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EVALUATION OF HIGHER MODES EFFECTS IN ESTIMATION OF SEISMIC RESPONSE PARAMETERS OF TALL HYBRID MEGA ZIPPER SKELETONS

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This research investigates the analytical capability and effectiveness of modal pushover method (MPA) in predicting the important responses of high-rise steel buildings subjected to both far and near-field earthquake records. This was performed based on comparing the predicted values by MPA with the corresponding parameters obtained through comprehensive non-linear dynamic time history analyses (NLTH). For this purpose, three 30-story structural models with rigid castled tube resistant skeleton were selected and designed. The first studied model is classified as the basic structure with a castled tube structural system and is identified by the CT symbol. The second and third studied models are introduced by setting two different multi-level configurations of large scale zipper elements in the structure of the basic model. The large scale zipper elements are connected to one or two perimeter columns at the first story level and introduced with the symbols MZCT-1C and MZCT-2C, respectively.

The reason for setting a multi-story arrangement of large scale zipper elements is preventing the formation of expanded plastic mechanism and block the occurrence of possible lateral-torsional buckling in the columns of lower-stories. The connection of the large scale zipper elements to the columns is considered flexurally rigid. The plan and configuration of the studied structures are shown in Figure 1. The studied structures were loaded and designed based on the Iranian national building codes (issues six and ten) as well as the Standard 2800 (fourth edition). The assigned performance profiles of plastic hinges for describtion of non-linear behavior of structural elements have been adapted from the reports FEMA 356 and 440. All of the nonlinear analyses were conducted through SAP2000 software.

In this research, the seismic tremors were selected in an ensemble of twelve earthquake records, including six far-field and six near-field ground motions which contain forward directivity effects. The distance of recording stations related to the aforementioned near-field ground motions is not more than 20 kilometers away from the fault rupture plate. The main criterion in choosing these records is the existence of coherent pulses and high-amplitude spikes in the velocity time history caused by powerful rupture directivity process (Mukhopadhyay & Gupta, 2013, Vafaee & Saffari, 2016).

In this research, the response parameters of the studied structures CT and MZCT-1C and 2C (Figure 1) were obtained and assessed analytically through conducting NLTH analyses. The other phase of this study was accomplished via performing modal pushover analyses subjected to assigned lateral load patterns corresponding to three separate participations of the essential mode (load case 1), the first three lateral modes (load case 2) and the first five lateral modes (load case 3). To investigate the accuracy of MPA method in estimating seismic demands of the studied structures, the nonlinear dynamic responses were calculated under two sets of near and far-field records. These results were considered as the exact values. Then, MPA analyses were conducted for the studied structures under assigned lateral load patterns explained above. The target displacement value was adopted equal to the maximum lateral movement of the mass center CM at the top level (i.e. z=H) subjected to each record which is calculated through NLTH analysis. Then, the mean value of the response parameters obtained via MPA was compared with the corresponding ones calculated through NLTH analyses. The evaluation of the higher

modes effects was investigated by assessing the calculated values related to the maximum lateral displacement of CM, the inter story drift ratio and the maximum rotation of the plastic hinges formed in beam-columns which all have been obtained via MPA and NLTH analyses.

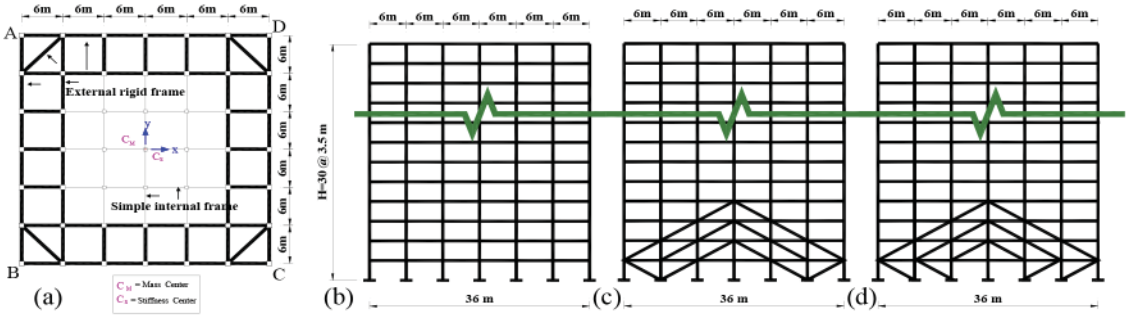

Figure 1. The structural configuration of the studied models: (a) The plan of castled tube skeleton; (b) The CT model; (c) The MZCT-2C model; (d) The MZCT-1C model.

By comparing the maximum displacement profiles, it is observed that in most cases the estimated values obtained based on the assigned lateral load patterns, are very close to the exact values. Moreover, the aforementioned results would exceed in a little domain respect to companion values obtained based on NLTH analyses, especially for the height ratios of 0.2 to 1. These analytical results directly lead to well estimation of the structural response parameters under assigned lateral load patterns which were formulated subjected to the selected ensemble of earthquake records (Figure 2).

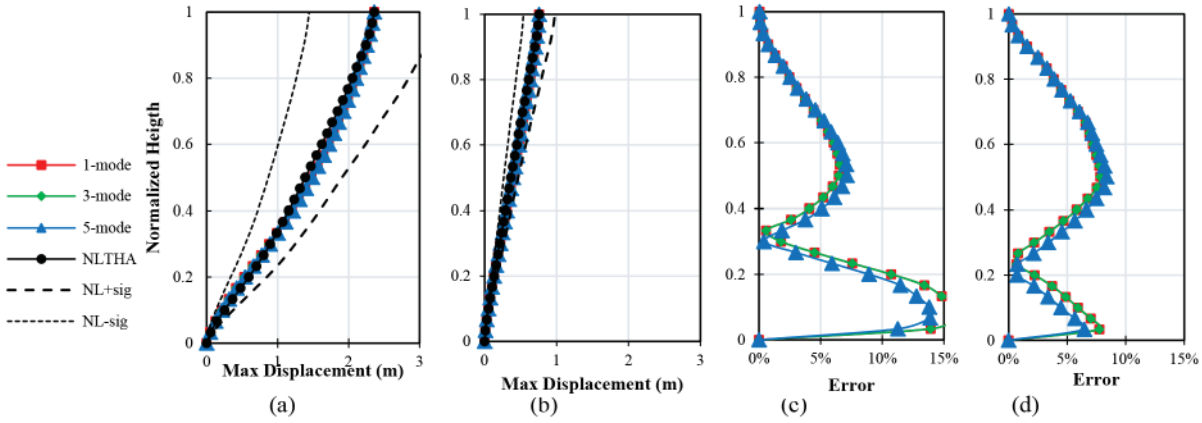

Figure 2. The mean values of the maximum lateral displacement related to floor mass centre (CM) of the CT model in y direction of plan (Figure 1); (a) the near field records, (b) the far field records, and the relative error due to the estimated response parameter under; (c) the near field records, (d) the far field records.

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