EVALUATION OF RANDOM SEISMIC RESPONSE OF MID-RISE BUILDINGS WITH MASS IRREGULARITY CONSIDERING SOIL-STRUCTURE INTERACTION EFFECTS

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Seismic response of non-geometric vertically irregular buildings with non-uniform distribution of mass along the height is investigated in the framework of random analyses. As foundation flexibility influences structural responses (Shakib and Fuladgar, 2004; Moghaddasi, et al., 2011; Rajeev and Tesfamariam, 2012), soil-structure interaction effects are also considered. A 10 story frame building with fully restrained moment connections was considered. Efficiency of structural elements was evaluated according to the Iranian Seismic Code (Building and Housing Research Centre, 2005). Similar to common residential building of Iran, gravity loads was supposed to be 700 kg/m^2 and 200 kg/m^2 for dead and live loads, respectively. A rigid diaphragm was also assumed according to the roof system of usual structures. The amount of mass irregularity at different story levels was limited to 200% compare to the regular structure. To make a fair comparison, the main specifications of regular and irregular structures were kept the same(Pirizadeh and Shakib, 2013).

The model of superstructure was considered as an elastic shear building. The mass of each story level was assumed to be concentrated at the center of mass (CM) and eccentricity distance of CM to CR (center of stiffness) was assumed zero (no eccentricity in plane). The floor systems were assumed to be rigid in their own planes and inextensible columns are used to support rigid floor decks. For the superstructure, 3 DOFs namely, two lateral translations and a rotation about the vertical axis, were considered per floor.

Equations of motion of the superstructure resting on an elastic homogeneous half-space were established. The whole SSI system has 35 DOFs, consisting 30 DOFs for two transitions and one twisting of story floors. For the interaction forces at foundation level, frequency-independent spring and dashpot set in parallel (Richart et al., 1970) was used. Five degrees of freedom due to interaction, include two rocking motions, one rotation about the CM and two horizontal transitions.

Since in many engineering cases, the applied loads are random, in this study, structural responses are evaluated in the framework of random excitation. The ground acceleration $\ddot{v}_g(t)$ was assumed to be a uniformly modulated non-stationary random process:

$$\ddot{v}_g(t) = \beta(t) f(t) \tag{1}$$

where, $\beta(t)$ is a given modulation function and $f(t)$ is a stationary random Gaussian process with zero mean. Note that the modified version of Kanai-Tajimi model was used in describing ground acceleration excitation (Li et al., 2004; Gao 2007). For the whole system, subjected to non-stationary random ground motion, the equations of motion can be expressed as:

$$[M]\{\ddot{v}(t)\} + [C]\{\dot{v}(t)\} + [K]\{v(t)\} = -[M]\{r\}\ddot{v}_g(t) \tag{2}$$

Using Duhamel integral and performing a Fourier transform of the correlation function, the power spectral density (PSD) matrix of displacement $\left[S_v\left(t;\omega\right)\right]$ would be evaluated. After obtaining the mean square value of structural displacement by integrating PSD matrix of displacement within the frequency domain, structural random seismic response and its components could be obtained.

Curves of mean square value of structural responses have been developed (Figure 1). In spite of the same specifications of structures, the non-uniform mass distribution through structure height influences displacement demands. It is shown that regardless to the position of irregularity; a large portion of displacement demand has been concentrated on lower stories. Meanwhile, depending on the position of heavier mass through structure height, demand distribution would be affected.

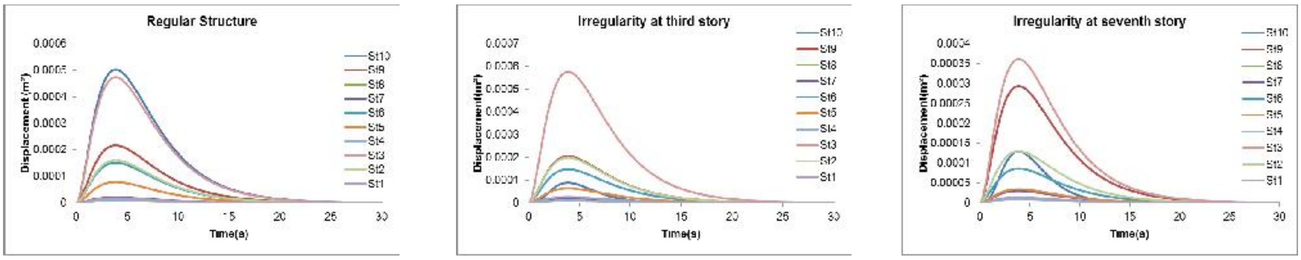

Figure 1. Displacement response of structures

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