Sesimic Design of Structures Based on ductility

Milad Farahanchi Baradaran, Farhad Behnamfar, Kiachehr Behfarnia, June 2016

The concept of seismic design of structures in building codes is based on determination of elastic forces and reducing them to the design level by use of the response reduction factor, R. The current code-based method has some shortcomings including the need to reiterate the design process when the limitations on story drifts are not met. Besides, there are uncertainties involved in determination of the response reduction factor for each structural system. In recent years, many attempts have been made to enhance the seismic design procedure. The displacement-based method is one of these examples that uses displacement spectra and designs a structure based on displacement limitations. The New Zealand building code utilizes a ductility-based method for seismic design of structures. In this regard, the main objective of this research is to propose a simple method based on the desired ductility as a design target. For this purpose, a consistent set of earthquake records has been chosen on firm soil in two categories of far and near-field earthquakes and sorted based on maximum acceleration at the ground surface from small to large peak ground accelerations. The scaled records are applied as base motions to a single degree of freedom system with strain hardening that presents a simple model of a structural system in any of its natural modes and the maximum response acceleration is determined for ten levels of ductility demands. The results are functions of the peak ground acceleration, period of structure and target ductility. The calculated maximum acceleration is presented in the shape of design graphs varying with the above parameters. Designing with these graphs totally removes the need for use of the response modification factor. In this thesis two methods are presented to use the design diagrams and complete the process of designing a structure. An energy-based approach is also proposed to extend the method for modal analysis of structures based on a certain value of the ductility factor. In this method, the required ductility demand is distributed between the important modes of a structure. Application of the proposed method is discussed for building samples where contribution of the higher modes is important. These include three model frames, 4, 6 and 9 in stories in which three kinds of irregularities are imposed on the 6-story building. The mentioned frames are evaluated by nonlinear static pushover analysis. The results show that studied buildings satisfy the inelastic design requirements and the intended performance objective in terms of the target drift level and no trial and error difficulty is needed to tackle. This advantage is due to the fact that the proposed method is a direct design method and the nonlinear behavior is already built into the design process.

Key Words

Ductility, seismic design, nonlinear, pushover, hardening.