

Dynamics of Structures – Part I

Note: Any missing data is to be reasonably assumed.

Question 1: (15%)

A portal frame with two equal columns rigid jointed and fixed to the base supports a reciprocating machine which exerts a horizontal periodic force of 155 kN at a frequency of 4.55 Hz in the plan of the frame. The total mass of the machine and the structure is equal to 67000 kg and is concentrated on the beam. The columns are assumed weightless and each has flexural rigidity (EI) of 3.25×10^7 N.m² in the plane of the structure. If the structure is assumed to have a viscous damping ratio of 4%, calculate the steady-state amplitude of vibration and the maximum dynamic stress in the columns.

Question 2: (15%)

Calculate the natural frequencies and modes of vibration of a two storey-two bay building frame. Assume that the horizontal members are very rigid compared to the columns. The mass of the structure, which is lumped at the floor levels, has values 14000 kg at the first floor and 11000 kg at the second floor. The height of each floor is equal to 3.65 m. The flexural rigidity (EI) of each column is equal to 15×10^6 N.m². Check the orthogonality conditions of the modal matrix.

Question 3: (20%)

A three storey reinforced concrete shear building has dimensions in the plan equal to 14 m * 55 m. The height of each storey is equal to 4.35 m. This building is normal moment resisting frames with structural factor R_w equal to 4.5. The building lies in a seismic region with seismic zone factor ($z = 0.35$) and the soil type is good. Using the Response Spectra Method, perform the seismic analysis in the direction normal to the long dimension of the building. The total mass on the roof is 8000 kg and the total mass for each of the second and first floor is 11750 kg. Assume a suitable mode shapes for this structure. The natural frequencies can be assumed equal to 1.85, 12.30 and 18.10 Hertz, respectively.

My best wishes,

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