An accurate uncoupled modal response history analysis procedure based on modal pushover responses

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ABSTRACT

Modal analysis is the foundation of seismic analysis. The Uncoupled Modal Response History Analysis (UMRHA) method can efficiently extract complex nonlinear seismic responses into individual mode responses, providing valuable insights into the contribution from each mode. The computation time of UMRHA is also significantly less than the well-known Nonlinear Response History Analysis (NLRHA). The application of UMRHA could significantly reduce computational efforts when structures need to be analyzed with various ground motions. While UMRHA accurately estimates global and story-level responses, the accuracy of its predictions at the component level (e.g., force in each column and force in each shear wall) is questionable due to assumptions about the force distribution pattern. The assumption made in previous studies, that the force distribution pattern of each structural member remains constant, is valid only within the elastic response of the structure. In reality, the lateral stiffness of a damaged component generally decreases, and the force will distribute more toward undamaged components. Assuming that force distribution patterns remain unchanged is not appropriate when a structure experiences a notable degree of nonlinearity. Furthermore, the use of a symmetric hysteretic model in UMRHA is unsuitable for real irregular structures, as a symmetric hysteretic model will lead to inaccurate predictions of the overall structural response. To address these issues, this study proposes a new approach that involves mapping between UMRHA and Modal Pushover Analysis (MPA). The proposed technique uses the UMRHA response to select force demands from MPA based on the actual degree of nonlinearity. This study also proposes a new unsymmetric hysteretic model that can capture the response of both the positive and negative sides of the structure while it is vibrating. The overall results from this study show an improved estimation of nonlinear seismic responses. The validity of the proposed technique is examined using two high-rise reinforced concrete buildings (a 34-story and a 44-story building) subjected to three ground motions with different mechanisms.

Keywords: Uncoupled Modal Response History Analysis, UMRHA, Modal Pushover Analysis, Hysteretic Model, Modal Decomposition

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