THE PROBLEM OF RESONANCE IN THE EVALUATION OF FLOOR RESPONSE SPECTRA

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SUMMARY

One of the major problems in deriving floor response spectra is the case of resonance; i.e. the case of component frequencies being in the neighbourhood of building frequencies. The purpose of this paper is to show that also in this case floor response values can be obtained by simple formulas.

We consider an one-degree-of-freedom system with small mass, circular frequency ω_0 and degree of damping D_0. This system is attached to a support structure with circular frequencies ω_i and damping degrees D_i. Let Γ_i and φ_i be the participation factors and relevant eigenvector components respectively. We assume ω_0 to be in the neighbourhood of ω_1. If $\ddot{\eta}_i$ are the relative modular accelerations, the acceleration $\ddot{x}$ of the one-degree-of-freedom system due to seismic input b is proved to be described approximately by

$$\ddot{x} = \Gamma_1 \varphi_1 \ddot{z} + \sum_{i=2}^{n} \frac{\omega_0^2}{\omega_0^2 - \omega_i^2} \Gamma_i \varphi_i (\ddot{\eta}_i + b), \tag{1}$$

$$\ddot{z} = \frac{\omega_0^2}{\omega_0^2 - \omega_1^2} (\ddot{\eta}_1 + b) + \left(1 - \frac{\omega_0^2}{\omega_0^2 - \omega_1^2}\right) (\ddot{\eta}_0 + b). \tag{2}$$

It is shown that max $\ddot{z}$ may be estimated to be less than $V(D_0, D_1) \cdot \max \ddot{\eta}_1$ with the "magnification factor"

$$V(D_0, D_1) = \frac{0.5}{\sqrt{D_0(D_1 + D_0)}}; \tag{3}$$

V is derived from spectral density arguments and has been counter-checked on the basis of 9 earthquake like accelerations. If b is characterized by a response spectrum S, we get from Eq. (1) and (2) the following value $F(\omega_0, D_0)$ of the floor response spectrum:

$$F(\omega_0, D_0) = \left[[V(D_0, D_1) \Gamma_1 \varphi_1 S(\omega_1, D_1)]^2 + \sum_{i=2}^{n} \left[\frac{\omega_0^2}{\omega_0^2 - \omega_i^2} \Gamma_i \varphi_i S(\omega_i, D_i) \right]^2 \right]^{\frac{1}{2}}. \tag{4}$$

Together with the theory for the non-resonance case, that has been developed by D. Schmitz, INTERATOM and the author, there is a simple and time saving method to develop floor response spectra.