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**UNIVERSITI SAINS MALAYSIA**

1<sup>st</sup> Semester Examination  
2010/2011 Academic Session

November 2010

**EAS 664/4 – Principle of Structural Design**

Duration : 3 hours

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Please check that this examination paper consists of..... printed pages before you begin the examination.

[Instructions: This paper contains \_\_\_\_\_ ( ) questions. Answer \_\_\_\_\_ ( ) questions only.

You must answer the questions in English.

All question **MUST BE** answered on a new sheet.

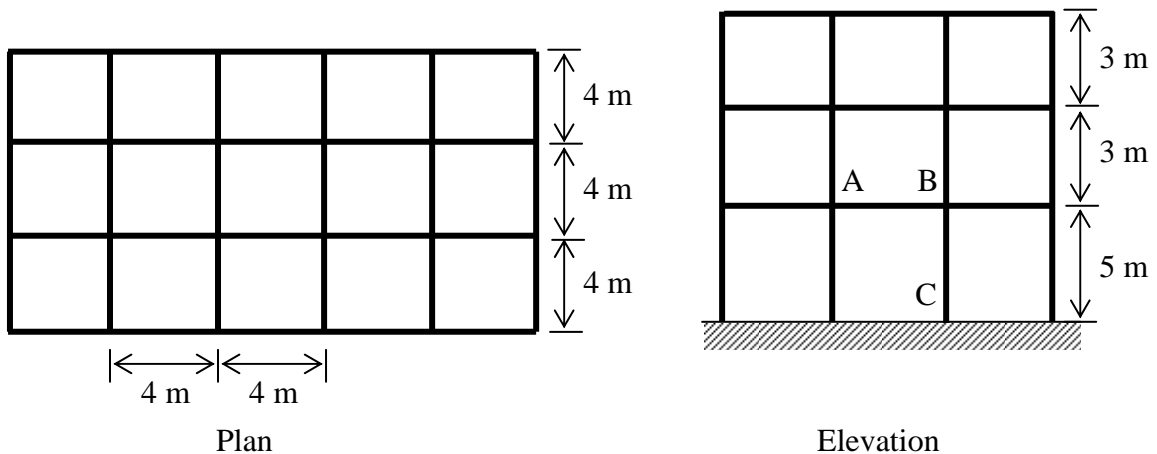
1. a) Explain
  - i. Ductility,
  - ii. Equal displacement concept, and
  - iii. Equal energy concept.

[6 marks]

- b) Figure 1 shows a reinforced concrete framed building. The beams are 200 mm wide by 400 mm deep. Column sections are 300 mm by 300 in the first two (lower) stories and 200 mm by 200 mm elsewhere. The dead load per unit area of floor slabs (100 mm thick) including screeding and plastering is 360 kg/m<sup>2</sup>. The weight of the wall, considered lumped on each floor level, is 12530 kg for the first floor, 9050 kg for the second floor and for the third floor, and 3830 kg for the roof. The building is located in Zone 1 and the site soil is classified as S<sub>E</sub>.

Determine the seismic forces for this structure in accordance with UBC 1997, and design the interior beam AB and column BC as part of an intermediate moment resisting frame. The interaction diagrams for column BC is given in Figure 2.

[14 marks]



**Figure 1**

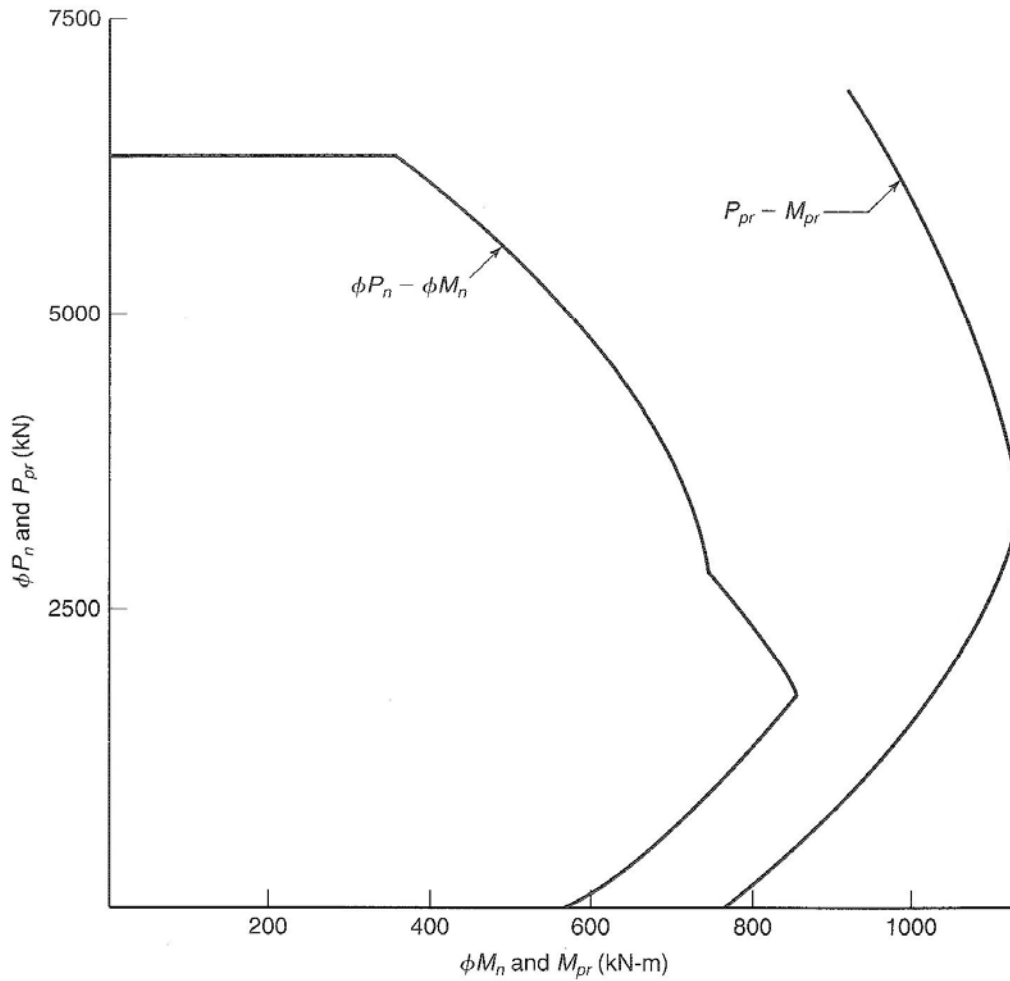


Figure 2

2. a) State **FOUR (4)** structural attributes of tsunami-resistant structures.

[4 marks]

b) A rectangular-shaped building is constructed at 300 m from the shoreline of Batu Ferringgi, Penang. The building is located at 3 m above the mean sea level. It has 15 m wide facing the beach with a slope 1/100. The tsunami inundation map indicates the maximum run-up height of 9 m at the location of 600 m from the shoreline as shown in Figure 3. Use the chart of Figure 4 to determine the maximum flow velocity of depth,  $d$ , at the ground elevation,  $z$  and maximum run-up elevation,  $R$ . Then calculate

- i. Hydrostatic and buoyant forces,
- ii. Hydrodynamic and impulsive forces,
- iii. Impact forces from a fishing boat estimated to be 10 tonnes with the stiffness of  $6 \times 10^8$  N/m, and
- iv. Damming effect of waterborne debris.

[16 marks]

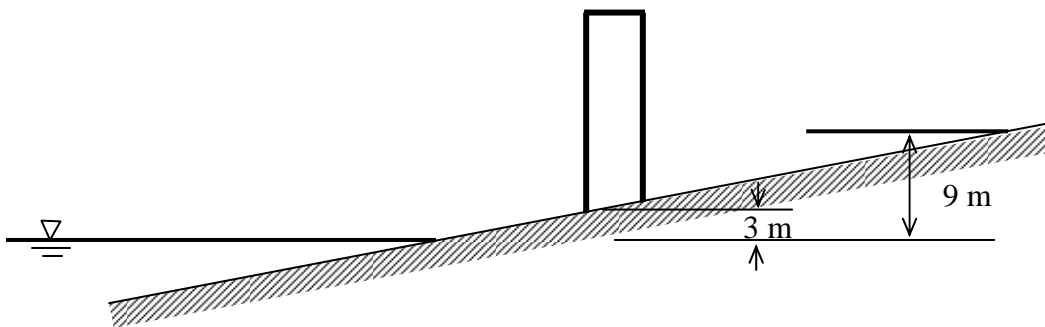


Figure 3

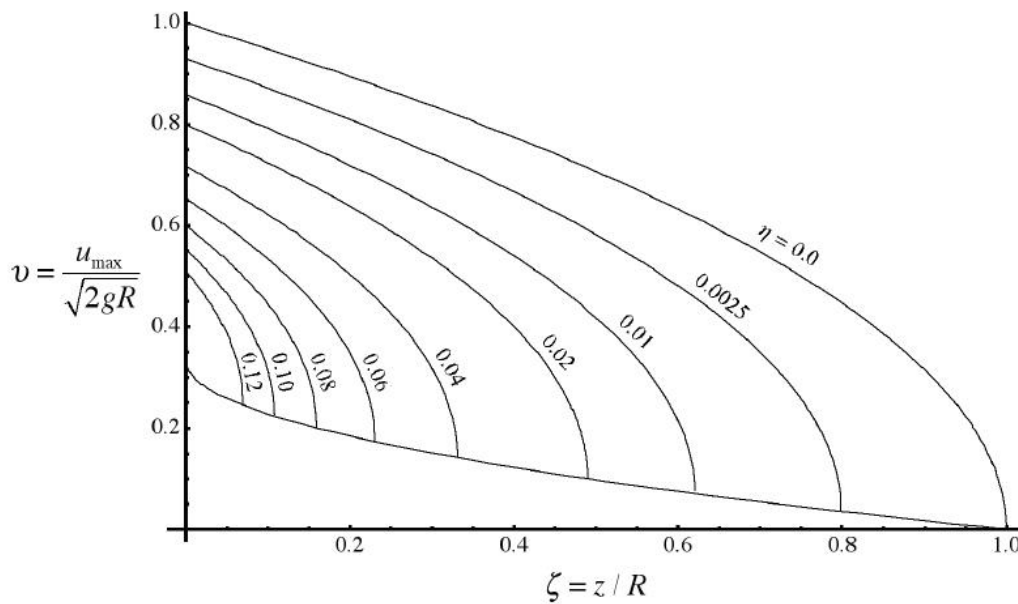


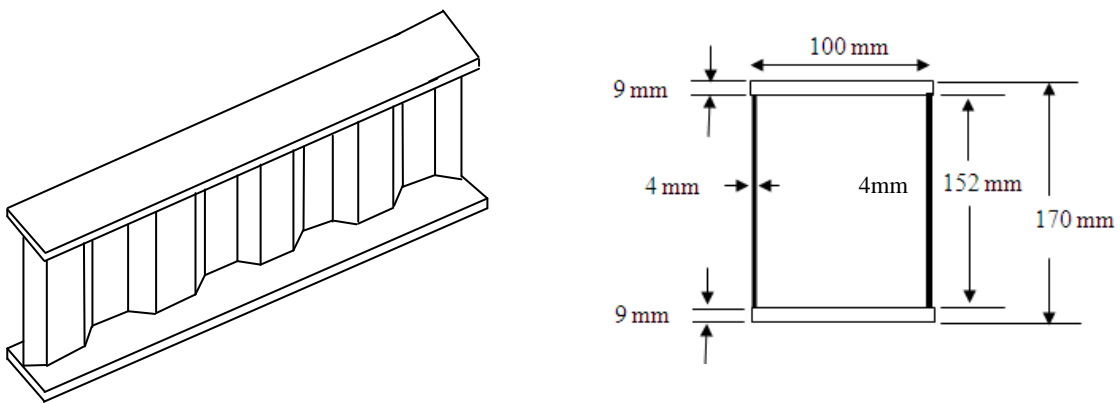
Figure 4

3. a) Rephrase on the calculation of section properties for non-uniform steel section in BS 5950 : 2000 (Part 1).

[2 marks]

- b) From the Figure 5, calculate **FIVE (5)** of the section properties of the non-uniform steel that influence the Lateral Torsional Buckling behavior.

[10 marks]



**Figure 5 : Trapezoidal Web Profile Steel Beam Section**

- c) Explain the differences between warping behavior and torsion behavior of the I-beam steel section.

[8 marks]

4. a) Explain the mechanism of Hillerborg's Strip Method.

[8 marks]

- b) List out the rules of yield line theory. Figure 6 portrays a yield line pattern for a slab supported at three edges only with a uniformly distributed load of  $w$  per unit area. The steel in the shorter  $y$ -direction provides a moment of resistance of  $m_2$  per unit length and the steel in the longer  $x$ -direction provides a moment of resistance of  $m_1$  per unit length. Determine the value of  $w$ .

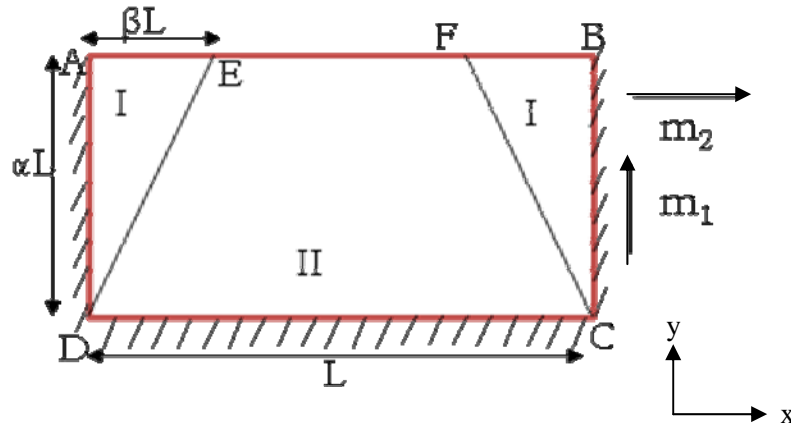


Figure 6

[12 marks]

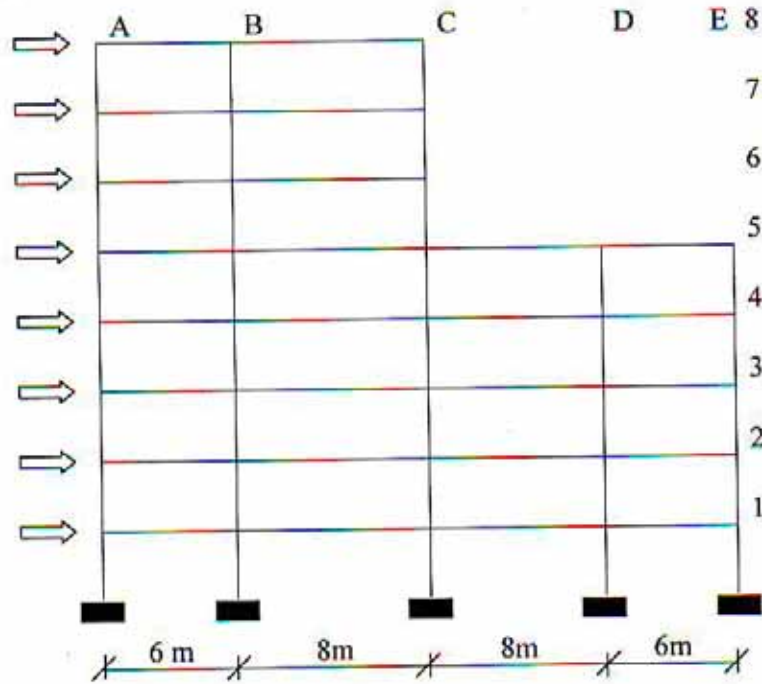
5. a) Briefly describe **FIVE (5)** factors influence the wind load calculation in code of practices.

[5 marks]

- b) Eight storey rigid frame building with setback as shown in Figure 7 is located in Bintulu with terrain category 3. Calculate the value of the design wind force from first floor to roof level of the frame as shown in Figure 7 according to MS1553:2002. The storey height is typically 3.0 m, with a total height of 24m. The frames are spaced at 6m, the width of building is 28 m and the length is 40m. Please indicate all assumed values used in the calculations.

[15 marks]

**Wind Load (kN)**



**Figure 7**

6. a) Describe **THREE (3)** important role of floor systems in a tall building. Briefly describe the advantages and disadvantages of Braced Frame Structures and Infilled Frame Structures as structural form in a high-rise building.

[8 marks]

b) A subframe of eight stories rigid frames has experienced an equivalent horizontal force as shown in Figure 8. The story height is typically 3.0 m, to give a total height of 30m. The frames are spaced at 9m. Using the Portal Method, calculate :

- i) The horizontal external shear at mid-story level for each story.
- ii) The shear to half-columns above and below of fifth story
- iii) The maximum moment above and below joint at fifth story.
- iv) The shear in the girder at fifth story.

Indicates all values ( i – iv) on the diagram.

[8 marks]

- c) What are the main differences between Portal Method and Cantilever Method in determining of member forces caused by horizontal loading in tall building

[4 marks]



## APPENDIX 1

### *Hydrostatic Force*

$$F_h = \frac{1}{2} \rho_s g b h_{\max}^2$$

where  $\rho_s$  is the fluid density including sediment (1200 kg/m<sup>3</sup>),  $g$  is the gravitational acceleration,  $b$  is the breadth of the wall and  $h_{\max}$  is the maximum water height above the base of the wall at the structure location (= 1.3 times the predicted maximum runup elevation).

### *Buoyant Force*

$$F_b = \rho_s g V$$

where  $V$  is the volume of water displaced by the building.

### *Hydrodynamic Force*

$$F_d = \frac{1}{2} \rho_s C_d B (hu^2)_{\max}$$

where  $C_d$  is the drag coefficient (= 2.0),  $B$  is the breadth of the structure in the plane normal to the direction of flow,  $h$  is the flow depth and  $u$  is the flow velocity at the location of the structure.

### *Impulsive Force*

$$F_s = 1.5 F_d$$

### *Debris Impact Force*

$$F_i = C_m u_{\max} \sqrt{km}$$

where  $C_m$  is the added mass coefficient (= 2.0),  $u_{\max}$  is the maximum floe velocity carrying the debris at the site,  $m$  is the mass and  $k$  is the effective stiffness of the debris.

### *Damming Effect of Waterborne Debris*

$$F_{dm} = \frac{1}{2} \rho_s C_d B_d (hu^2)_{\max}$$

where  $B_d$  is the breadth of the debris dam.

### *Momentum flux per unit mass*

$$(hu^2)_{\max} = gR^2 \left( 0.125 - 0.235 \frac{z}{R} + 0.11 \left( \frac{z}{R} \right)^2 \right)$$

where  $R$  is the design runup elevation and  $z$  is the ground elevation at the base of the structure.