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EXTENDED ABSTRACT

Assessment of Different Analysis Methods for Seismic Evaluation of RC Buildings with Irregularities in Plan and Height, Retrofitted Using Steel Bracing

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Seismic performance assessment, Reinforced concrete structure, Plan and elevation irregularities, Steel brace, Non-linear analyses.

1. Introduction

One of the seismic retrofitting methods in concrete structures is the use of steel bracing. The present paper attempts to investigate the seismic response of 4 reinforced concrete structures with 10 and 15 stories and two different plans. The structural models are geometrically irregular in plan and they also have vertical structural irregularities due to the soft story. In this study, the seismic response predicted using different linear and nonlinear analysis methods are compared for the case of structures with combinations of irregularities in plan and height. The effect of combinations of irregularities has not been studied in the past and is not considered in current seismic design provisions.

2. Methodology

With respect to the complexity of the seismic behavior of irregular structures and based on the building codes requirements, linear and non-linear static analyses, as well as, linear and non-linear dynamic analyses have been performed for the design and evaluation of the primary structural models. In the first step, by conducting non-linear static and dynamic analyses, the process of plastic-hinge formation and structural performance levels are evaluated. Subsequently, the structures are strengthened with steel braces in X and zigzag configurations and their seismic performance is determined using different analysis methods. The predictions obtained using different methods of analysis are compared for all the primary and rehabilitated structures.

3. Results and discussion

The comparison between the results obtained from the analyses of the primary structures and the retrofitted models with different plan types (e.g., plans S1 and S2, as shown in Fig. 1) indicates that employing both types of steel braces, X and zigzag configurations, leads to significant improvement in the seismic performance level of the structures (Fig. 2). Predictions obtained using different methods of analysis were compared for all structural models and the results indicated that the predictions obtained using the linear dynamic analysis method, that is permitted in the current design codes, were not appropriate for some cases (e.g., Fig. 3).

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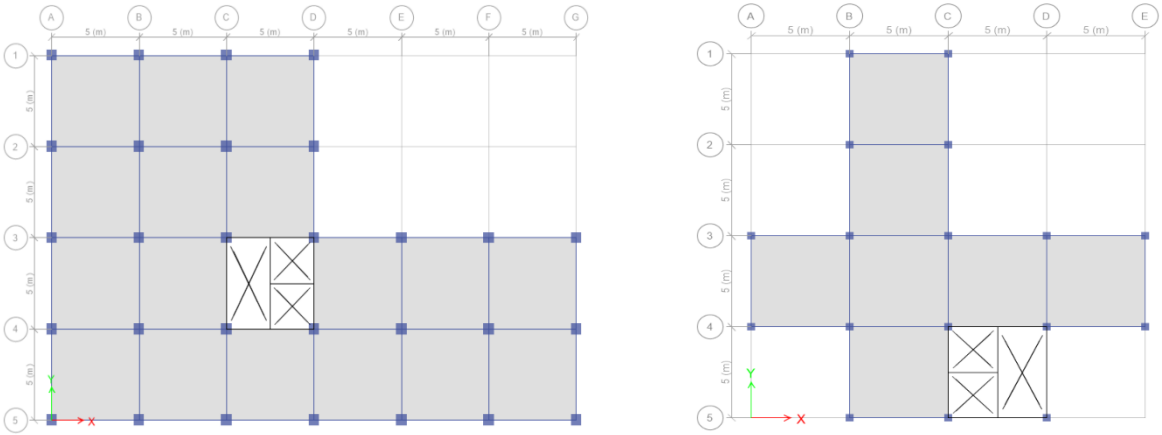

Fig. 1. Plan S1 (left) and S2 (right) considered in this study

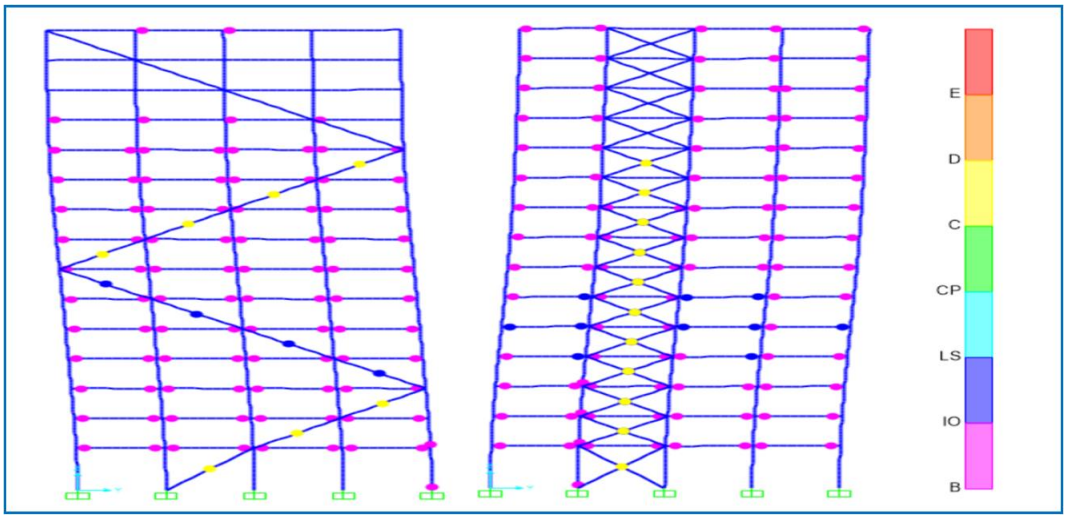

Fig. 2. Example of the condition of the plastic hinges at the target displacement for the rehabilitated structures

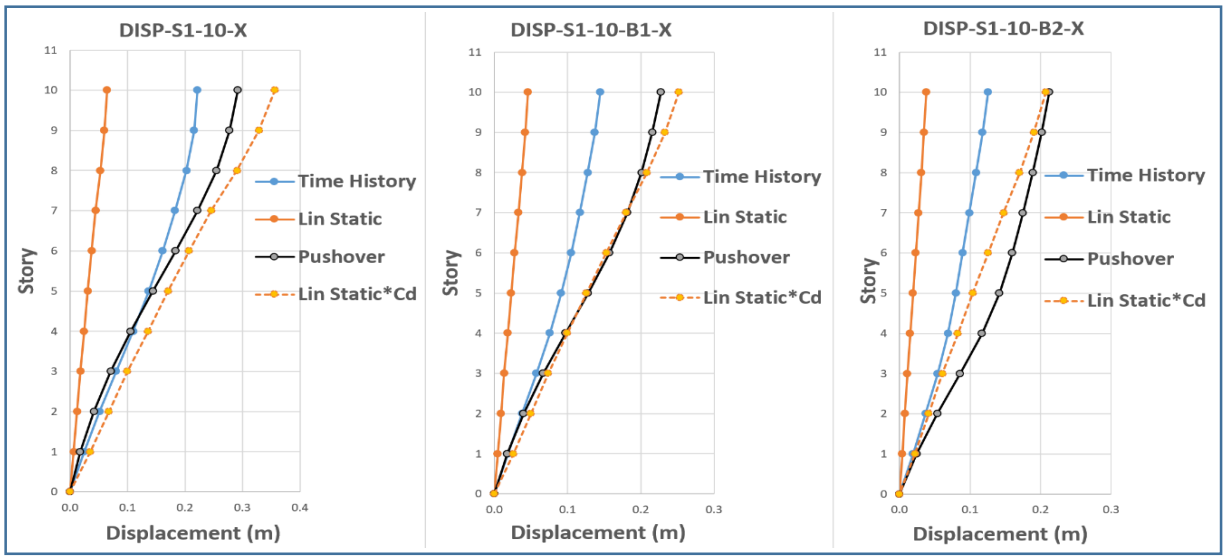

Fig.3. Comparison of the floor displacements predicted using linear and nonlinear analyses for the S1-10 structure in X direction

4. Conclusions

According to the results obtained from the nonlinear analysis, it was observed that the reinforced concrete structures considered in this study, that had simultaneous irregularities in plan and height and were designed according to the fourth edition of the Iranian Standard 2800, achieved life safety (LS) performance level at the design earthquake level.

A comparison of the results from linear static analysis and nonlinear analysis in all primary and rehabilitated models shows that although the linear analysis can typically predict the maximum displacements with sufficient accuracy, it is not capable of predicting the overall displacement pattern of the structure particularly the displacements at the middle floors.

By examining the relative torsion at different floors (i.e., rotation of each floor relative to the lower floor), the negative effect of the soft story irregularity on the torsion of the structures with irregularity in the plan was observed. Therefore, the effect of the simultaneous existence of different types of irregularities and their interaction is a case that can adversely affect the seismic behavior of structures and needs more investigation.

5. References

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