UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: December 2018

Module Number: CE 6252 **Module Name: Dynamics and Control of Structures**

[Three Hours]

[Answer all questions. Each question carries 12 marks]

Q1 a) What is free vibration test?

[1 Mark]

b) A 3 m high, 8 m wide single-bay single-storey frame is rigidly jointed with a beam, having a mass of 5,000 kg and columns having negligible mass. For columns, EIc = ~~4.5×103~~ 4.5×10^3 kNm^2.

i) Determine the natural frequency and period of motion in lateral vibration.

ii) Determine the force required to be applied at the beam level to deflect the frame 25 mm laterally, at the same level.
(state clearly any assumption made)

[6 Marks]

c) To the frame in Part (b), a jack applied a load of 100 kN at the beam level and then instantaneously released. On the first return swing, a deflection of 19.44 mm was observed. Determine the damping coefficient of the system.

[5 Marks]

Q2 a) What is "free vibration response" and "force vibration response" of a system?

[1 Mark]

b) Compare total response and steady-state response of an undamped system to harmonic forces. Use neat sketches to support the answer.

[3 Marks]

c) A single storey building with a roof slab as shown in Figure Q2 is newly constructed for a factory. The mass of the roof slab, M, is 24 000 kg and EI for columns is 27×10^3 kNm^2. The machine, installed on the roof slab generates an unbalanced horizontal force of 5000 N varying sinusoidally.

i) Determine the natural frequency of the frame for free vibration in horizontal direction.

ii) Determine the maximum displacement when the machines speed is 360 rpm (revolutions per minute).

iii) Determine the speed of the machine at resonance.

iv) Determine the displacement of the frame at resonance.

[neglect the mass of the machine]

[8 Marks]

Q3 You are assigned a task to perform dynamic analysis for a Lecture Theater proposed to be constructed in a university. A roof slab is planned for this building. The structure can be considered as "shear frame structure" and is shown in Figure Q3 (a). The masses of the building are lumped onto the floor slabs and the stiffnesses are provided by columns.

a) Idealize the frame for dynamic analysis for horizontal vibration.

[2 Marks]

b) Draw free-body diagrams for each mass representing relevant floors of the building, and hence

i) Derive the equation of motion for each mass.

ii) Formulate the equation of motion for the system.

[2 Marks]

c) Determine the natural frequency and the mode shape associated with each vibration mode of the structure. Assume k/m =25, where k and m are shown in Figure Q3(a).

[4 Marks]

d) It has been proposed to modify the Lecturer Theater by removing one middle column at the first storey level as shown in Figure Q3(b), due to the requirement of seminar room facilities.

i) Derive the equation of motion for the modified shear frame structure.

ii) How significantly the mode shapes and associated natural frequencies would change?

[4 Marks]

Q4 a) What is the Dynamic magnification factor?

[1 Mark]

b) A single storey school building, having a shear frames can be considered as an un-damped Single Degree of Freedom (SDOF) system. From the un-damped free vibration response shown in Figure Q4, determine the natural frequency of the building.

[2 Marks]

c) Of the control measures suggested below, determine which one will minimize the steady-state vibration amplitude, effectively.

i) Doubling the structural stiffness

ii) Doubling the structural stiffness and the mass

iii) Adding a damper to make the structural damping ratio equals to 10%.

[9 Marks]

Q5 a) What are the types of seismic waves? Compare their characteristics.

[3 Marks]

b) What are the advantages and disadvantages of application of Tunned Mass Dampers (TMD) to control human induced vibration in bridge structures?

[3 Marks]

c) What are the vertical structural forms that can be used to enhance seismic resistance of masonry in-filled reinforced concrete building structures? Explain how mechanism (s) of each structural form contributes to enhance the seismic resistance of the building structures.

[3 Marks]

d) Figure Q5 (a) shows a seismograph record of a seismic wave generated from a recent earthquake occurred in the Pacific Ocean. Determine the magnitude of the earthquake that generated the waves as shown in Figure Q5(a). You may use the Richter scale given in Figure Q5(b) .

Note: Attach Figure Q5(b) to the answer book.

[3 Marks]

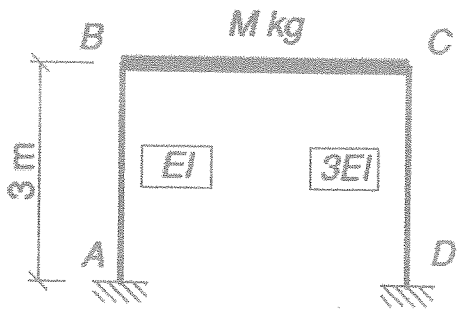

Figure Q2 Single Degree of Freedom building frame

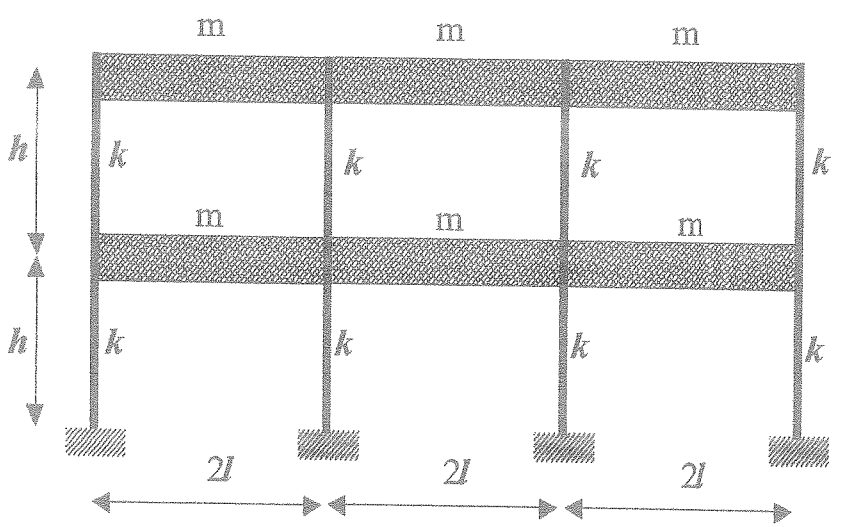

Figure Q3(a) : Shear frame structure

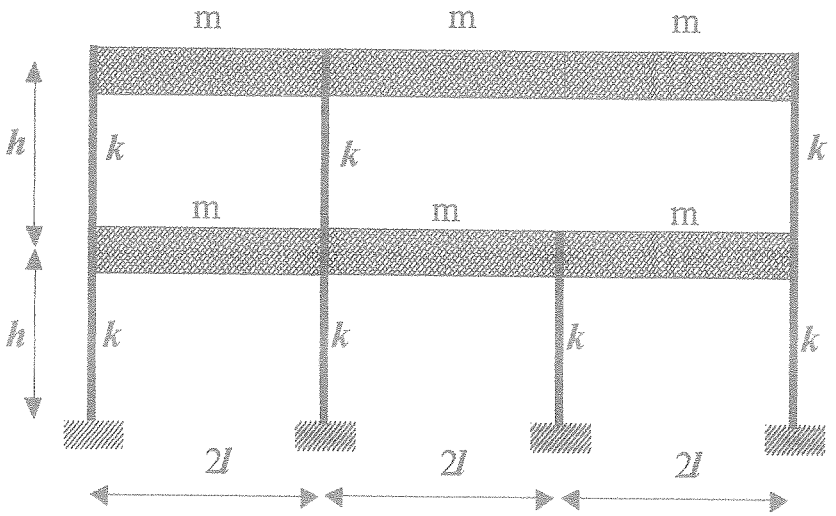

Figure Q3(b) : Modified shear frame structure

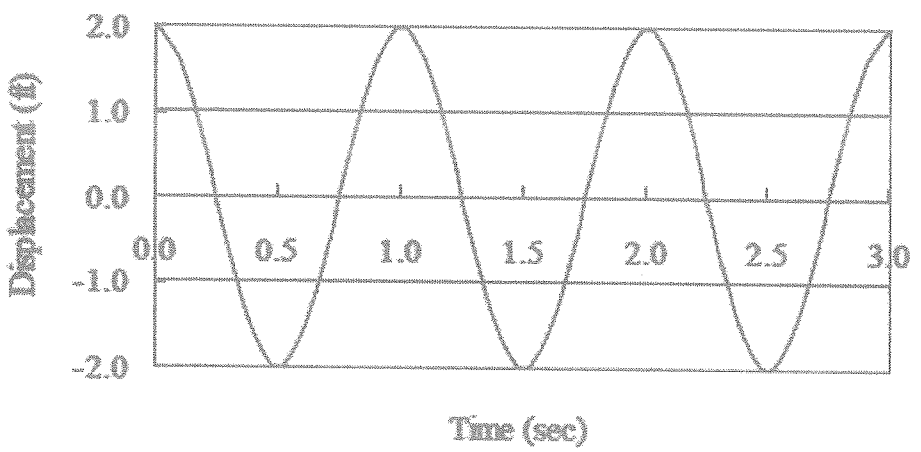

Figure Q4: Free vibration response

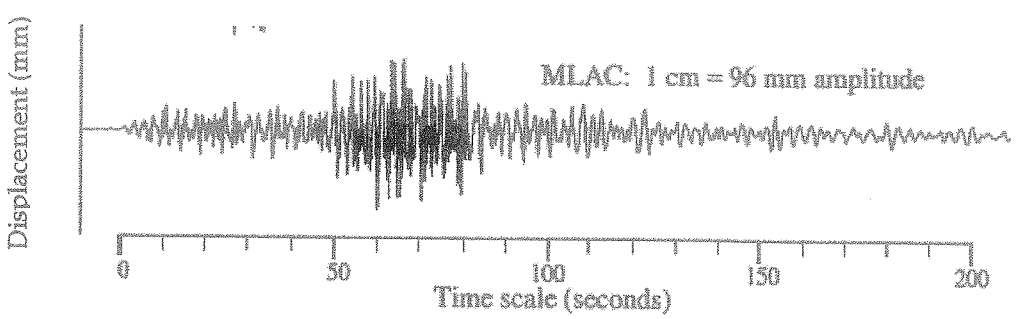

Figure Q5 (a). Seismograph record of a seismic wave

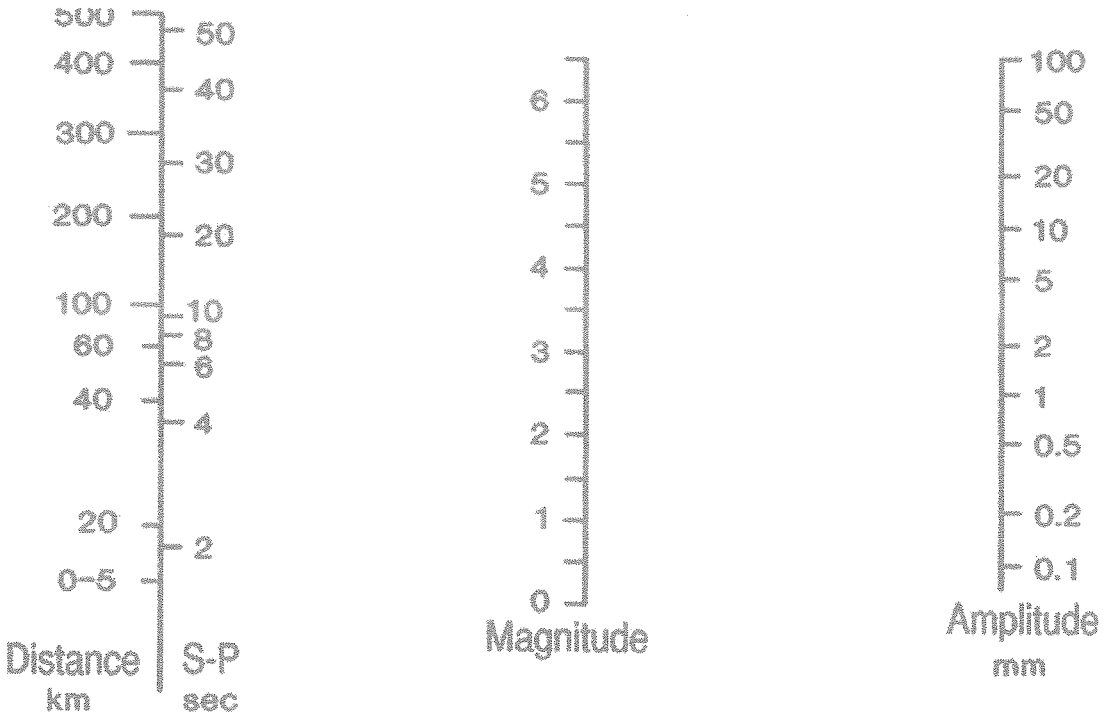

Figure Q5 (b) : Richter scale