UNIVERSITI SAINS MALAYSIA

First Semester Examination
2012/2013 Academic Session

January 2013

EAS 664/4 – Principle of Structural Design

Duration : 3 hours

Please check that this examination paper consists of **TEN (10)** pages of printed material including 1 appendix before you begin the examination.

Instructions : This paper contains **SIX (6)** questions. Answer **FIVE (5)** questions.

All questions must be answered in English.

Each question **MUST BE** answered on a new page.

1. (a) Describe the advantages of the nonlinear static and disadvantages the nonlinear dynamic analysis.

[4 marks]

(b) Earthquake engineering relies on nonlinear finite element analysis (NFEA) to evaluate the performance of a structure, based on the fact that real structures yield when subjected to a severe earthquake. NFEA has become in high demand in the earthquake engineering field because it can evaluate the performance of the structural systems at the life safety and collapse prevention level. Therefore, the nonlinear analysis procedure must be used for evaluation purposes, as inelastic behaviour is possible to be determined directly by an elastic analysis. There are two popular ways in nonlinear analysis that can be used to assess the performance of a structure, either by static analysis and dynamic analysis.

(i) Discuss in detail background for each approach, which are nonlinear static and dynamic analysis.

[16 marks]

2 (a) Tall building is succeptable to horizontal forces; wind and earthquake loadings. Compare the design procedures against wind and earthquake action on a building.

[6 marks]

(b) A 20-storey rigid frame building with setback as shown in Figure 1 is located in Zone I with terrain category 2. The interstory height is 3m. Calculate the value of the design wind pressure on the wind ward direction at the top floor of the frame as shown in Figure 1 according to MS1553:2002. Please indicate all assumed values used in the calculations. Design data can be extracted from MS1553 (2002).

[14 marks]

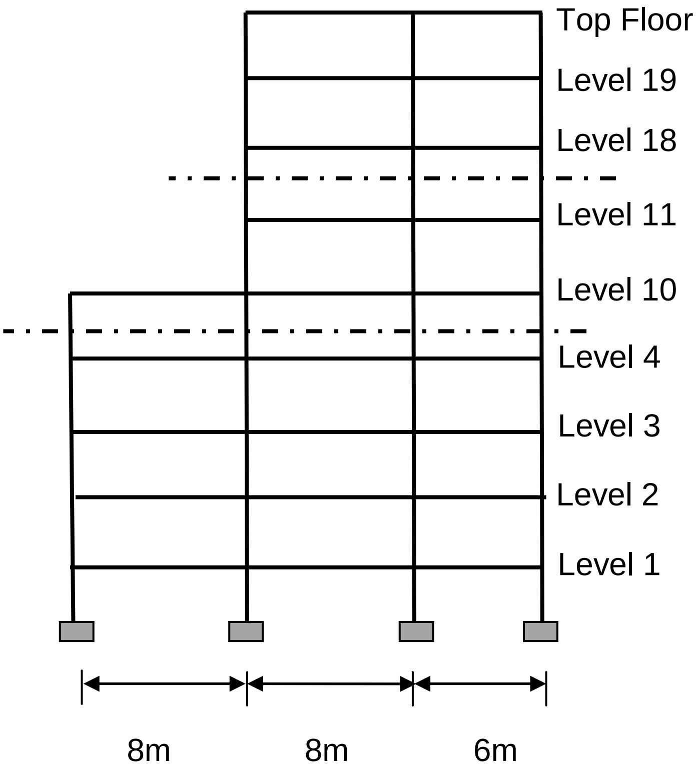


Figure 1

3. (a) Describe the Rigid Frame Structures, Braced Frame Structures, One way steel framing floor systems and Composite Steel-Concrete Floor systems in a high-rise building.

[8 marks]

(b) A 15-storey rigid frames is shown in Figure 2 with its intensity of wind loading of 1.5 kN/m^2 throught out the height. The typical story height is 3m, to give a total height of 45m. The frames are spaced at 6m. Determine the member forces and moments of the top floor using Cantilever Method and the 13th floor using Portal Method.

[12 marks]

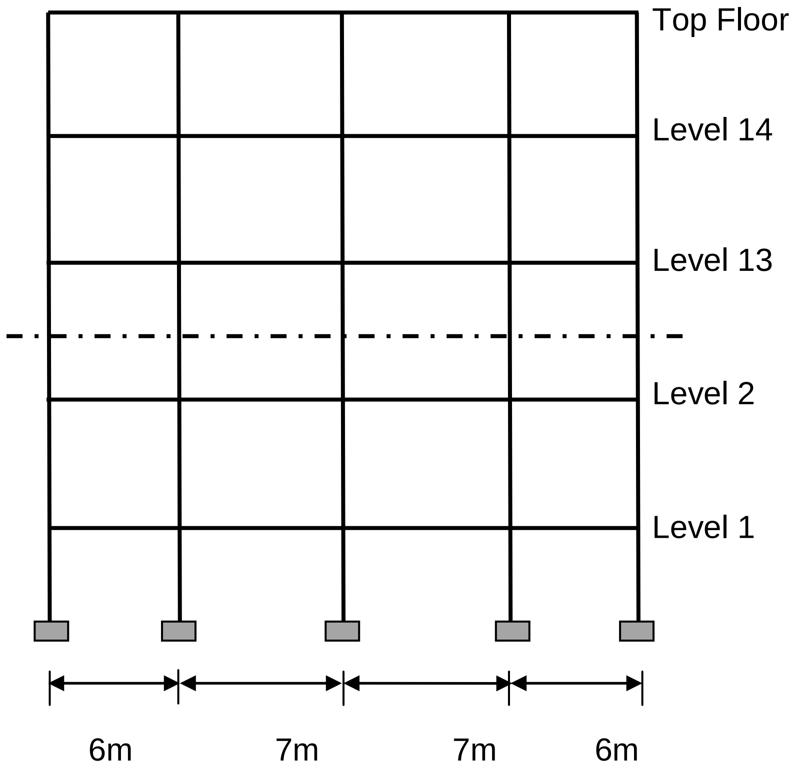


Figure 2

4. (a) Two types of column mechanisms may occur during earthquake. With the help of sketch(es), explain the differences between storey mechanism and sway mechanism.

[4 marks]

(b) Concrete moment framed buildings should have sufficient ductility in order to withstand earthquake load. Explain **THREE (3)** detailing requirements of Ordinary, Intermediate and Special Concrete Moment Frames.

[6 marks]

(c) Figure 2 shows a reinforced concrete framed building. The beams are 230 mm wide by 450 mm deep. Column sections are 300 mm by 300 in the ground floor and 230 mm by 230 mm elsewhere. The dead load per unit area of floor slabs (150 mm thick) including screeding and plastering is 4.8 kN/m^2. Assume full height brickwall of 115 mm thick is constructed on the beams for the ground to third floors and 1.2-meter high parapet (115 mm thick brickwall) is constructed for the roof floor. The density of reinforced concrete is 24 kN/m^3. The building is located in Zone 2B and the site soil is classified as S_D. The known seismic source is located more than 50 km away from the site. Determine the seismic forces for Frame A-A in accordance with UBC 1997.

[10 marks]

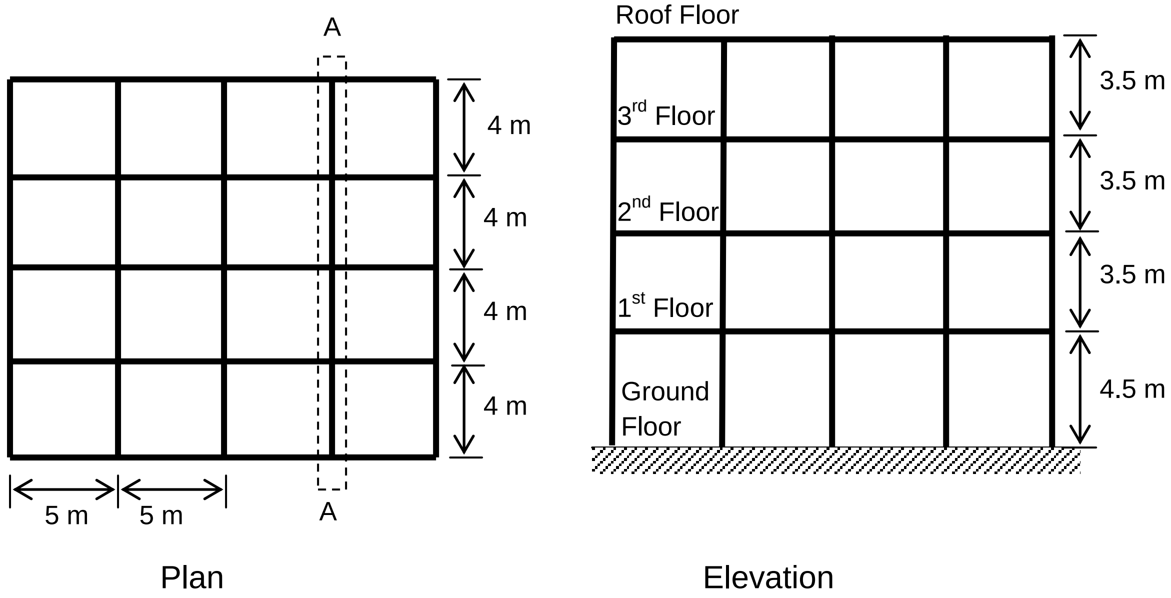


Figure 2

5. (a) Explain **TWO (2)** types of damage on building caused by tsunami and **THREE (3)** design concepts for structural systems (foundation, columns, walls and floor systems) engineered to resist tsunami load effects.

[10 marks]

(b) A rectangular-shaped building is constructed at 500 m from the shoreline of Penang. The building is located at 1.5 m from the mean sea level. It has 30 m wide facing the beach with a slope 1/200. The tsunami inundation map indicates the maximum runup height of 10 m as shown in Figure 3. Figure 4 shows the plan and section views of the building. Use the equations in Appendix 1 to calculate the following forces on the building.

i. Hydrostatic and buoyant forces if the wall is designed as non-breakway and breakaway brickwall,

ii. Hydrodynamic and impulsive forces if the wall is designed as non-breakway and breakaway brickwall,

iii. Impact forces from a 6-meter standard shipping container. Use Figure 4 to determine the maximum flow velocity that can carry a shipping container at the ground elevation, *z*, and maximum runup elevation, *R*. Assume the ratio between the depth relative to the design runup elevation (η) as 0.01, and

iv. Hydrodynamic forces due to damming effect of waterborne debris.

[10 marks]

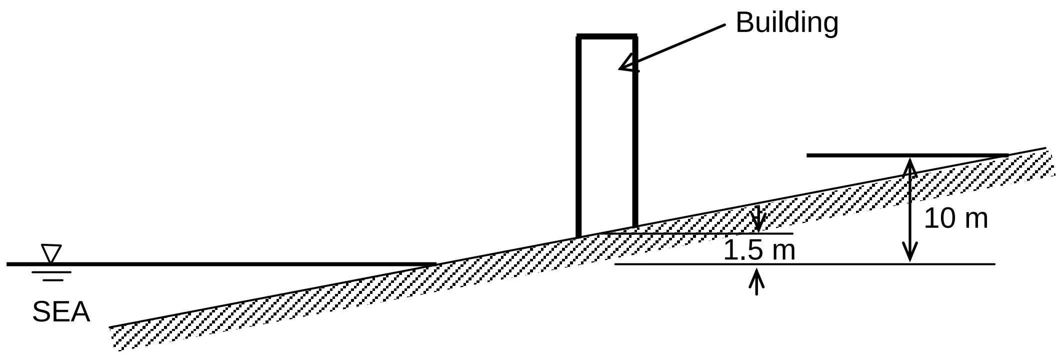
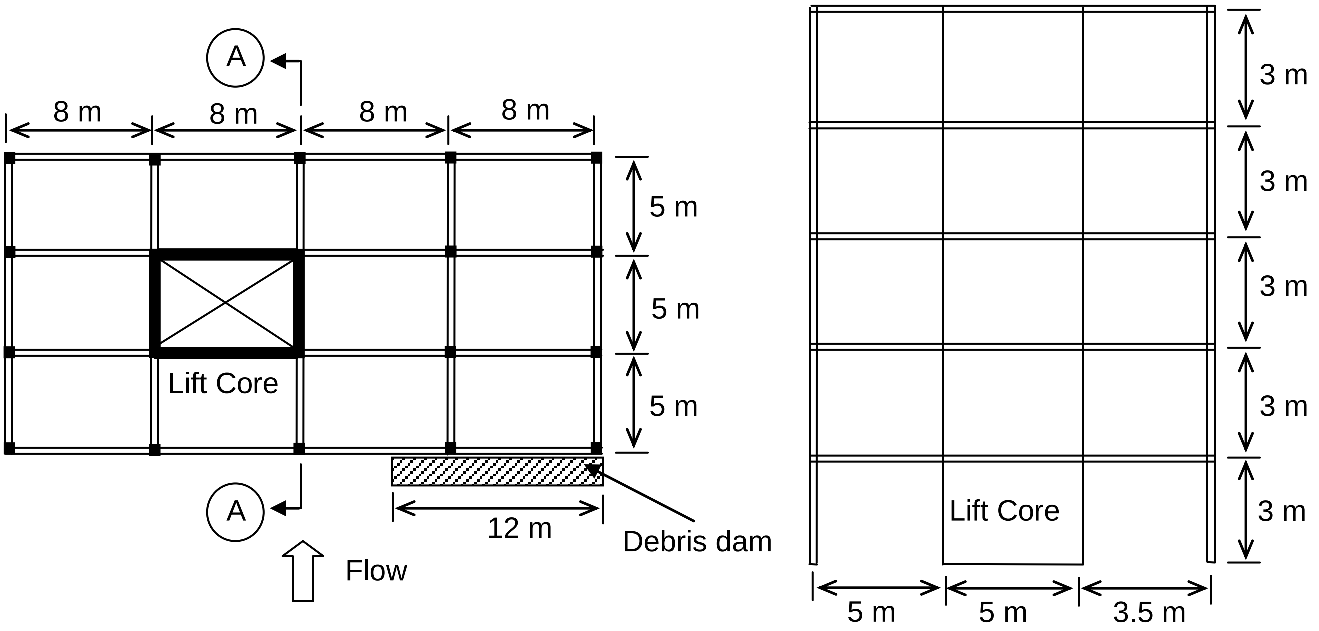


Figure 3



Note: Size of column = 450mm × 450 mm

Plan View

Section A-A

Figure 4

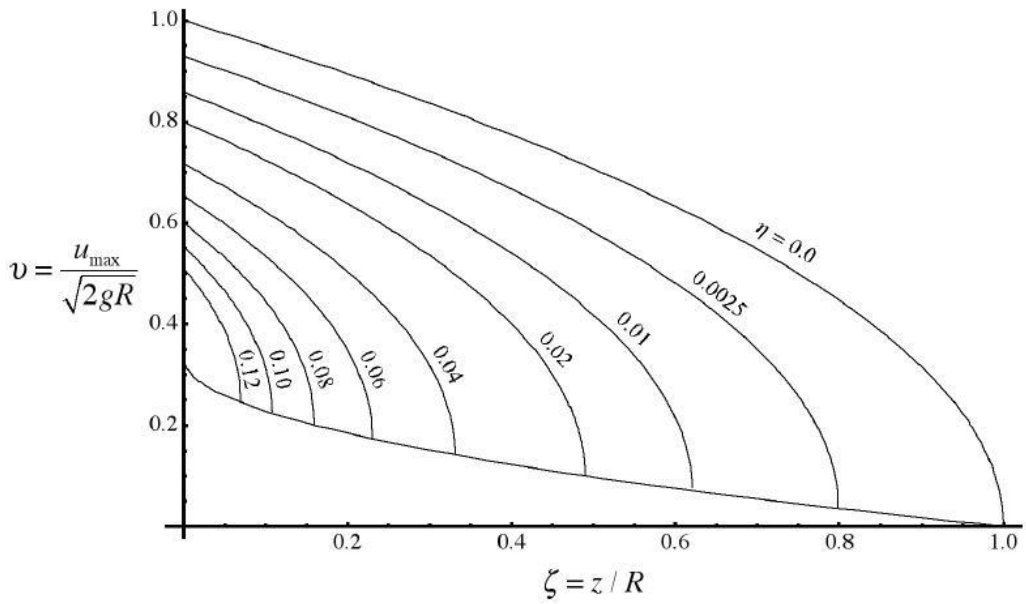


Figure 5

6 . (a) You are given a task to check the suitability of CMU sizes on the unreinforced single leaf wall. By using Design Code BS5628 Part 1 : 2005 : Structural use of unreinforced masonry, evaluate the suitability of CMU size with the design load proposed? (Show all calculation for 90mm, 140mm and 190mm thick CMU unit).

Given

i. Unit compressive strength of CMU= 7.30 N/mm^2

ii. Mortar for joint (M6); use mix of masonry cement : sand = 1:3

iii. Characteristic compressive strength, fk = 3.2 N/mm^2 (for 390mm length, 90mm thick, 190mm height), 3.2 N/mm^2 (for 390mm length, 140mm thick, 190mm height), and 3.2 N/mm^2 (for 390mm length, 190mm thick, 190mm height)

iv. Concrete infill for reinforced CMU cores
- cement : sand : 10mm max sized aggregate 1 : 2 : 3
- slump between 75mm to 175mm for unplastisize mix

v. Design load for CMU
- 90mm thick (width) = 50 kN
- 140mm thick (width) = 100 kN
- 190mm thick (width) = 120 kN

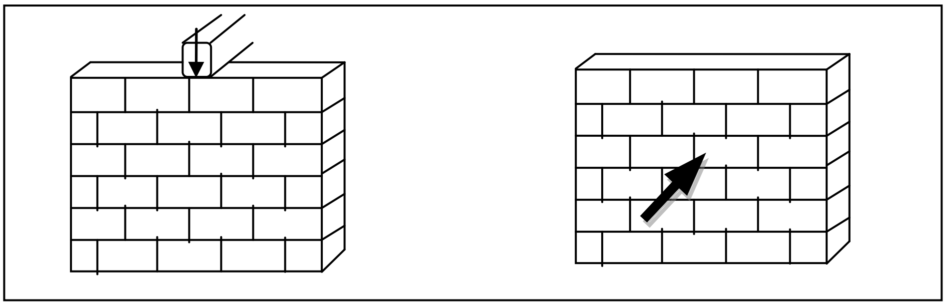
vi. Height of wall h_{eff} = 3500

[13 marks]

(b) The profile of mortar finishing work in masonry have an effect to the durability of structure cause by rain water. With the aid of appropriate sketch, list down the profile of mortar finishing work.

[3 marks]

(c) Sketch the distribution of load pattern in both horizontal and vertical direction for single leaf masonry wall.



[2 marks]

(d) With the aid of appropriate sketches, explain briefly the term ‘hog in the wall’.

[2 marks]

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APPENDIX 1

Hydrostatic Force

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

where ρ_s is the fluid density including sediment (1200 kg/m^3), 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 breath 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

$$F_s = 1.5F_d$$

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 (= 12 m).

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.