Stochastic Analysis of Maximum Earthquake Responses of Structures

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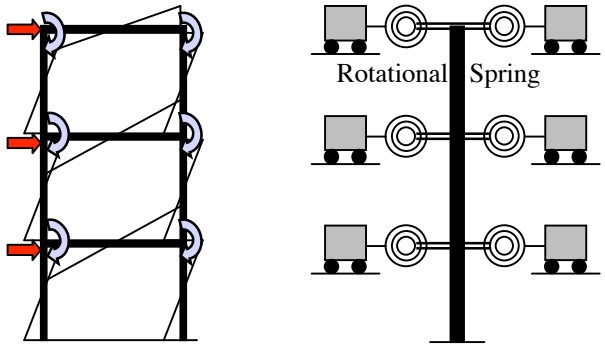
Introduction

To evaluate the probability of safety or failure, the statistical indices, such as the mean value, variation, etc., of inelastic earthquake responses are generally needed. Two methods are available to compute the statistical indices of structural responses: the time history analysis and the stochastic analysis using the mean response spectrum as earthquake load input. Comparably, the stochastic analysis method is computationally more efficient. To estimate the effect of plastification of beams, the fish-bone shaped mode of frame structure is introduced into this study. The fishbone-shaped model condenses the columns and beams of one floor into one column and one beam, respectively. Compared with the shear model, the fishbone-shaped model considers the variation of stiffness and strengths caused by the development of the beam plasticitification. In this study, the stochastic analysis of effect of column over-design factor on the maximum responses of frame structures are conducted through fish-bone shaped model.

Fish-bone Shaped Model



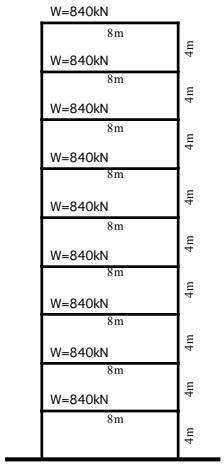
Equivalent Linearization

The inelastic deformations of structures are estimated from an equivalent elastic system with a lateral stiffness smaller than that of the initial stiffness of the inelastic system and with a damping ratio larger than that of the inelastic system. The equivalent stiffness and equivalent damping ratio are as follows:

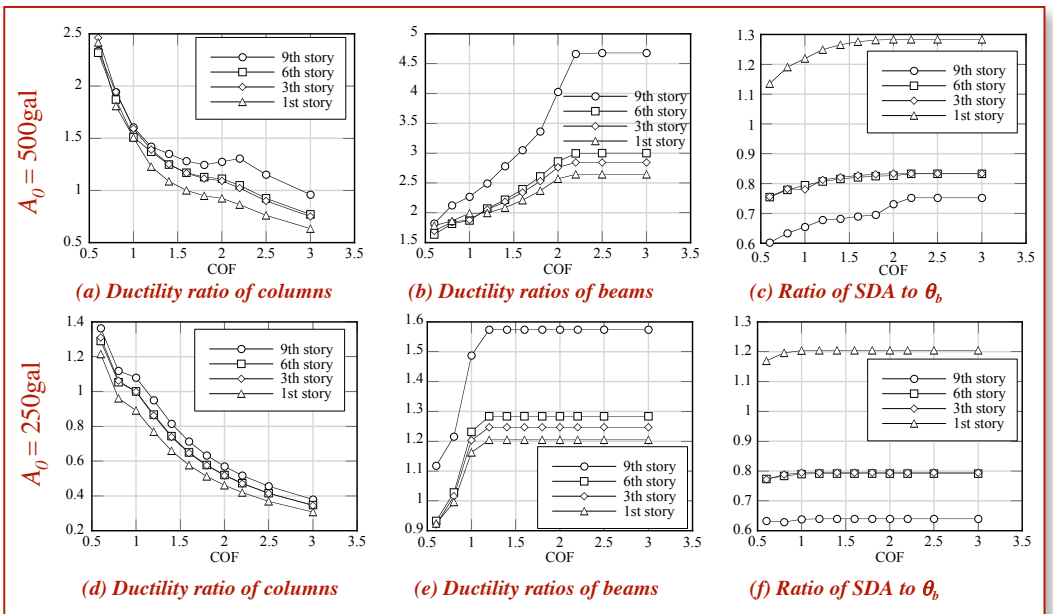
$$K_e(\gamma) = \frac{K_0}{\gamma}\left[(1-\alpha)(1+\ln\gamma)+\alpha\gamma\right]$$

$$\xi_e(\mu) = \xi_0 + 0.15\left[1-\frac{1}{\mu}\sqrt{1+\alpha(\mu-1)}\right]$$

Analysis Results (9-story frame)



COF: Column Over-design Factor
SDA: Story Drift Angle
Θ_b: Beam Rotation Angle
A0: Maximum Ground Acceleration



(a) Ductility ratio of columns
(b) Ductility ratios of beams
(c) Ratio of SDA to θ_b
(d) Ductility ratio of columns
(e) Ductility ratios of beams
(f) Ratio of SDA to θ_b

Conclusions

The maximum displacements of frame structures are estimated through stochastic analysis based on elastic response spectrum, and the effect of column over-design factor on the plastic deformation of structural members is investigated. It is found that the the ductility ratios of columns decrease with the increase of COF, and the ductility ratios of beams increase with the increase of COF lower than a particular value dependent on intensity of ground motion. The change of COF has little effect on the ratio of story drift angle to beam rotation angle.