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Exercise #5: Response spectrum

Problem 1

A one-story reinforced-concrete building is idealized for structural analysis as a massless frame supporting a dead load of $5000\,kg$ at the beam level. The frame is $8\,m$ wide and $4\,m$ high. Each column, fixed at the base, has a $25\,cm$-square cross section. The Young's modulus of concrete is $20\,GPa$, and the damping ratio of the building is estimated as 5%. If the building is to be designed for the design spectrum of Fig. 1.1 scaled to a peak ground acceleration of $0.5g$, determine the design values of lateral deformation and bending moments in the columns for two conditions:
(a) The cross section of the beam is much larger than that of the columns, so the beam may be assumed as rigid in flexure.
(b) The beam cross section is much smaller than the columns, so the beam stiffness can be ignored. Comment on the influence of beam stiffness on the design quantities.

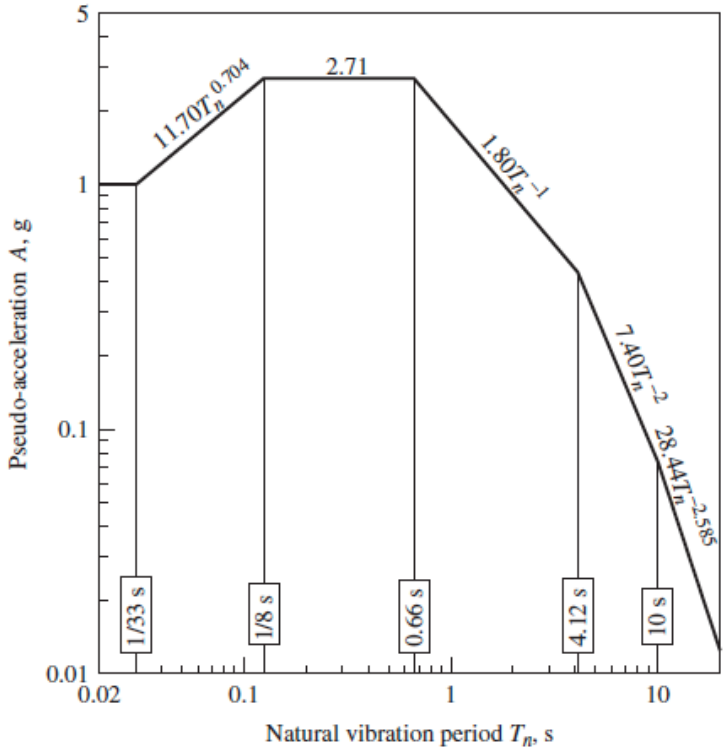

Figure 1.1 Elastic pseudo-acceleration design spectrum for ground motions with $\ddot{u}_{go} = 1g, \dot{u}_{go} = 122\,cm/s\,, u_{go} = 91cm, \zeta = 5\%$

Problem 2

The system shown in Figure 2.1 consists of a bin mounted on a rigid platform supported by four columns 8 m long. The mass of the platform, bin, and contents is 50,000 kg and may be taken as a point mass located 2 m above the bottom of the platform. The columns are braced in the longitudinal direction, that is, normal to the plane of the paper, but are unbraced in the transverse direction as shown in the figure. The column properties are: $A = 120\,cm^2$, $E = 200\,GPa$, $I = 80{,}000\,cm^4$, and $W_{el} = 2800\,cm^3$. Taking damping ratio to be 5%, find the peak lateral displacement and the peak stress in the columns due to gravity and the earthquake characterized by the design spectrum of Fig. 2.2 scaled to $1/3g$ acting in the transverse direction. Take the columns to be fixed at the base and at the rigid platform. Neglect axial deformation of the column and gravity effects on the lateral stiffness.

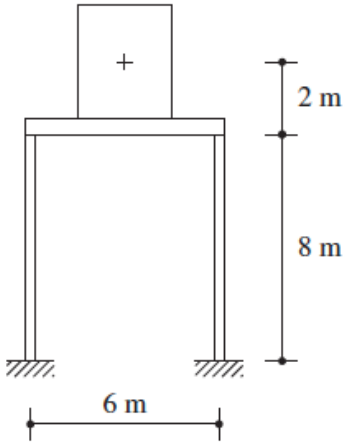

Figure 2.1

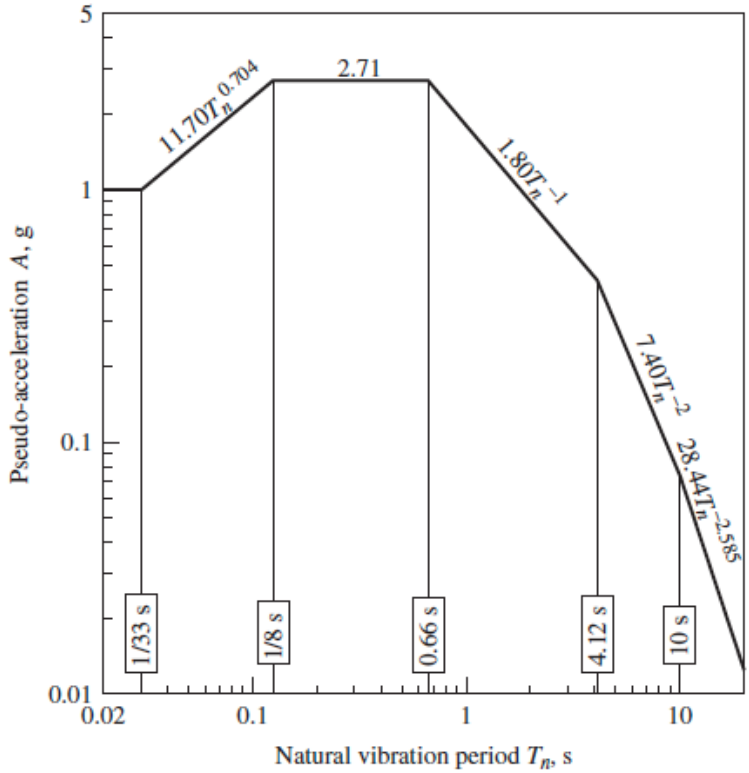

Figure 2.2 Elastic pseudo-acceleration design spectrum for ground motions with $\ddot{u}_{go} = 1g, \dot{u}_{go} = 122\,cm/s\,, u_{go} = 91cm, \zeta = 5\%$