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Evaluation of the behavior factor of vertically irregular moment resisting reinforced concrete frames considering the influence of masonry infill walls

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ABSTRACT: Although infill panels are considered as non-structural elements in the analysis and design process of building frames, these members may significantly affect the seismic performance of the frames. Nowadays, the tendency to design and construct irregular buildings has increased. Behavior factor (BF) plays an important role in the seismic design of buildings. Seismic codes usually present the same BF for the regular and irregular lateral load-carrying systems. In this investigation, the influence of masonry infill walls on the behavior factor of the vertically irregular moment resisting reinforced concrete frames was evaluated. To do so, 3-, 6-, 9- and 12-story moment resisting reinforced concrete frames with various types of vertical irregularities were considered. These frames were assessed with/without considering the influence of infill walls. The capacity curves of the frames were derived using incremental dynamic analysis using 14 acceleration ground motions and then the BFs were achieved. Outcomes demonstrated that infilled frames present higher BFs and more efficient performance in lateral load-carrying rather than bare frames. For the regular frames, considering infill walls effects increased the behavior factor between 18 to 25%. For the irregular frames, due to considering the influence of infill walls, the highest and lowest enhancements of BFs were 3 to 25% (for 3-story frames), 13 to 25% (for 6-story frames), 18 to 25% (for 9-story frames) and 14 to 22% (for 12-story frames). Furthermore, comparing the BFs of regular and irregular frames indicated that vertical irregularity made 14 to 32% reduction in the BF of considered moment resisting reinforced concrete frames. Eventually, two approximate relations were developed to acquire the behavior factors of bare- and infilled- vertically irregular moment resisting reinforced concrete frames. Comparing the behavior factors achieved using the developed approximate relations and an analytical method for three new irregular frames showed that the error of the proposed relations was lower than 7%.

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1- Introduction

Reinforced concrete frame buildings with masonry walls are widely applied in building constructions. The experiences of previous earthquakes have shown that the presence of infill walls can significantly affect the seismic performance of buildings. Due to complicated interaction between the frame and the infill wall, especially in the inelastic range coupled with the dependence of this interaction on various factors e.g., the properties of RC frame and infill wall, the aspect ratio of the wall, and so on, masonry infill walls are generally disregarded in analyzing and designing process. In the literature, plethora analytical micro and macro models have been developed to consider infill wall effects on the responses of frame structures [1-14].

Behavior factor reflects the capability of ductile framing structures to tolerate inelastic large deformation without collapse. BF is inversely proportional to the design forces and considers the inherent ductility and overstrength of a structure coupled with the difference in the level of stresses assumed in its design [15]. Nowadays, there are a lot of irregular buildings such as constructions with various types of setbacks or stepped building frames in all around the world [16-22]. The behavior factor is one of the key parameters in designing constructions. Although the seismic responses of regular and irregular buildings may be completely different, the separated behavior factors for regular and irregular buildings are not presented in some seismic codes such as the Iranian one [23].

A literature review on the BF for irregular moment resisting reinforced concrete frames (MRRCFs) revealed that studying the influence of masonry infill walls on BF of this lateral load-carrying structural system is relatively rare. This investigation focuses on the behavior factor of irregular MRRCFs with/without modeling the infill walls. To consider changing dynamic characteristics during the nonlinear

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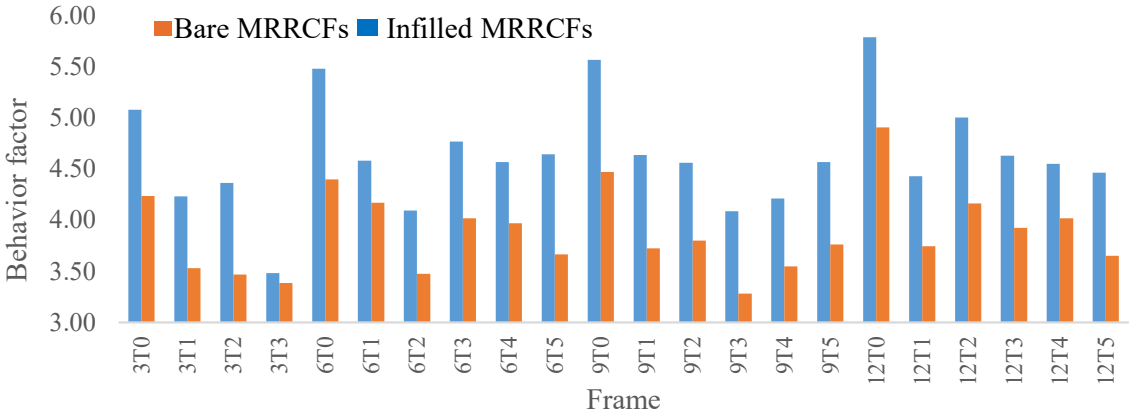

Fig. 1. Behavior factors of bare- and infilled-MRRCFs

response of assumed MRRCFs, the behavior factors are derived using incremental dynamic analysis.

2- Methodology

In this research, the BF of irregular MRRCFs inclusion/exclusion of the infill walls is studied. Hence, several MRRCFs with different stories and bays and various kinds of vertical irregularity are designed based on the value of BF prescribed in the Iranian Code of Practice for Seismic Design of Buildings (Standard No. 2800) [23]. After that, incremental dynamic analysis (IDA) is performed on the MRRCFs inclusion and exclusion of masonry infill walls subjected to a set of 14 seismic ground motions, and IDA capacity curves of these frames are achieved. Then, the BFs of these frames are acquired, and a comparative study is conducted on these values and the prescribed value of Standard No. 2800. To evaluate the inelastic dynamic behavior of MRRCFs, the macro model developed in Ref [3] containing a system of two diagonal compression struts is utilized to simulate the influence of masonry infills wall in lateral load-carrying.

3- Results and Discussion

3- 1- IDA capacity curve

This investigation proves that the masonry infill walls improve the lateral load-carrying, strength and secant stiffness of IMRRCFs. Regarding the different seismic characteristics of the frames and seismic ground motions, this improvement for some frames is higher than others.

3- 2- Behavior factor

In Figure 1, the values of BFs for all bare- and infilled-frames are compared.

As shown in Figure 1, for all frames, the BFs of infilled frames are higher than bare frames. Comparing the BFs of the frames with similar stories indicates that type of irregularity can remarkably affect the BFs. The BFs of all irregular frames are lower than regular frames (T0). Comparing the analytical BFs with the BF of the Iranian seismic code (R=5) shows for any of the irregular frames, the BF of the Iranian seismic code does not meet.

4- Conclusions

In this research, the behavior factors of irregular MRRCFs considering the masonry infill walls effect were achieved. To do so, IDA was conducted on several MRRCFs and IDA capacity curves of these frames were acquired. Then, two approximate relations based on the height of the frame and horizontal and vertical irregularity indices were developed to achieve the BF of bare- and infilled-MRRCFs. Comparing the outcomes of these relations with analytical BFs for three new irregular MRRCFs confirmed the validity of these relations.

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