



UNIVERSITY OF RUHUNA

Faculty of Engineering

Mid-Semester 6 Examination in Engineering: November 2014

Module Number: CE 6234

Module Name: Dynamics and Control of Structures

[Two Hours]

[Answer all questions]

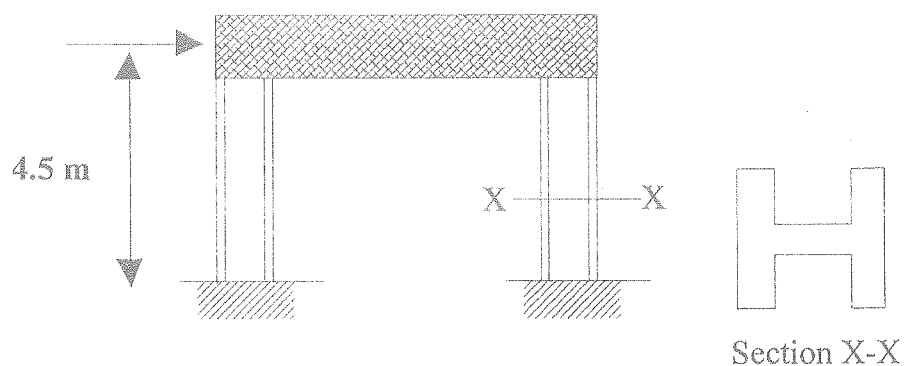
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- Q1 a) Briefly explain the following terms.
- Natural Frequency
 - Multiple degree of freedom
- [1 Mark]
- b) Discuss types of failures that could occur due to human induced dynamic loads exerted in the following structures. What is the mechanism(s) involved with the failure of each structure.
- Foot bridges
 - Dancing floors
 - Stadium structures
- [2 Marks]
- c) Discuss the advantages of structural vibration.
- [2 Marks]
- Q2 a) Illustrate the following motions using neat diagrams.
- Transient motion
 - Periodic but non-harmonic motion
- [1 Mark]
- b) As a civil engineer, you are hired to determine the dynamic properties of a frame system for which it has lost the original blue print. Based on your engineering experiences, you have decided to conduct free vibration test and observed the motion of the frame. The frame structure is constructed using H 200 x 200 x 7 x 10 steel columns (H section with depth of 200 mm, width of 200 mm, web thickness of 7 mm and flange thickness of 10 mm) as shown in Figure Q2. The frame deflects by 5 mm under a horizontal jacking force applied to the frame. Once the frame was released from the jack, on the first return swing after release, the frame does not come back to the release point but rather only 4 mm in towards it. It has been recorded that the time between the time of release, and the first return of 4 mm is 1.6 seconds. Young's modulus of steel is 205 GPa.
- Idealize the frame structure with appropriate degree of freedom for dynamic analysis.
 - What would be the expected time history response (i.e., motion) of the frame? Explain your answer by using a neat diagram.
 - Determine the lateral stiffness of the frame.
 - Determine the natural frequency and mass of the frame.
 - Determine the maximum displacement of the frame when it is subjected to a harmonic wind load of $50 \sin(4t)$ measured in kN. *Clearly state assumptions you may made.*
- [4 Marks]

- c) If the frame is loaded with machineries having total mass of 20 000kg, what will be the natural frequency of the frame? [1 Mark]
- d) What are the other dynamic properties of the frame structure that can be determined from the free vibration test? [1 Mark]

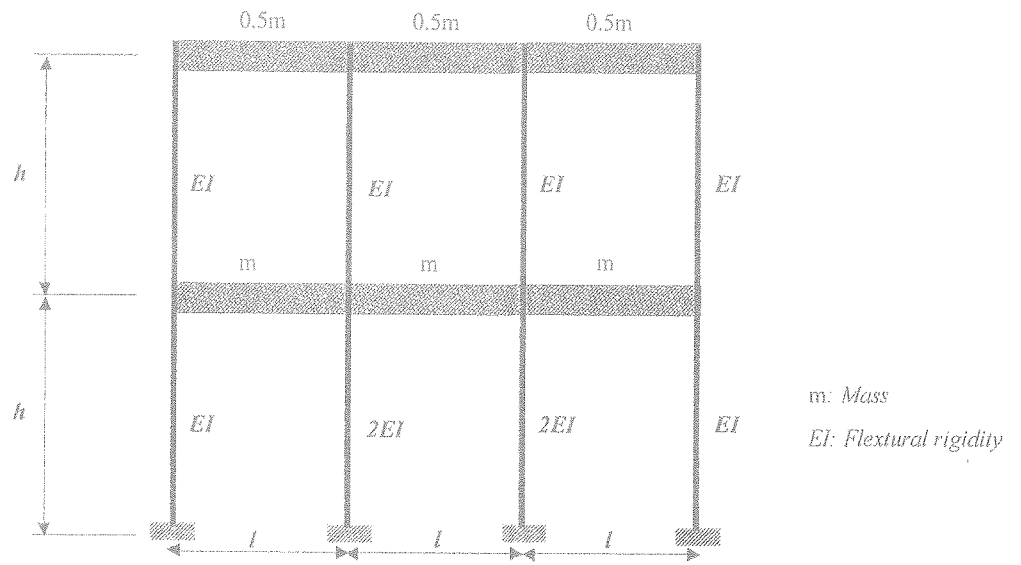
- Q3 a) What are "Free vibration response" and "Force vibration response" of undamped systems? [1 Mark]
- b) There were several complaints on floor vibrations in a two-storey apartment building, raised by occupants. As a young engineer, you are assigned to conduct dynamic analysis of the building and identify possible reasons for the complaints. The roof of this building has been used as a "green roof" so that mass of roof is not identical with the mass of the floor of the building. Mass of each frame of the building is lumped at each floor level as shown in Figure Q3 (a). Ground vibration measured near by the building is shown in Figure Q3 (b). Figure Q3 (c) shows the computed Fast Fourier Transformation (FFT) of the measured ground vibration.

The frame can be considered as a "shear frame structure". Assume that $EI/mh^3=370$, where EI is flexural rigidity of columns, m is mass and h is storey height as shown in Figure Q3(a)

- Idealize the frame as two-degrees of freedom system showing the masses and the stiffnesses for dynamic analysis for lateral vibration.
 - Draw the free body diagram and derive the equation of motion for the system.
 - Determine the natural frequencies and associated mode shapes of the building.
- [4 Marks]
- c) Can the ground vibration near by the building cause for the floor vibration? Justify your answer? [3 Marks]



Figures Q2: Steel system



Figures Q3 (a) : Shear frame structure

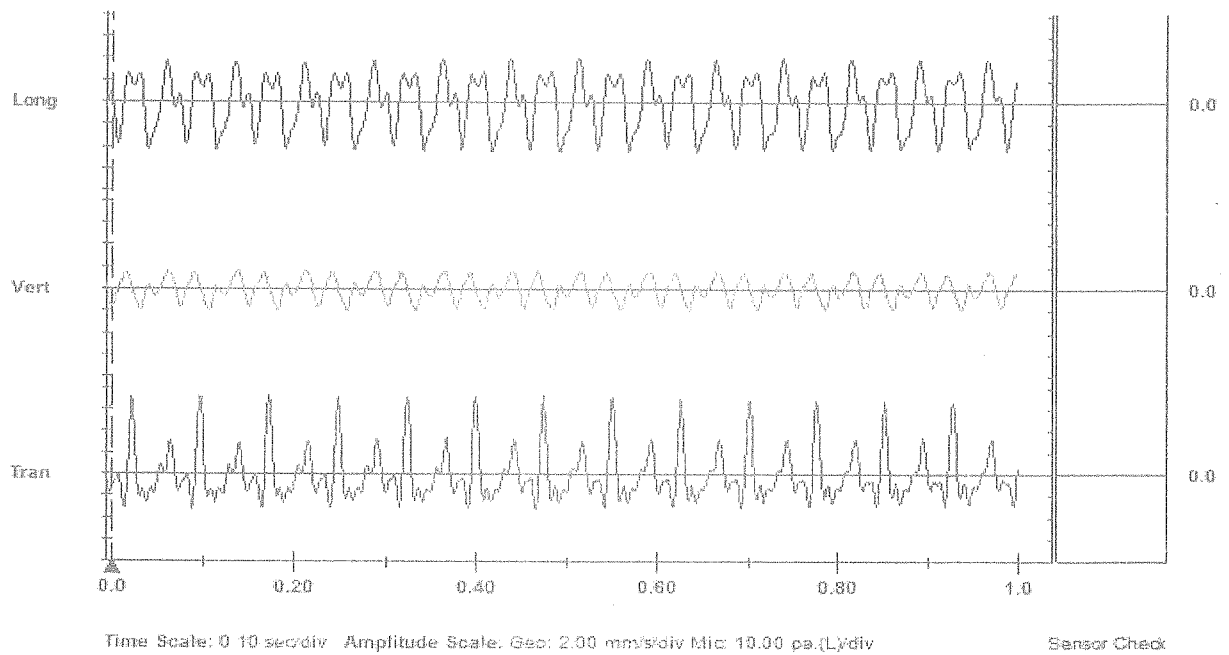


Figure Q3(b): Time history of ground vibration

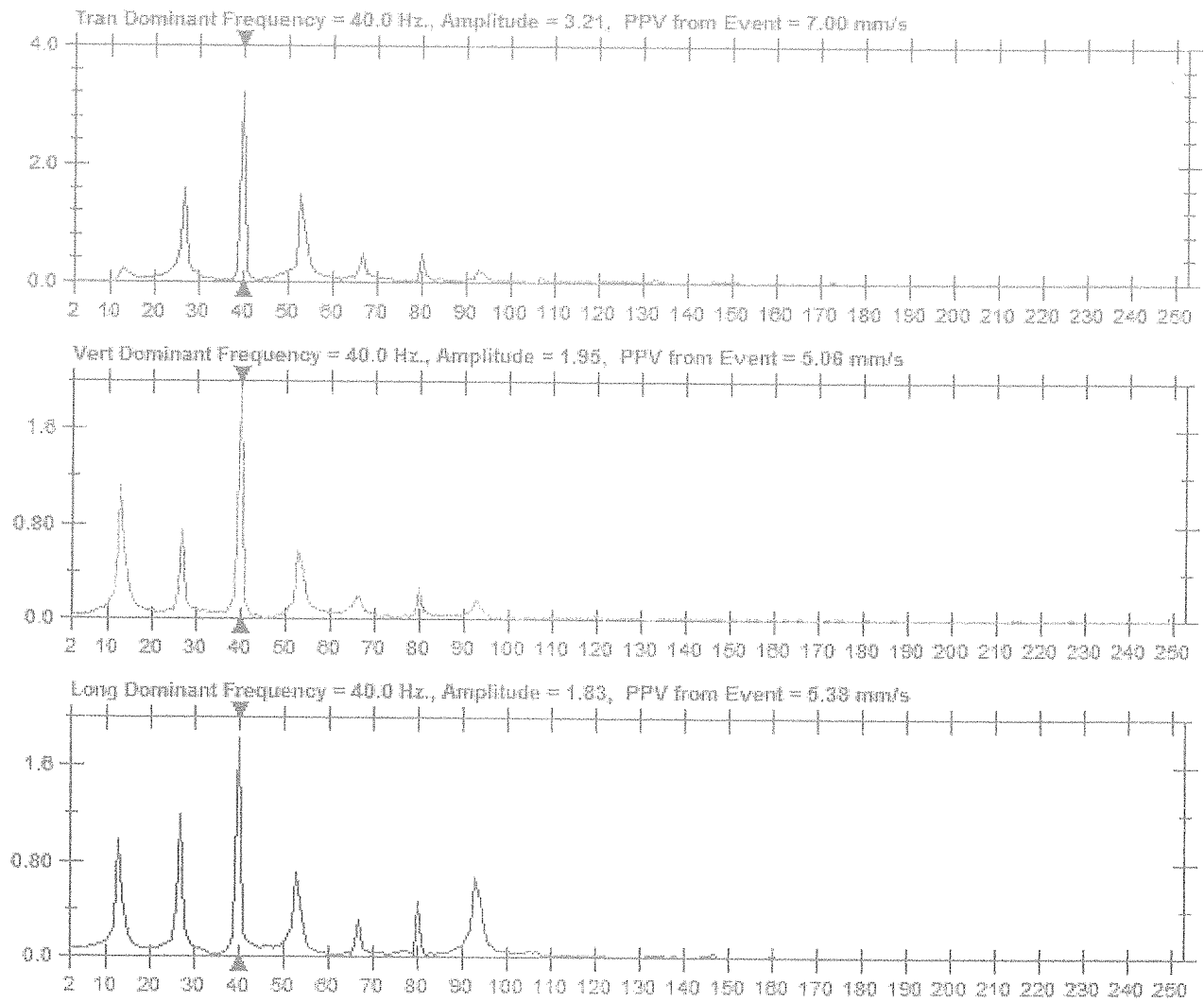


Figure Q3 (c): FFT report of the ground vibration