UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: November 2016

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

[Three Hours]

[Answer all questions]

Q1 a) What is free-damped vibration? Elaborate the answer by providing examples.

[2 Marks]

b) Discuss the effect of different level of damping on free vibration response. Use sketches to illustrate the answer.

[2 Marks]

c) A free vibration test has been recommended to be used for determining the stiffness co-efficient and damping co-efficient of a mass-spring-damper system at single degree of freedom system. For the test conducted in the field, the mass was displaced 24 mm by a hydraulic jack first and then suddenly released. At the end of 20 complete cycles, the total time was recorded as 4.0 seconds and the amplitude of displacement was found as 4 mm. The mass of the system was identified as 400 kg.

i) Determine the damping ratio of the system.

ii) Determine the stiffness co-efficient and damping co-efficient of the system.

iii) If there is some reciprocating machinery with a frequency of 32 rad/sec is attached to the system, determine the possible dynamic amplification of the system.

[8 Marks]

Q2 a) Explain briefly,

i) Steady-state response.

ii) Total response.

iii) Half-power band width.

[3 Marks]

b) Compare total response and steady-state response of a damped system to harmonic forces? Use sketches to support the answer.

[3 Marks]

c) The steady-state acceleration amplitude of a model structure induced by a shaking table was measured for several excitation frequencies. The measurements are summarized in Table Q2.

i) Plot the acceleration amplitude with excitation frequencies.

ii) Determine the natural frequency and damping ratio of the structure.

[6 Marks]

Q3 Dynamic analysis is needed to be carried out for a two storey frame structure which is proposed as a hotel building in the coastal region. For the analysis, the building can be idealized as two-dimensional frame and considered as a "shear frame structure" as shown in Figure Q3. 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.
   i) Derive the equation of motion for each mass.
   ii) Formulate the equation of motion for the system.

[4 Marks]

c) 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.

[4 Marks]

d) If the building is subjected to lateral wind forces with the frequencies closer to the second mode of vibration, how do you reduce the building response to 1/3 of the uncontrolled response of the building?

[2 Marks]

Q4 a) What is critical damping?

[2 Marks]

b) You are assigned a task to analyse the effect of the ground vibration induced by soil compaction on surrounding building structures. As an initial study, ground vibrations at the compaction site were monitored and ground velocities were recorded as shown in Figure Q4 (a). Frequency responses of the measured velocities are shown in Figure Q4 (b). It has been identified that, most of the two storey buildings near by the soil compaction site are having vibration modes at 19 Hz and 40 Hz without significant amount of damping.
   i) Determine the frequencies and the maximum magnitude of the ground velocity in each direction induced by the soil compaction.
   ii) Determine the magnification of the building responses to the ground vibration induced by the soil compaction.
   iii) Discuss possible methods to reduce the magnification of the building responses and the propagation of ground vibration.

[10 Marks]

Q5 a) What are the advantages and disadvantages of application of passive control techniques to control earthquake induced building vibration?

[3 Marks]

b) What are the structural forms that can be used to enhance seismic resistance of reinforced concrete buildings? Explain mechanism (s) how each structural form contributes to enhance the seismic resistance of reinforced concrete buildings.

[3 Marks]

c) What are P-waves and S waves? Compare the characteristic of these two different types of waves.

[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]

Table Q2. Steady-state acceleration amplitude of a structure at several excitation frequencies

Frequency (Hz)	Acceleration (10^{-3}g)	Frequency (Hz)	Acceleration (10^{-3}g)
1.2	0.65	1.5	7
1.3	0.89	1.513	5.4
1.4	1.25	1.52	4.7
1.45	1.5	1.53	3.8
1.5	2.3	1.54	3.4
1.453	3.05	1.55	3.1
1.462	4.05	1.567	2.5
1.477	7	1.605	1.95
1.487	8.6	1.628	1.7
1.493	8.5	1.658	1.3
1.497	7.8		

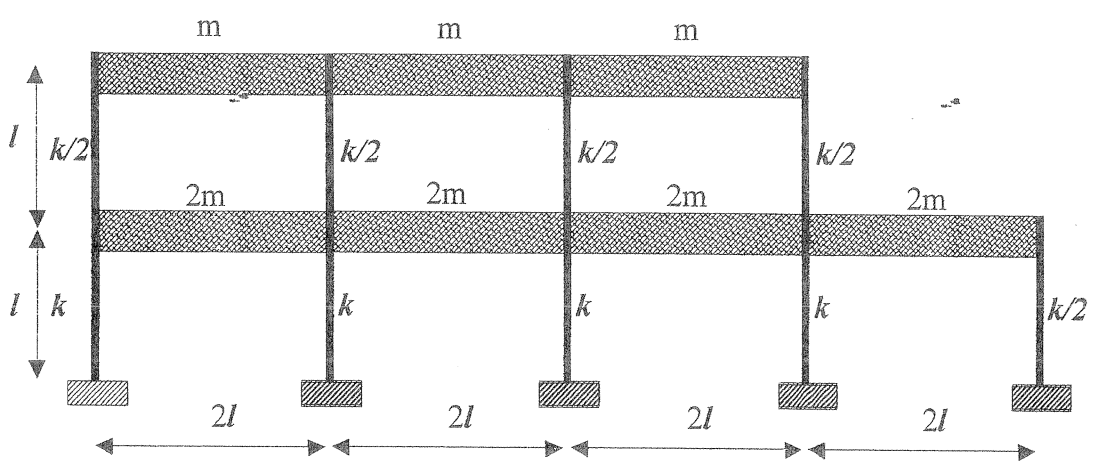

Figure Q3: Shear frame

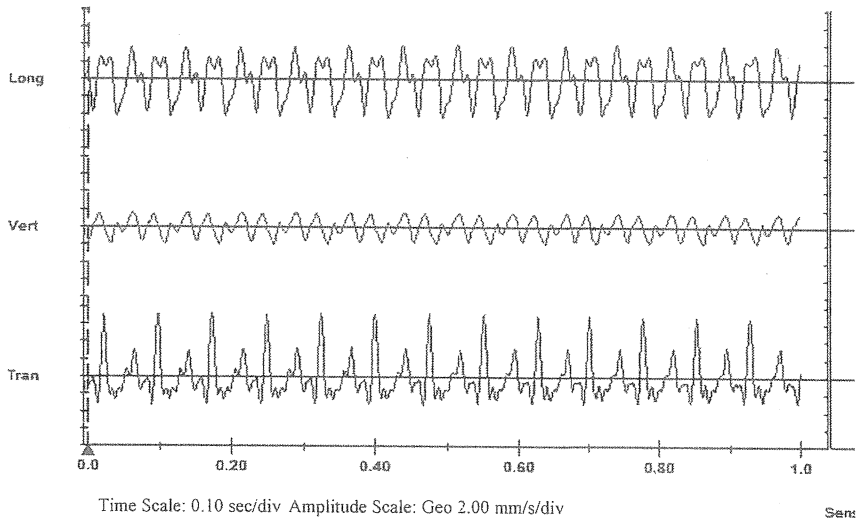

Figure Q4 (a) Time response

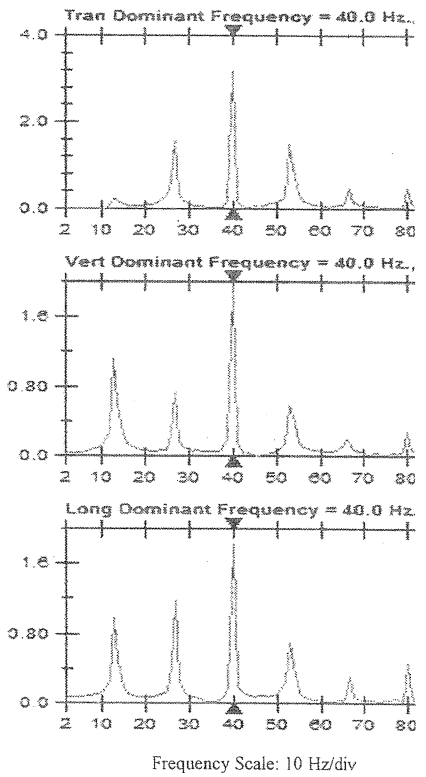

Figure Q4(b) : Frequency response

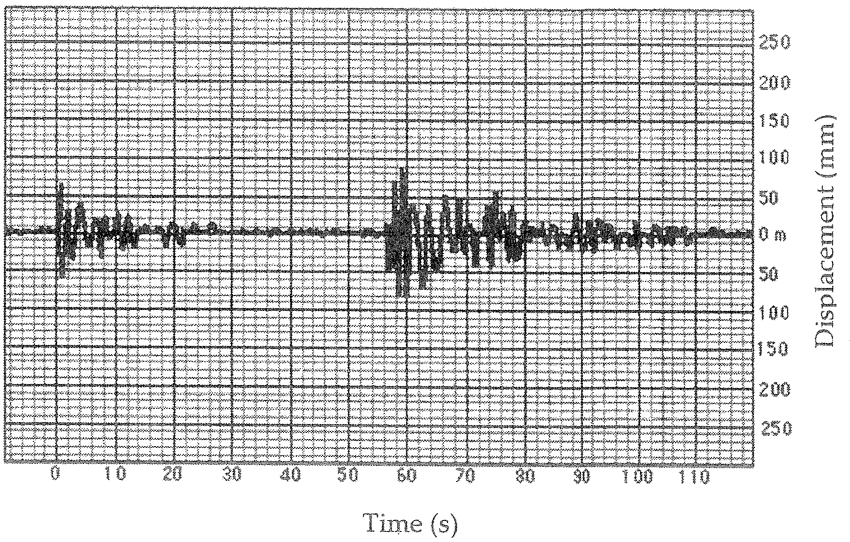

Figure Q5 (a). A seismograph record of a seismic wave

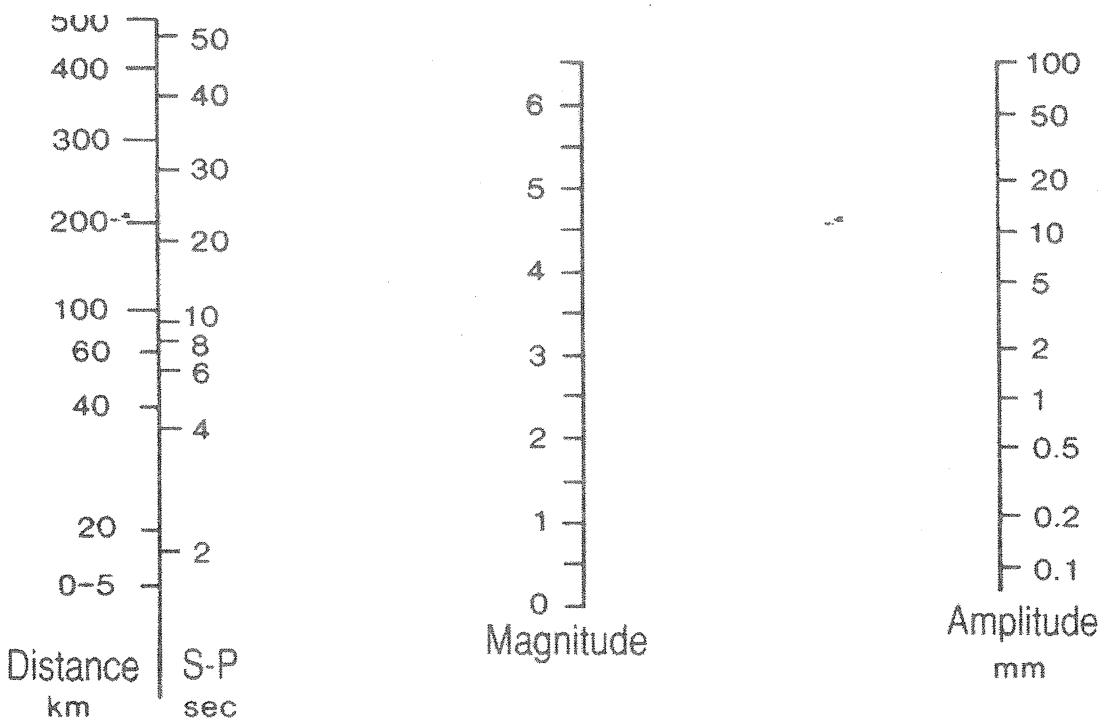

Figure Q5 (b) : Richter scale