UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: January 2022

Module Number: CE 6252 **Module Name: Dynamics and Control of Structures (N/C)**

[Three Hours]

[Answer **all questions.** Each question carries **12 marks]**

Q1 a) Explain the method of conducting the free vibration test.

[2 Marks]

b) What are the limitations of the free vibration test measurements over the force vibration test measurements if the test was performed on a two degrees of freedom system?

[2 Marks]

c) A 3 m high, 8 m wide single-bay single-storey frame is rigidly jointed with a beam of mass 5,000 kg, and columns of negligible mass with EIc value of 4.5×10^3 kNm^2, where E is the young's modulus of the column materials and Ic is the second moment of area of a column section. Neglect the damping of the frame.

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

ii) What is the force required to deflect the frame by 35 mm laterally.

iii) What is the deflection of the frame during the first 0.5 seconds, if the frame was subjected to the free vibration induced by the initial deformation of 25 mm? Draw a graph to support the answer.

[8 Marks]

Q2 a) What is the "Steady state response" of a damped system for a harmonic force?

[2 Marks]

b) Compare the steady state response of a system with critical damping, over damping and underdamping. Use neat sketches to support the answer.

[4 Marks]

c) A single-storey single-bay frame of 4 m height and 7.5 m width is proposed to be used in a factory building. The frame, which includes a beam of mass 4500 kg, has a reciprocating machine put on it. The mass of this machine is 4 tonnes (=4000 kg). Columns have negligible mass with EIc value of 5×10^3 kNm^2, where E is the young's modulus of the column materials and Ic is the second moment of area of a column section. It is estimated that the machine can exert a periodic force of 8.5 kN at a frequency of 1.75 Hz. Determine the steady-state amplitude of vibration ,

i) If the damping ratio is 5%.

ii) If the forcing frequency was in resonance with the structure.

[6 Marks]

Q3 Dynamic analysis of proposed shopping complex shown in Figure Q3 is needed to be performed. Initially, the structure has two storied (ground floor and the first floor) with the column arrangement shown in Figure Q3 and it can be considered as a "shear frame structure". The masses of the building are lumped onto the floor slabs and the stiffnesses are provided by columns.

a) Formulate the equation of motion for the system.

[2 Marks]

b) Determine the natural frequency and the mode shape associated with each vibration mode of the structure. Assume k/m =12, where k and m are as illustrated in Figure Q3.

[6 Marks]

c) Due to the demand of various usages of the first floor, the building is proposed to be modified by removing all middle columns located at the first floor level.

i) Determine the natural frequency and the mode shape associated with the modified structure.

ii) Discuss the dynamic response of the modified structure for possible human induced vibration at 1.15 Hz, and 2.3 Hz.

[4 Marks]

Q4 a) What are the sources of bridge vibration?

[2 Marks]

b) Discuss active vibration control systems and passive vibrations control systems that can be used to control bridge vibration?

[3 Marks]

c) What are the advantages and limitations of the each system in Part (b) for controlling the bridge vibration?

[3 Marks]

d) Determine the first natural frequency and associated vibration modes of a simply supported bridge of mass 8 tonnes with a 2 tonne lorry at its quarter point. It is known that a load of 10 kN causes a 3 mm deflection. 1 tons=1000 kg.

[4 Marks]

Q5 a) List out and compare different types of seismic waves.

[2 Marks]

b) Explain briefly the methods that can be used to quantify significance of the earthquake?

[2 Marks]

c) What are the vertical structural forms and the mechanisms that can be used to reduce dynamic responses of high-rise building structures for earthquake loadings?

[4 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.*

[4 Marks]

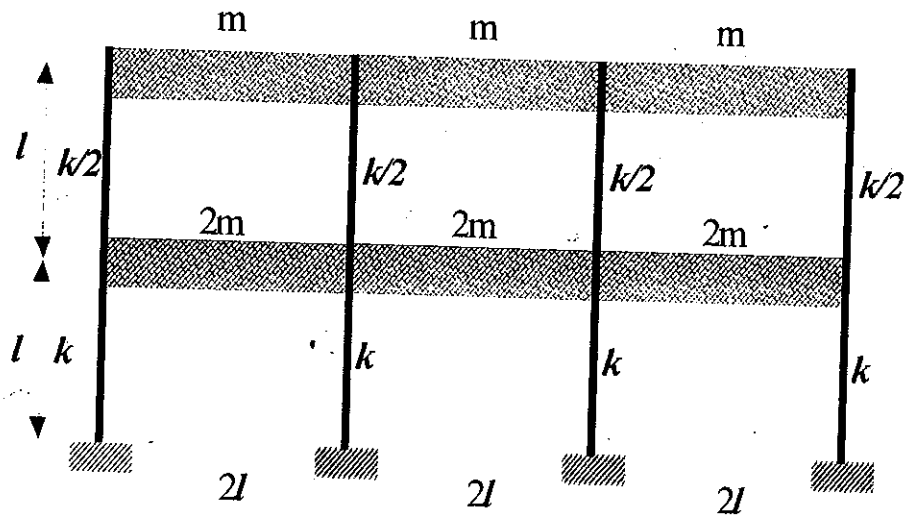

Figure Q3 : Shear frame structure

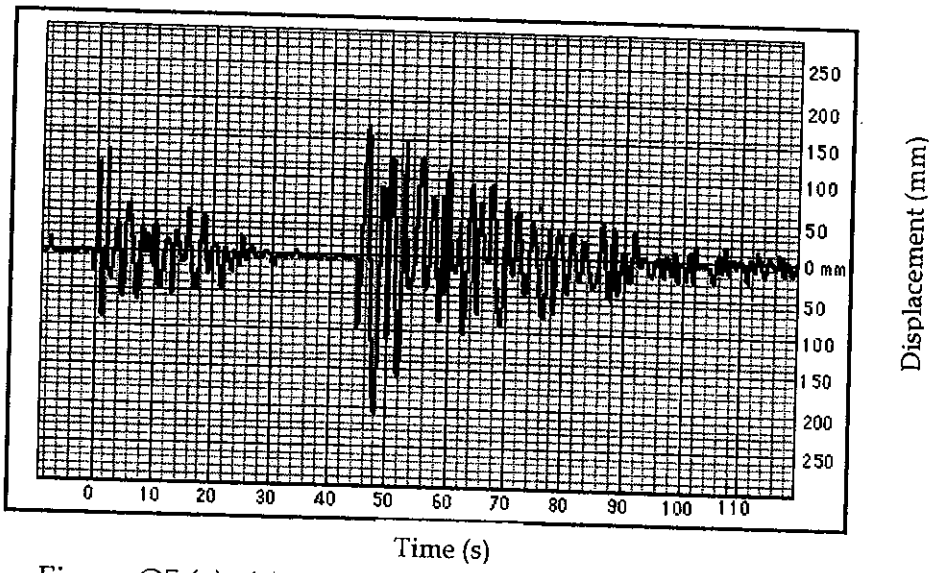

Figure Q5 (a). A seismograph record of a seismic wave

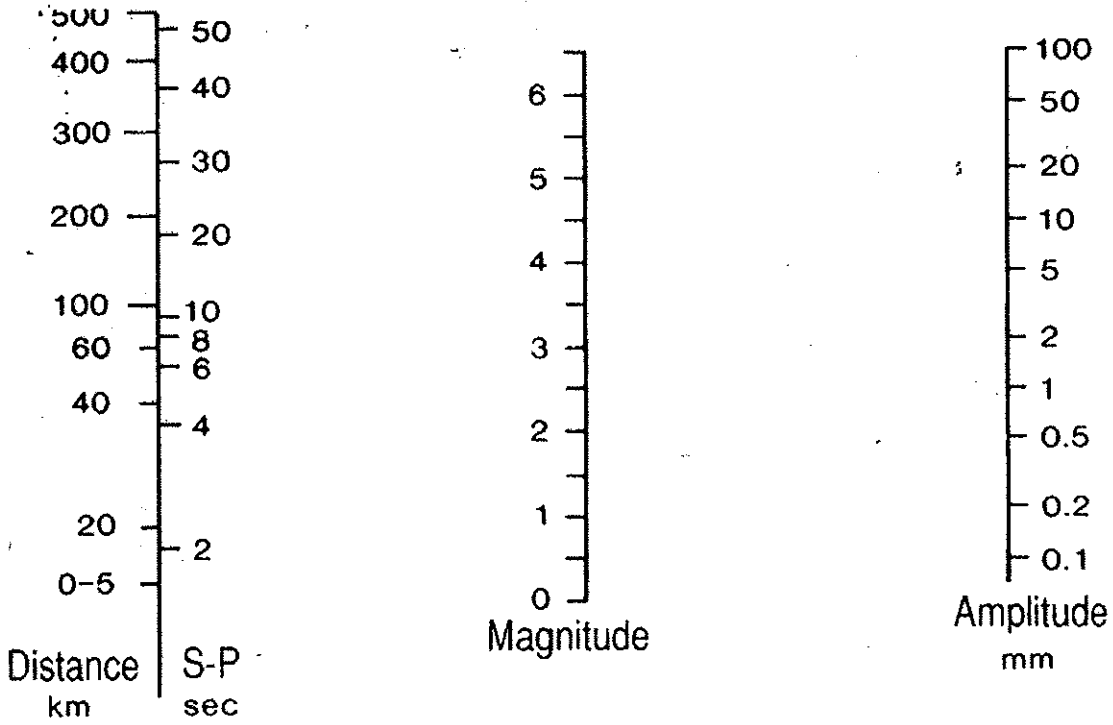

Figure Q5 (b) : Richter scale