Evaluation of Simplified Non-linear Analysis Methods in Estimating the Seismic Collapse Capacity of RC Frames

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Abstract

Incremental Dynamic Analysis (IDA) procedure is currently considered as a standard tool for accurate estimation of the seismic demand and capacity of structures. The method requires several nonlinear Response History Analyses (RHAs) of the structure for a set of ground motions, each scaled to multiple levels of intensity. Recognizing that IDA is extremely time-consuming for practical applications, some simplified pushover analysis-based methods have recently been developed by researchers. These methods often combine the nonlinear dynamic response of an equivalent single-degree-of-freedom (SDOF) system with the results obtained from a standard pushover analysis to provide a rather closed-form solution for the collapse problem. This paper explores the accuracy and effectiveness of some approximate pushover analysis-based methods (i.e., SPO٢IDA, MPA-based IDA and Hamidia *et al*. (٢٠١٣) methods) in estimating the median sidesway collapse capacity of regular RC moment-resisting frames. Four RC buildings with ٣, ٦, ٩ and ١٢ stories are designed and subjected to the approximate analysis methods. A detailed comparison is then performed between the results obtained by the approximate methods with those given by the exact IDA approach. Finally, it is revealed that all the methods based on equivalent SDOFs studied in this paper provide acceptable collapse capacity estimates of the frames. However, less accurate predictions are obtained by SPO٢IDA and MPA-based IDA methods for ١٦th and ٨٤th fractile IDA curves in all cases. The paper also presents additional guidelines to improve the MPA-based IDA method in estimating the median collapse capacity of intermediate RC moment-resisting frames.

Keywords: Collapse capacity, Simplified non-linear analysis methods, IDA, RC moment-resisting frame

١. INTRODUCTION

The primary goal of building codes is to guarantee the life safety of building occupants and prevent the structures from the total dynamic instability during the strong earthquakes. Although the life safety performance level is now almost met by using some conservative design provisions, but the exact collapse response of the structures is still unclear. The main reason may be related to the empirical nature of the design codes and their development [١]. Recent advancements in performance-based design concepts, structural analysis tools and seismic hazard analysis have enabled engineers to evaluate the collapse response of structures with more accuracy.

Incremental Dynamic Analysis (IDA) is now introduced as a standard analytical tool for accurately estimating the seismic demand and capacity of structures over the entire range of structural responses, from elastic behavior to global dynamic instability [٢]. The procedure involves performing several nonlinear Response History Analyses (RHAs) of the structure under various ground motion records, each scaled to multiple levels of intensity to cover a broad range of structural responses. The rapid growth of computer powers and the development of more sophisticated algorithm solutions have enabled IDA to be employed in professional practice. However, it remains burdensome for practical applications since it requires more computational efforts and a thorough understanding of nonlinear RHA. It is therefore some simplified nonlinear pushover analysis-based methods have recently been proposed by researchers for estimating the median seismic collapse capacity of building structures.