ON THE OPTIMUM ASEISMIC DESIGN DATA OF TALL BUILDING STRUCTURES BASED ON THE ELASTO-PLASTIC EARTHQUAKE RESPONSES

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Abstract

For the purpose of obtaining the pertinent aseismic design data of tall elasto-plastic building structures, the earthquake responses of a large number of bi-linear elasto-plastic, multi-story shear type structural models having various distributions of stiffness and shear strength at the elastic limit are analyzed systematically by using an analog computer.

The distributions of stiffness and shear strength of standard model are expressed in the form, $\{\kappa_i\}=\{\beta_i\}=\{1-\lambda(i-1/n-1)^{\nu}\}$ in which λ and ν are variable structural parameters corresponding to the distribution characteristics, i and n denote the number of mass ordered from the base to top and the number of the degree-of-freedom of the structural model, respectively. Also, to find the effect of the fluctuation of the strength distribution on the earthquake responses, the models having the irregular distribution of shear strength are considered in this study.

On the other hand, the mass distribution is supposed to be uniform over the height. As regards the damping characteristics, it is assumed that its distribution is identical to the stiffness distribution and that each structural model has 2 % critical damping with respect to the fundamental harmonics. Also it is assumed that the rigidity ratio of the second to the first branch of the bi-linear hysteresis loop is uniformly 0.2 over the hight.

As regards earthquake excitations, the five typical wave-shape functions of acceleration records of the past strong earthquakes are considered and the time-constant represented by the duration-time is varried for giving various reference frequencies to the spectral characteristics of each wave-shape function. On the other hand, the maximum amplitude of acceleration for each wave-shape function is adjusted so as to give the same level of the average value of the maximum ductility ratios of the multi-story structural model.

Defining the optimum distribution of shear strength as that giving rise to the uniform distribution of the maximum ductility ratio over the height, the following remarks are obtained based on this analysis:

1) The distribution of the maximum ductility ratio is strongly dependent on the distribution of shear strength whereas the distribution of the maximum relative displacement depends upon that of stiffness.

2) The increment of the average value of the maximum ductility ratios over the height is almost inversely proportional to that of the average value of shear strengths of a multi-story structural model for a given earthquake excitation.

3) For practical purpose, the optimum distribution of shear strength is determined by averaging the distributions of the maximum shear force or those of the maxtmum equivalent shear force, which is defined as the maximum elastic shear force giving the same potential energy to the elasto-plastic energy corresponding to the maximum relative displacement, for various models having different distribution characteristics and for earthquake excitations having appropriate wave-shape functions and time-constants.

4) The optimum distribution of shear strength is varried depending upon the level of the average value of the maximum ductility ratios as well as the range of the fundamental natural frequency of structures. Hence, in general, it has to be determined according to the allowable ductility ratio of structures and the relation between the natural frequencies of structures and the dominant frequencies of excitations.