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MODIFICATION FACTORS FOR RESIDUAL DRIFT ASSESSMENT OF ADJACENT SMRFS CONSIDERING STRUCTURAL POUNDING

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Maximum Residual Interstory Drift Ratio (MRIDR) is permanent lateral deformations at the end of the severe earthquake, even though the structure did not experience severe damage or total collapse. It was noted that Reinforced Concrete (RC) structures having members with stiffness-and-strength degrading features experience smaller Residual Drift (RD) than those steel structure having members with non-degrading features. Due to record-to-record variability of RD, the estimation of this parameter is important during the performance-based assessment of existing structure. Therefore, some researchers proposed approximate methods to estimate RD (Ruiz-García and Chora, 2015). Yahyazadeh and Yakhchalian (2018) evaluated the effects of using fluid viscous dampers on the MRIDR response of steel structures and concluded that linear dampers have better performance than nonlinear one. Approximate estimation of RD is important especially for adjacent structures because pounding phenomenon can significantly influence the amount of RD. Recently, Kazemi et al. (2019) investigated the effects of pounding phenomenon on the seismic collapse capacity of the 2, 4-, 6- and 8-Story adjacent structures, and proposed modification factors to estimate seismic collapse capacity of a structure considering pounding.

In this study, the 4- and 8-Story RC SMRFs designed by Haselton and Deierlein (2007) were considered (design ID of 4- and 8-Story structures are 1003 and 1011, respectively). The site of interest was considered in Northern Los Angeles, which is a high seismic regions of California, with soil class D and seismic design parameters of SD_S=1.5g and SD_1=0.9g. Moreover, adjacent structures of the 3- and 6-Story steel SMRFs designed by Kitayama and Constantinou (2016) were considered. Steel SMRFs were assumed to be located in California at latitude 37.8814°N and longitude 122.08°W, with soil class D and seismic design parameters of SD_S=1.25g and SD_1=0.6g. To consider the P-Delta effect, which this effect plays a key role in sideway collapse, all columns except those in the SMRFs are assumed as gravity columns and were modeled as leaning column. In addition, nonlinear behavior of the structures' elements were modeled as a nonlinear rotational spring at both ends of each element using the Modified Ibarra–Krawinkler bilinear-hysteretic model (Kazemi et al., 2018a and 2019). Therefore, an element in the SMRFs was modeled with an elastic beam-column element in the middle and two zero-length elements located at both ends. The linear viscoelastic contact model (Kelvin-Voigt model) was developed in OpenSees software to model pounding phenomenon. For all pounding SMRFs, the impact damping coefficient, C_{imp}, and the impact stiffness, K_{imp}, were obtained from studies presented by Kazemi et al. (2018b) and Mohebi et al. (2018). Different condition of adjacency of RC and steel SMRFs assuming three separation distance of 0.0, 0.5d and 1.0d, where d is the minimum separation distance prescribed by the provisions, were considered. Incremental Dynamic Analysis (IDA) were performed to assess the values of MRIDR capacity, Sa_{RD}, which is displayed by the flat part of each IDA curves. The values of median MRIDR capacity, median Sa_{RD}, corresponding to different MRIDR levels of 0.2%, 0.5%, 1.0% and 2.0% are determined by performing IDAs assuming 28 near-field records having pulse subset and 28 near-field records having no-pulse subset presented in FEMA P695.

Figure 1 shows the IDA curves of the 4-Story RC SMRF in alone condition and pounding with adjacent 6-Story steel SMRF corresponding to MRIDR levels of 1.0%. According to this figure, considering pounding phenomenon increases the median Sa_{RD} of 4-Story RC SMRF without any adjacent structure from 0.565 to 0.663 (14.78%), while the median Sa_{RD} of 6-Story steel SMRF decreases by 11.23%. Moreover, by increasing the separation distance between adjacent structures, the median Sa_{RD} taller SMRF decreases, while the median Sa_{RD} shorter SMRF increases correspondingly. As result, to determine the effects of pounding, which cannot be considered during design process, the modification factors for predicting the median Sa_{RD} of adjacent RC and steel SMRFs are proposed. Using this modification factors, it is possible to compute the median Sa_{RD} of RC or steel SMRFs in real condition, without involving in complicated analytical difficulties.

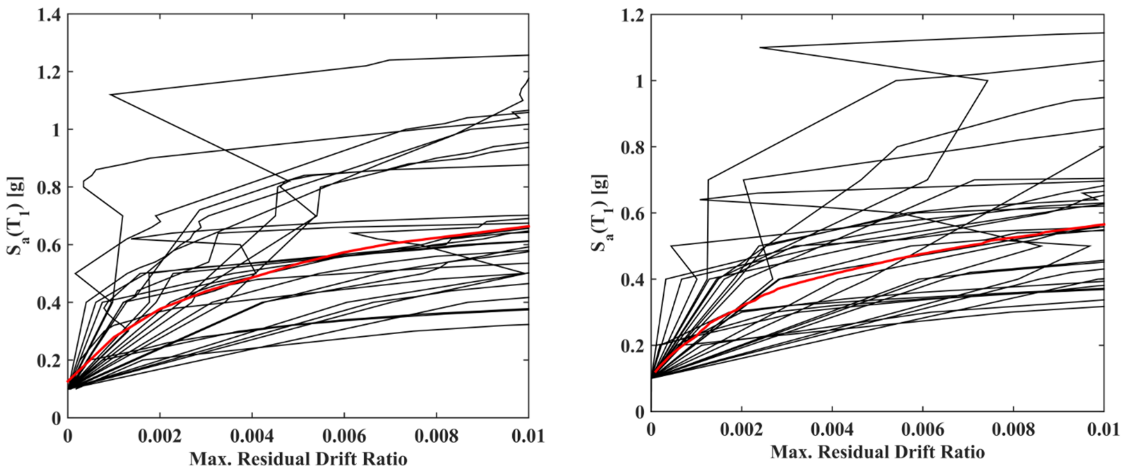

Figure 1. IDA curves of the 4-Story RC SMRF with and without pounding corresponding to MRIDR levels of 1.0% with separation distance of 1.0d, subjected to 28 near-field records having pulse subset.

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