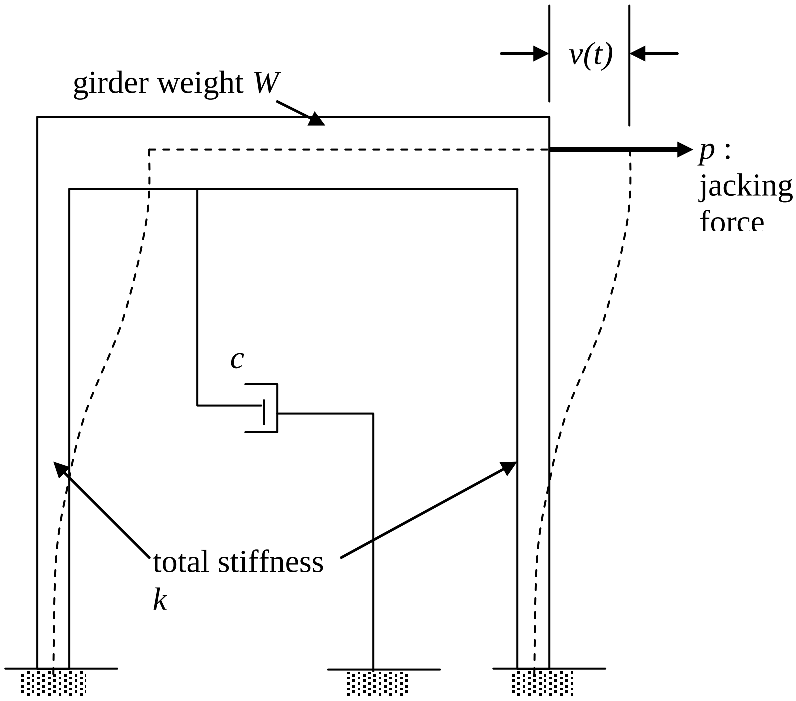

Fig.Q2-2

3. (a) Clearly define THREE (3) differences between a triangular and rectangular finite element in plane elasticity.

(5 marks)

(b) Two plates shown in Figure 1a and 1b, shall be analysed as a plane strain problem. The meshes that shall be employed are using 6 and 12 elements respectively. Each nodes has been labelled accordingly. Calculate the bandwidth, B = (R+1) NDOF for the plate assuming two degrees of freedom at each node.

(5 marks)

(c) Rearrange the node labelling in such a way that a minimum value of R is obtained.

(5 marks)

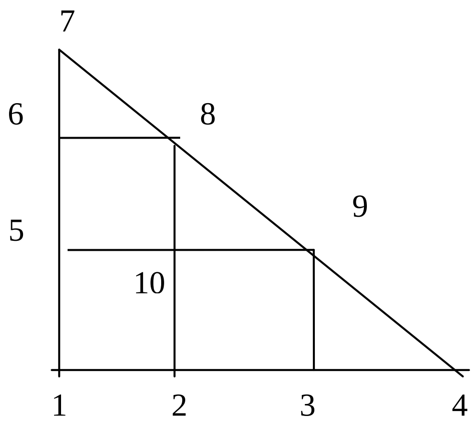

Figure 1a

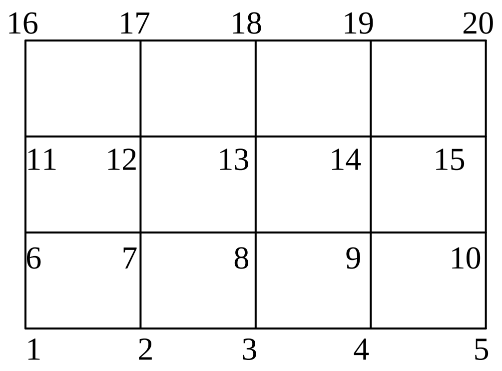

Figure 1b

4. (d) Calculate the displacement at node 2 (u2 and v2) , for a triangular element in a state of plane stress as shown in Figure 2. Assumed node 1 and 3 are fixed . Given the applied force at node 2 is x direction is 100kN, E = 200 GN/m^2 , ν = 0.3 and t = 2 cm.

(15 marks)

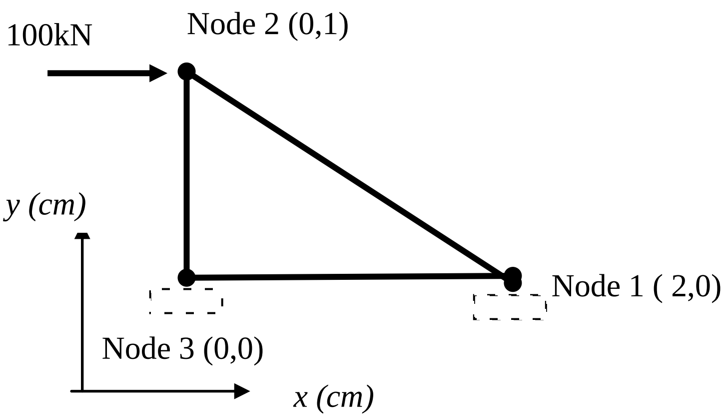

Figure 2

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