UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: February 2020

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

[Three Hours]

[Answer all questions. Each question carries 12 marks]

Q1 a) Compare free vibration response of an "un-damped system" with free vibration response of a "damped system". Use neat sketches to support the answer.

[2 Marks]

b) A reinforced concrete overhead water tank is supported by a column of 60 m height. The column is made of reinforced concrete with a tubular cross section having an inner diameter of 3.4 m and outer diameter of 5.2 m. Modulus of elasticity of concrete is 25 GPa and the total mass of the tank including water is estimated as 45 000 kg.

i) Idealize the structure for dynamic analysis in the lateral direction.
ii) Derive the equation of motion for the idealized structure.
iii) Determine natural frequency and natural time period of the system.
(state clearly any assumption made) [6 Marks]

c) Determine the vibration response of the tank due to an initial transverse displacement of 15 mm.

[4 Marks]

Q2 a) What is "force vibration response" of a damped system? Compare total response and steady-state response of a damped system to harmonic forces. Use neat sketches to support the answer.

[3 Marks]

b) A single storey building with a roof slab as shown in Figure Q2 is newly constructed in a sloping ground for a textile factory. The mass of the roof slab, M is 24 000 kg and EI for column is 27×10^3 kNm^2. Determine the natural frequency of the frame for free vibration in horizontal direction.

[3 Marks]

c) A reciprocating machine has been installed on the roof. The mass of this machine is 3640 kg and is in addition to the mass of the roof. The machine exerts a periodic force of 8.5 kN at a frequency of 1.75 Hz.

i) Determine the steady-state amplitude of vibration if the damping ratio is 4%.
ii) Determine the steady-state amplitude of vibration if the forcing frequency was in resonance with the structure.

[6 Marks]

Q3 You are assigned a task to perform dynamic analysis for a Lecture Theater building proposed to be constructed in a university. A roof slab is designed for this building. The structure can be considered as "shear frame structure" and is 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, 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 =15, where k and m are shown in Figure Q3.

[8 Marks]

Q4 a) Explain briefly the following condition of dynamic systems

i) Under damping

ii) Critical damping

iii) Over damping

[3 Marks]

b) A single storey building having a shear frame can be idealized as Single Degree of Freedom (SDOF) system. The mass of the roof is estimated as 25 000 kg. The lateral responses of the system have been measured in four conditions: (a): without applying dampers and (b), (c), and (d) with Damper 1, 2, 3, respectively. The recorded measurements are compared in Figure Q4.

i) Determine the un-damped natural frequency of the building.

ii) Determine the damped natural frequencies and associated damping ratios for Dampers 1,2, 3.

[6 Marks]

c) Evaluate the performance of Dampers 1,2,3 with respect to the critical damping of the building. [3 Marks]

Q5 a) What are the advantages and disadvantages of application of Tuned Liquid Column Dampers (TLCD) to control wind induced vibration in tall buildings?

[4 Marks]

b) What are the vertical structural forms that can be used to enhance wind resistance of tall building structures? Explain how mechanism (s) of each structural form contributes to enhance the wind resistance of tall building structures.

[4 Marks]

c) 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]

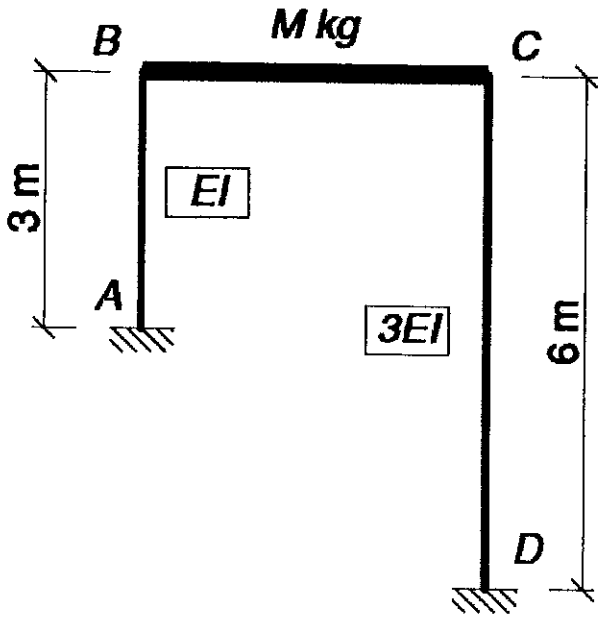

Figure Q2: A single storey building with a roof slab

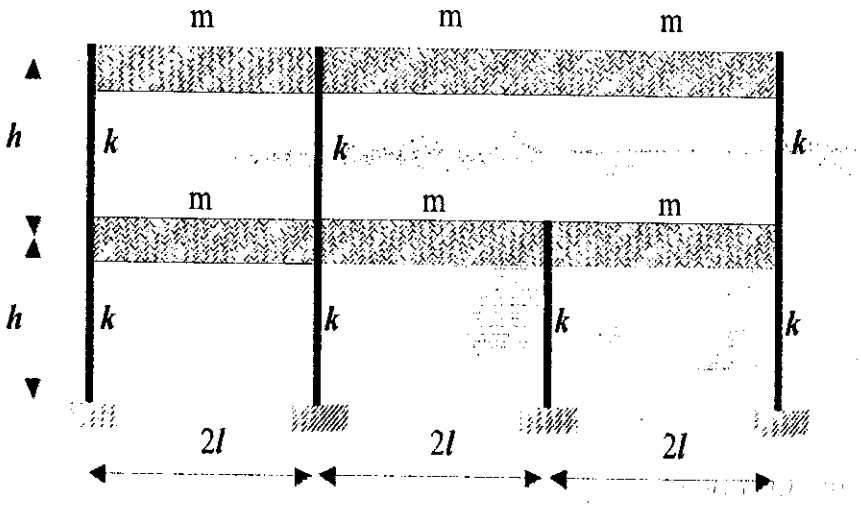

Figure Q3 : Shear frame structure

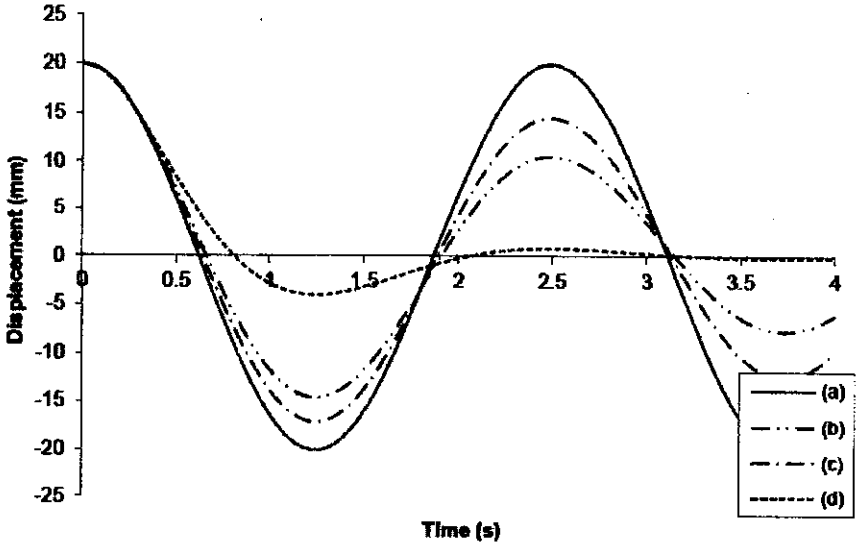

Figure Q4 Vibration response of the frame

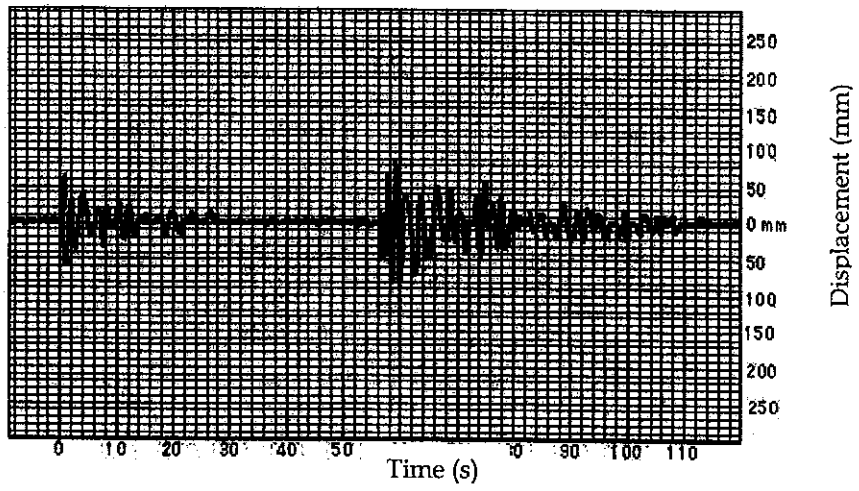

Figure Q5 (a). Seismograph record of a seismic wave

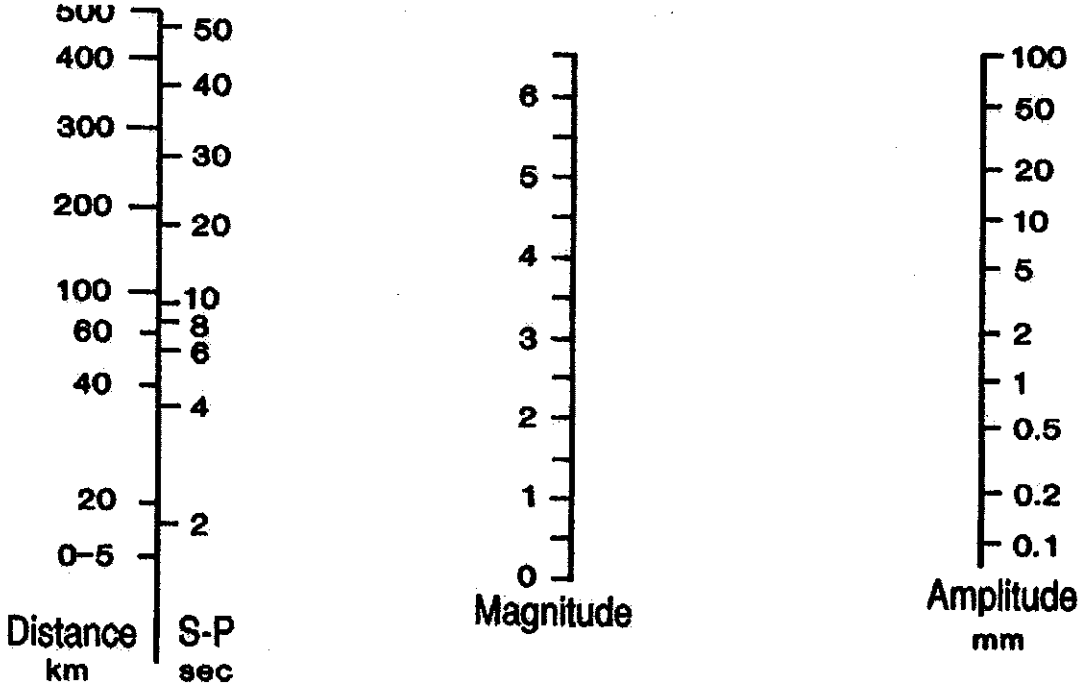

Figure Q5 (b) : Richter scale