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DYNAMIC BEHAVIOR ASSESSMENT OF MID-RISE RESISTANT SKELETONS BASED ON THE CONTINUUM MODEL IN NEAR-FAULT

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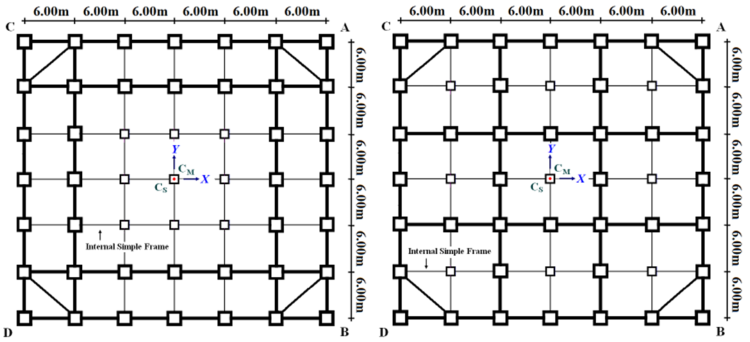
The results of many previous studies have shown that the relative deformation caused by the lateral displacement between successive stories is one of the major factors to evaluate the structural damage. This parameter indicates the correlation between structural response components and seismic damage characteristics. In order to reduce and limit the stories displacement in mid-rise to tall buildings, the use of multi-cell framed tube system can be considered which significantly increases the lateral stiffness of the structure (Alonso-Rodriguez et al., 2015). In this paper, two studied models were designed using separated hybrid and bundled moment framed tube skeletons as 10-story structures. The two studied structures are symmetric and regular with plan and height. The resistant skeleton of these structural systems behaves like a multi-cell rigid tube. The plans of the studied models are shown in Figure 1.



(a) (b)

Figure 1. The plans of the studied models: (a) Hybrid moment framed tube (model 1); (b) Bundled moment framed tube (model 2).

The resistant skeleton of the studied structures was designed according to the Iranian Standard no. 2800 (fourth edition) as well as the sixth and tenth issues of the Iranian national building code. The maximum story drift for the two studied multi-cell moment framed tubes was determined and compared with the “life safety” and “collapse prevention” performance limits, as recommended by AISC 341. Despite the use of building design standards, regulations and codes (such as mentioned above), seismic properties of strong ground motions as well as powerful effects of rupture directivity process are important in the design of buildings in near fault areas. Generally, near-field records have a relatively broad band of high-energy frequencies, large amount of kinetic energy and high-amplitude velocity and displacement pulses which are influenced by rupture directivity process. The most commonly applicable methods for estimating seismic responses and deformation demands of structures are nonlinear static and dynamic analyses. Nonlinear dynamic analysis is an accurate method for predicting seismic demands of structures. Moreover, having notifications to both, the random nature of earthquake records and the numerical fluctuations in the implementation of iterative-incremental computing approaches, nonlinear dynamic analysis is time consuming and relatively difficult to use. In this regard, the continuum analytical modeling was presented as an alternative computational method for estimating the seismic demand of structures by providing closed form equations based on the interaction of equivalent flexural and shear cantilevers (Alonso-Rodriguez et al., 2015; Khalili et al., 2018). The nonlinear static analysis method (i.e. pushover method) estimates structural responses within an error range. The reliable application domain of this method is limited to mid-rise and shorter structures that are especially symmetric in plan and elevations. Also, due to the fact that in many building designs codes the influence of higher modes is not considered more or less effective into the lateral load patterns, in this method the fundamental vibration mode dominates the behavior of structure. In order to develop the pushover method, the main criterion is to taking into account the effects of higher modes. Accordingly, the modal pushover analysis (MPA) has been developed based on the structural dynamics theory (Vafaee et al., 2017). In this research, the seismic responses of the studied structures were calculated using the closed-form continuum and modal pushover methods considering of two analytical case studies include 1 and 3 lateral modes characteristics. These results were compared with the corresponding ones obtained through linear and nonlinear dynamic time history analyses subjected to three components earthquake records contain different directivity effects. The calculated results subjected to the JFP record due to the Northridge earthquake 1994 (in California) and the BAM 2003 record (in Iran) respect to Y direction of the plan are shown in Figure 2. Based on the results of this study, both of the closed-form continuum and modal pushover methods denote the presence of an overestimation on the seismic drift demand with a relative precision. Meanwhile, the MPA results are relatively more accurate than those obtained based on the two case studies considered in application of the continuum approach. Also, the maximum drift usually happened in the middle third of the structure height. Yet, the maximum response parameters of story drift were individually exposed to a relative reduction, regarding to different skeletal configuration of hybrid and bundled moment framed tubes. It is noticeable that the future research topics in this regards would be focused on the more accurate assessment of the height-wise variation of the lateral drift of structures, especially in the middle floor levels.

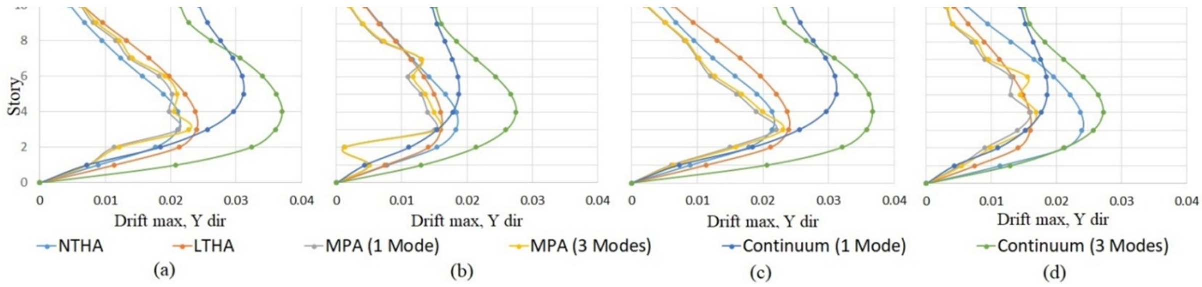


Figure 2. The maximum drift demand of the 10story studied models in Y direction of the plan: (a) The model 1 (under the BAM 2003 record); (b) The model 1 (under the JFP 1994 record); (c) The model 2 (under the BAM 2003 record); (d) The model 2 (under the JFP 1994 record).

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