6th International Conference on Advances in Experimental Structural Engineering
11th International Workshop on Advanced Smart Materials and Smart Structures Technology
August 1-2, 2015, University of Illinois, Urbana-Champaign, United States

Simplified Calculation of Plastic Energy Dissipation of MDOF System using Force Analogy Method

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ABSTRACT
Structure responds inelastic domain under a major earthquake, and this manifests such as inelastic extensions in braces, plastic rotations in beams and yield of isolated forms etc. Current inelastic analysis, which suggests an extension of the well-established knowledge gained from elastic analysis by changing structural stiffness, has mostly been done with strain-hardening materials while others remain difficult. Inelastic structures are dynamic stable under dynamic loadings with kinds of solutions, for instance, Newark-β method, Wilson-θ method and state space approach, which is widely adopted as the application of computer. However, for complex structure with large matrix, state space method is very time consuming and costly, bringing about inaccurate results. Considering this, a new algorithm termed the force analogy method (FAM) is proposed using only initial stiffness, and with the main concept of inelastic deformation first presented by Lin in 1968. One advantage of FAM is that it is dynamically stable and the other is that stress would be determined once strain is confirmed. Thus, the inelastic deformation at a particular location is defined as a degree of freedom, which would simplify the analysis.

The method of estimating plastic energy of a structure by using singe-degree of freedom (SDOF) system is simple and effective. But only few studies are conducted to calculate plastic energy by nonlinear analysis methods or equivalent SDOF system. Based on the force analogy method, firstly, the formulae of plastic energy dissipation of multi-degrees of freedom (MDOF) system and equivalent SDOF system are established. Secondly, the estimation method of plastic energy dissipation of MDOF system is proposed. At last, numerical simulations are performed on some multi-storey and high-rise structures with different heights and spans to compare the plastic energy dissipation of the MDOF system and the equivalent SDOF systems of different modes. Simulation results indicate that the proposed method and formulae are effective and accurate to estimate the plastic energy dissipation of multi-storey and high-rise structures.

KEYWORDS: *Force analogy method, plastic energy dissipation, multi-degree-of freedom system, equivalent single-degree-of freedom system*