

**CORK INSTITUTE OF TECHNOLOGY  
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ**

**Semester 2 Examinations 2009/10**

**Module Title: Advanced Theory of Structures**

**Module Code: CIVL8002**

**School: Building and Civil Engineering**

**Programme Title: B Eng (Hons) in Structural Engineering**

**Programme Code: CSTRU\_8\_Y4**

**External Examiner(s): Dr. MG Richardson  
Mr. J O'Mahony**

**Internal Examiner(s): Mr JJ Murphy**

**Instructions: Answer all four questions. All questions carry equal marks.**

**Duration: 2 hours**

**Sitting: Summer 2010**

**Requirements for this examination:**

**Note to Candidates:** Please check the Programme Title and the Module Title to ensure that you have received the correct examination paper.  
If in doubt please contact an Invigilator.

- Q1. The beams AE, DE, EB and EC shown in Fig. Q1 are rigidly connected at E and the structure, which lies on a horizontal plane, is loaded vertically and rigidly supported at A, B, C and D.
- (a) Use the stiffness matrix method to determine the joint displacements. (12 Marks)
- (b) Determine the bending moments at A, B, C, D and E. Hence draw the bending moment diagrams for the beams, noting all significant values. (13 Marks)

$$EI = 40000 \text{ kNm}^2; GJ = 32000 \text{ kNm}^2 (= 0.8EI)$$

- Q2. (a) Fig Q2(a) shows a structure housing ore crushing machinery. Each floor has a mass of 10000 kg. The ore crusher is permanently fixed to the lower floor, BE adding its mass of 10000 kg to that floor. The crusher operates at 1.75 hz (11 rads/ sec) but sets up large resonant vibrations in the structure. In an effort to reduce the vibrations, it is proposed to attach a large mass of 10000 kg to the structure. Calculate whether it is better to attach the extra mass to the upper (CD) or lower (BE) floor. The beams may be assumed to be infinitely stiff.

For columns AB and EF:  $EI = 4500 \text{ kNm}^2$

For columns BC and DE:  $EI = 2250 \text{ kNm}^2$

$$(\text{D.L.F.} = ((1-\beta^2)^2 + (2\xi\beta)^2)^{-0.5} \quad \beta = \omega/\omega_n \quad \omega_n = \sqrt{k/M})$$

(13 Marks)

- (b) Use qualitative analysis to sketch the bending moment diagrams and deflected shapes for the beams and frames shown in Fig Q2(b). Indicate also the direction in which the reactions are acting.

*Use Answer Sheet provided. Draw the bending moment diagrams on the tension faces of the members.* (12 Marks)

Q3. (a) Fig. Q3(a) shows a pin-ended strut. The left hand half has flexural rigidity EI, while the right hand half has flexural rigidity 0.25EI. Show that the critical load may be found from the equation:  $\tan kl - \tan 2kl = 2 \tan kl/2 (1 + \tan 2kl \tan kl)$  where  $k^2 = P/EI$ .

(9 Marks)

(b) The uniform frame shown in Fig. Q3(b) is attached to pinned supports at A, B and C and to fixed supports at D and E. It is subjected to a vertical load P at F as shown. Formulate equations in terms of stability functions, which express the conditions of instability of the frame in its own plane and hence determine the critical value of P. (8 Marks)

(c) The uniform frame shown in Fig. Q3(c) is attached to a pinned support at A and to roller supports at B and C. It is subjected to a vertical load P at D as shown. Formulate equations in terms of stability functions, which express the conditions of instability of the frame in its own plane and hence determine the critical value of P. (8 Marks)

$\rho$	$\alpha$	s	c	sc	s(1+c)	s(1-c*c)	m	m'
0.78	1.387	2.849	0.819	2.334	5.184	0.937	3.884	-0.139
0.79	1.396	2.833	0.826	2.340	5.173	0.900	4.059	-0.130
1.68	2.036	1.028	2.988	3.072	4.100	-8.150	-0.979	0.330
1.69	2.042	1.003	3.074	3.084	4.087	-8.479	-0.961	0.337
1.75	2.078	0.849	3.719	3.159	4.008	-10.897	-0.866	0.387
1.76	2.084	0.823	3.852	3.172	3.995	-11.395	-0.852	0.396
1.77	2.090	0.797	3.996	3.185	3.981	-11.928	-0.838	0.406
1.78	2.096	0.770	4.150	3.198	3.968	-12.501	-0.824	0.416

**Table of Stability Functions**

( $k = sEI/L$ ;  $scEI/L$  - fixed       $k = s(1-c^2)EI/L$  - pinned)

Q4. A conical umbrella-shaped concrete roof of thickness 125 mm is supported by a central column as shown in Fig. Q4 and is subjected to a uniform imposed load of 0.75 kN/m<sup>2</sup> (on plan) in addition to its self weight.

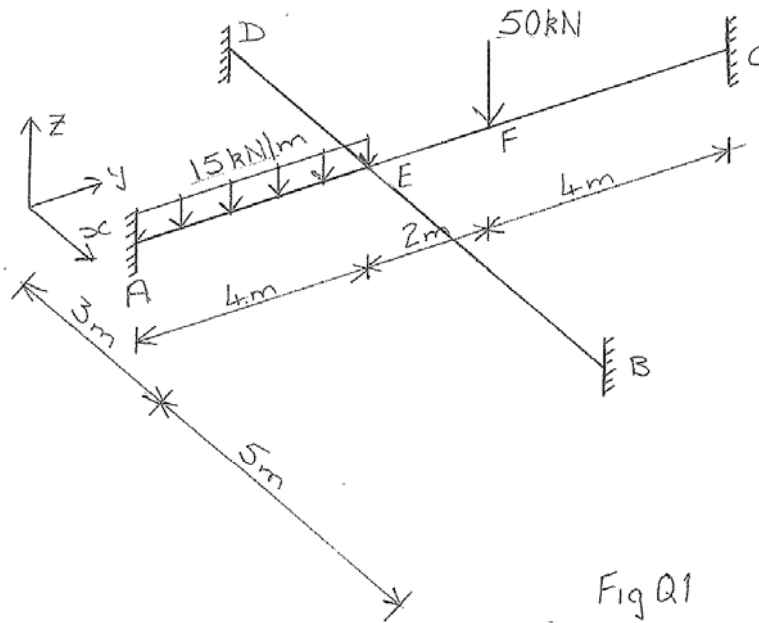
(a) Assuming that membrane theory is valid, determine general expression (in terms of x) for the circumferential (hoop) and meridional stresses in the roof. (17 Marks)

(b) Calculate values of the hoop and meridional stresses at  $x = 0; 0.25; 1.25; 2.5$  m and hence sketch the distribution of both stresses. (4 Marks)

(c) Determine the magnitude of the axial force in the column.

Unit weight of concrete: 24 kN/m<sup>3</sup> (4 Marks)

$$\left( \frac{\sigma_1}{r_1} + \frac{\sigma_2}{r_2} = \frac{p}{t} \right)$$



AE : 4m  
 EF : 2m  
 FC : 4m  
 DE : 3m  
 EB : 5m

Fig Q1

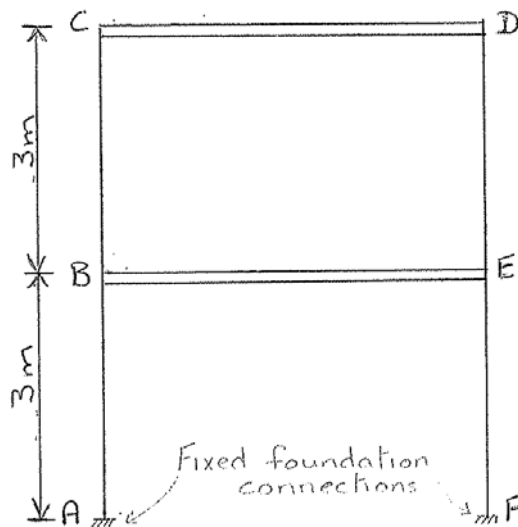


Fig Q2(a)

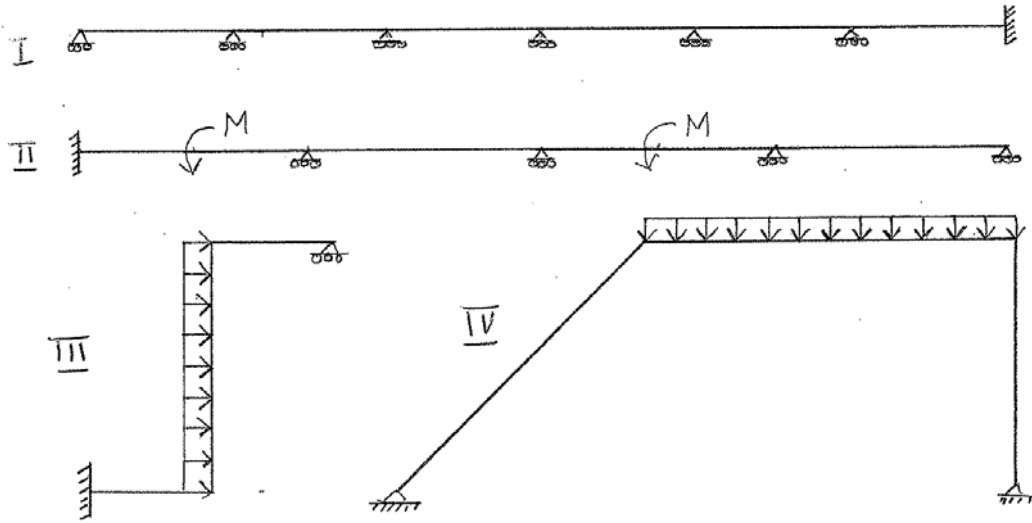


Fig Q2(b)

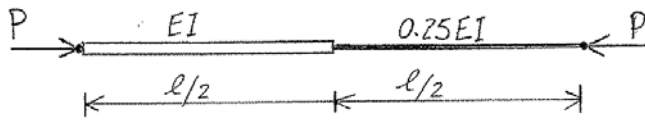


Fig Q3(a)

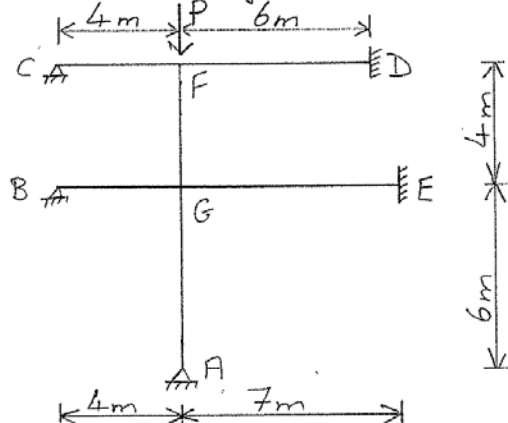


Fig Q3(b)

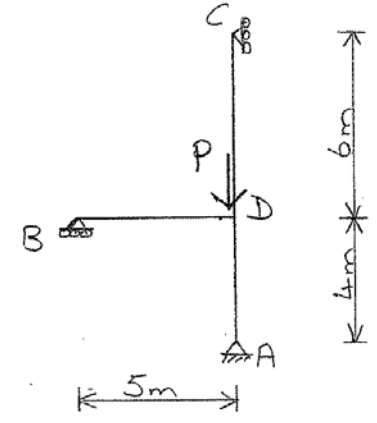


Fig Q3(c)

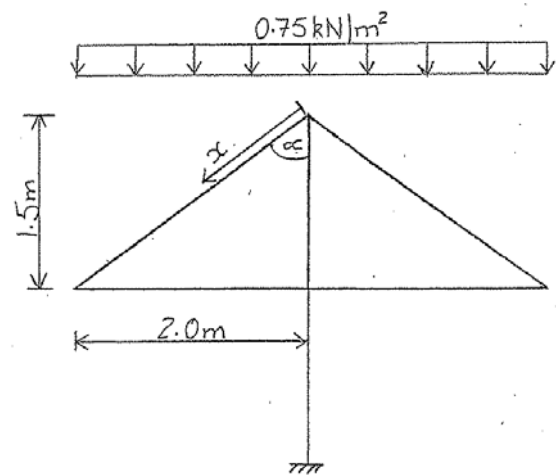


Fig Q4