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THE INFLUENCE OF MASONRY INFILL WALLS ON DYNAMIC BEHAVIOUR OF CONCRETE STRUCTURES

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SUMMARY

The masonry infill walls are mostly used in structures as non-structural elements. As a matter of fact, the behaviour of the structures is affected by these non-structural elements in earthquake loads.

To indicate the effect of the masonry infill walls on dynamic behavior of structures, different concrete structures were selected and designed. In each building, the infill walls were modeled and the whole structure was subjected to three different earthquake ground motions

The results of structures considering the effect of the infill walls are compared to the results of structures neglecting the effect of infill walls. It is shown that the contribution of the lateral loads along the height of the structure was changed and the values of base shears were increased. These changes are more pronounced in low structures.

By comparing the values of interstorey drifts in two types of modeling of these buildings, it is indicated that the interstorey drifts are decreased in structures considering the effect of infill walls. The important thing is that, when these structures were subjected to high accelerations of ground motions and undergone to inelastic behavior, the more interaction between infill walls and frames causes the changes in the location of plastic hinges especially in higher storey levels in structures.

It is concluded that the dynamic characteristics of concrete structures are varied when the influence of masonry infill walls are considered.

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INTRODUCTION

Many structures are built with infill walls and designed without considering the effect of infill walls on global behavior of the structures. The results of recent researches Saneinejad[1] and Liauw[2] show that the infill walls influence on the stiffness of the structure especially when the structure is undergone to inelastic range. In this research, the influence of the infill walls on dynamic behavior of concrete structures has been evaluated.

For this purpose, a few concrete structures with different storeys were designed and subjected to different records. In some selected models of structures, to consider the effect of geometric shapes of infill walls, the location of these non-structural elements along the vertical directions in different storeys were changed.

In this paper, the modeling of infill walls is described. The specification of the selected concrete structures are given and by indicating the results of nonlinear dynamic analysis of these models, the influence of infill walls on the base shears, inter storey drifts and location of plastic hinges in the elements are discussed.

THE MODELING OF INFILL WALLS

For modeling the behavior of infill walls, two compress diagonal columns replace the infill walls (Figure 1).

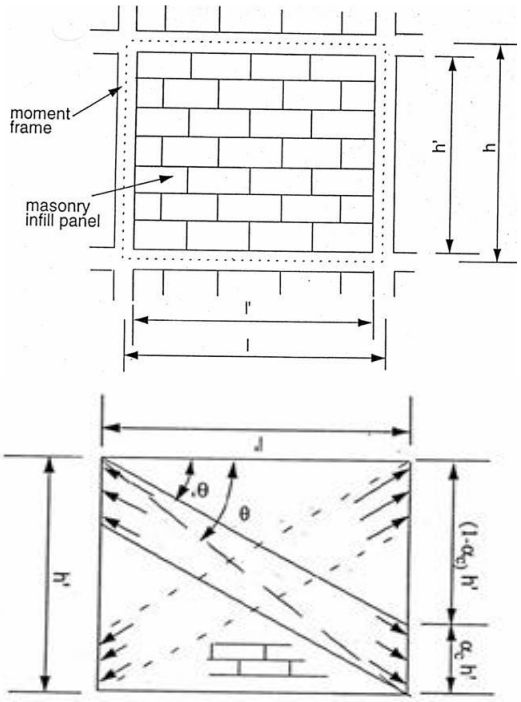

Figure 1: **modeling of infill walls**

The stress-strain relationship of masonry materials is shown in Figure 2. The column elements behave only in compression. This is because the tension behavior of masonry materials is neglected. The force-displacement relationship of the infill walls can be modeled as a bilinear curve as shown in Figure 3. This curve starts with a constant stiffness until the shear force comes to yield state, V_y. Then with changing the slope of the curve the second part of the curve extends up to the maximum shear force, V_{max}. More information about the modeling of infill walls is given in reference [1].

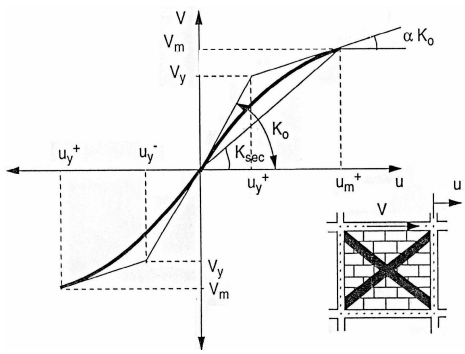

Figure 2: **Modeling of infill walls**

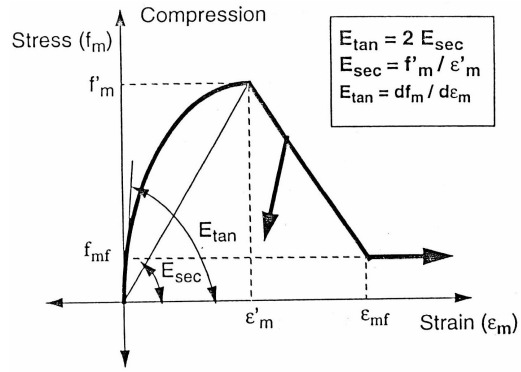

Figure 3: Stress-strain relationship

SPECIFICATION OF DESIGNED CONCRETE FRAMES

For covering the range of short, medium and tall buildings, the four, eight and twelve storey frames were selected in eight storey models, the locations of infill walls were changed in vertical direction. All of the frames were designed according to the Iranian code (Iran-2800). The design acceleration is selected for high seismic zone the concrete strength was fc`=280 kg/cm2 and the thickness of the walls was 20 cm. The full details of member sizes and other specification of all models are given in Behrang [3]. The geometric shapes of eight storey structural models are shown in Figure 4. The shapes of other models are as same as eight storey models and only the numbers of storey are different.

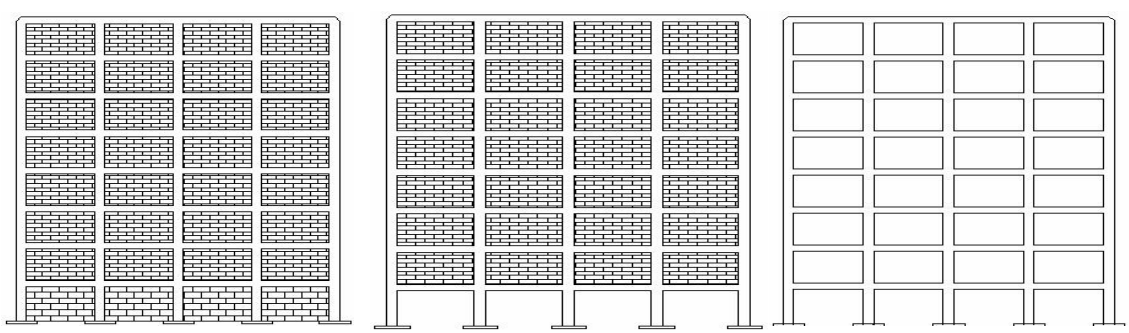

Figure 4: **The geometric shapes of eight storey frames**

RESULTS OF DYNAMIC BEHAVIOR OF THE FRAMES

For nonlinear dynamic analysis the IDARC computer program was used (Reinhorn [4]). This program is capable of modeling the infill walls. All of the frames were analyzed with this program and subjected to different records as the Tabas, Nagan and EL-centro ground motions. The ground accelerations spectra of three records are shown in Figure 5.

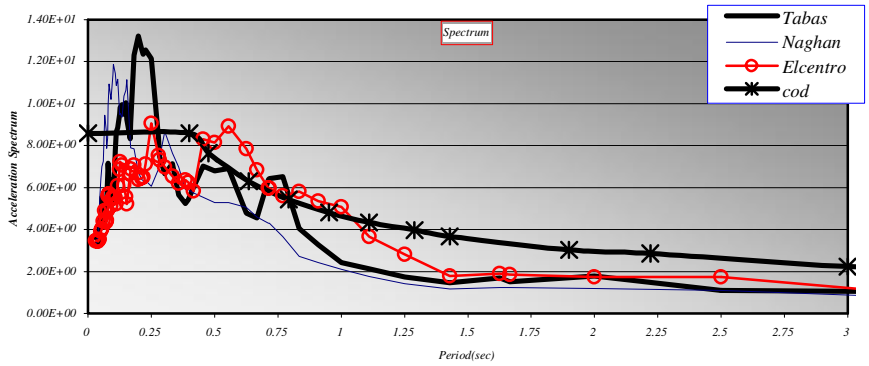

Figure 5: Accelerations spectra for three records and design spectra

All of the records were normalized to design acceleration 0.35g. To indicate the effect of infill walls on global behavior of the structure, the results of time history analysis of these models are presented and discussed in this section.

Base shear

The calculated base shears of all of the frames are compared to those results of the frames considering the effect of infill walls. As shown in Figure 6, the maximum base shears of the frames considering the effect of infill walls are higher than the others. This influence is more sensitive in four storey structures. In addition, it is shown that when the effect of infill walls was included in analysis of these frames, this effect also changes the contribution of these forces along the height of the structures.

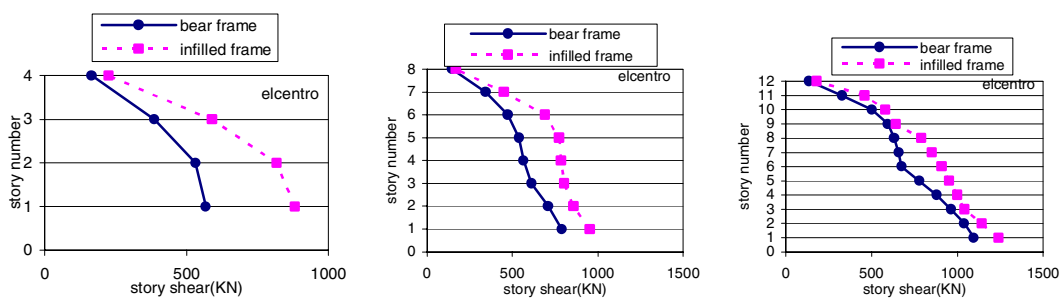

Figure 6: the base shear of different models influencing the infill walls

Interstorey drift

Generally, the interstorey drift in different storeys in all of the models is decreased. This is because the lateral stiffness of the models is changed and the increase of lateral stiffness causes an decrease on the displacement. The results of storey displacements of the frames that are subjected to EL-centro, Nagan and Tabas earthquake ground accelerations are shown in Figures 7-9. The results of displacements in four storey models for Tabas earthquake ground motion are different and are increased. The reason of this behavior is related to the frequency content of this especial record. The increase of latteral stiffness of the model causes an decrease on frequency of the model and this range of frequency is fell into the range of higher values of acceleration spectra of the Tabas record. Then, this model attracts higher forces and therefore, the interstorey drift is increased.

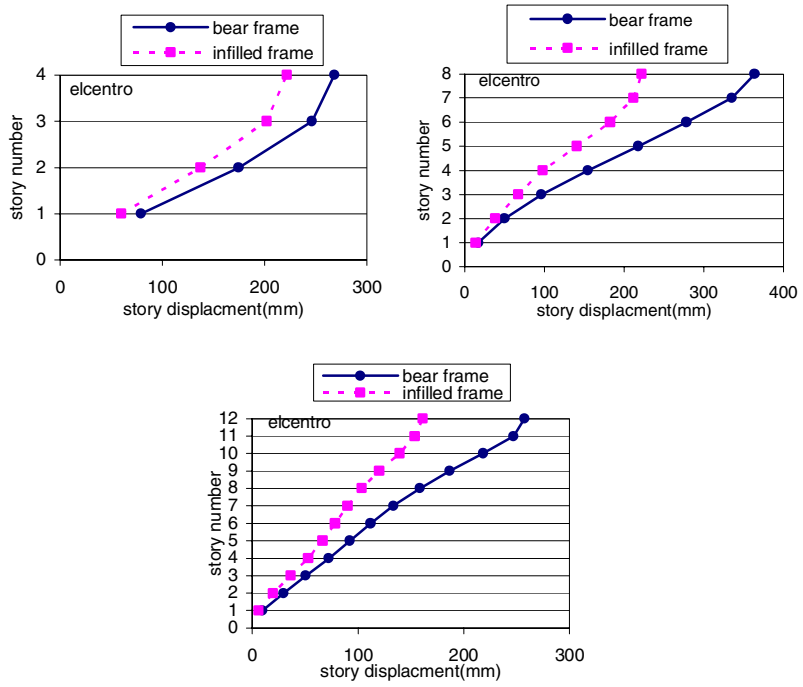

Figure 7: Storey displacement for different models for El-centro records

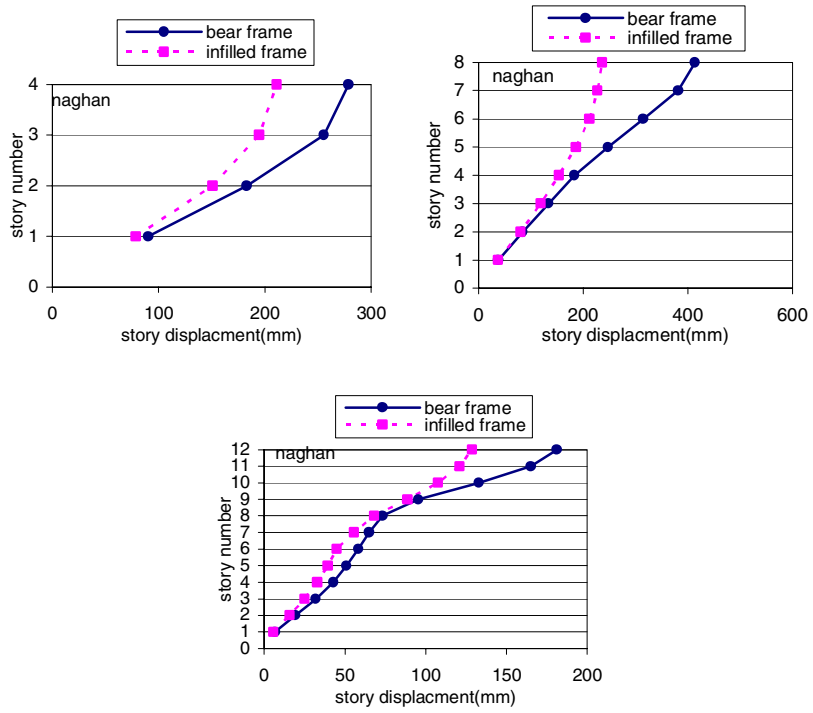

Figure 8: Storey displacement for different models for Nagan records

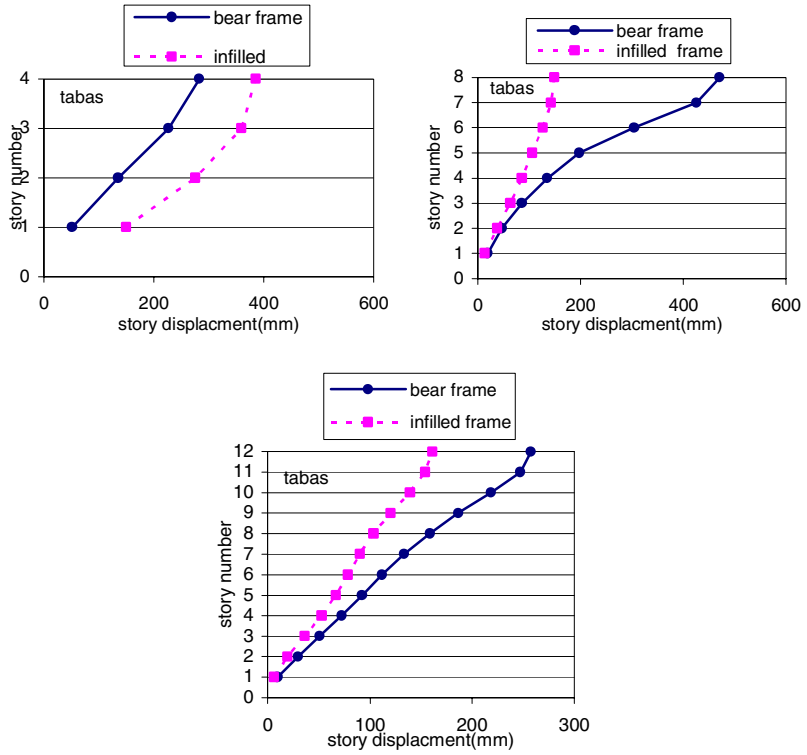

Figure 9: Storey displacement for different models for Tabas records

Location of plastic hinges

The plastic hinges in moment resisting frames normally are occurred in beam elements. It is shown that in eight and twelve storey frames, the plastic hinges are occurred in the beams in top storey.

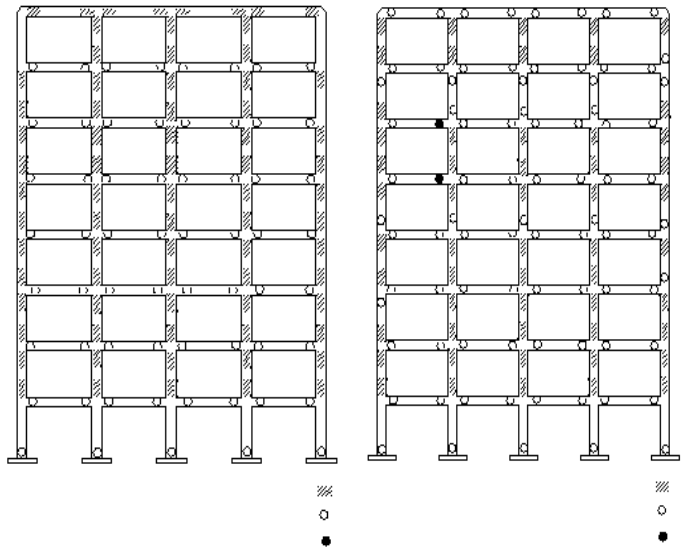

Figure 10: the changes of location of plastic hinges in eight storey frames (Nagan record)

The mechanism of plastic hinges is located in six and seven storey in eight storey structures and in nine and ten in twelve storey structures, when the effect of infill walls is not included in modeling of the frames. While in models considering the influence of infill walls, the infill walls prevent the structures from this type of mechanism and generally the changes in lateral stiffness along the height of the structures and also the interaction between walls and frames causes an decrease on damages concentrated on top storey and have a positive effect on damage contribution on the models. This is indicated in Figure 10.

The behavior of concrete structures without infill walls in first storey

In many structures, it is normal to have open spaces in first storey of the buildings. The opening has affected the behavior of the structures (Mallick[5] and Penelis[6]).This action causes an inconvenient contribution in lateral stiffnesses of the storey and soft storey mechanism occurred in first storey in these buildings. As shown in Figure 11, the displacements in first storey of the models with open spaces in four and eight storey frames are significantly increased and the damages is concentrated in this first storey. This effect also is shown in twelve storey buildings but its influences not as much as seen in low and medium structures. This is because, in tall building, the stiffnesses of low storey are very high.

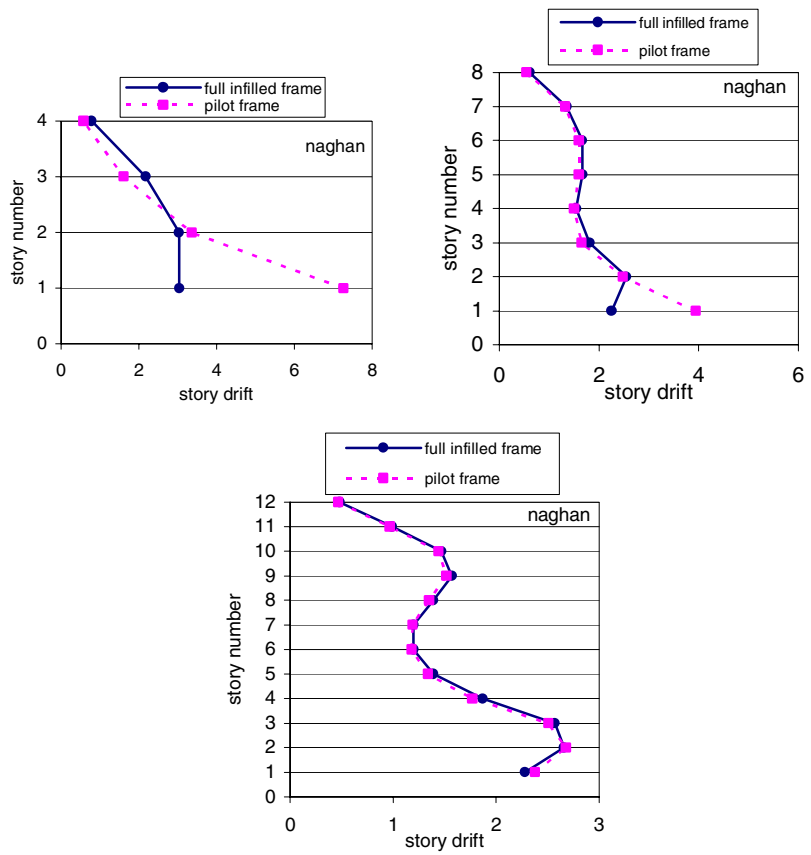

Figure 11: storey drifts of the frames with and without infill walls in first stroey

CONCLUSION

The results of time history analysis of models with and without infill walls that are designed according to Iranian codes and subjected to three different records are indicated that when infill walls are included in these models, the dynamic parameters of the structures are changed and should be considered in modeling and analyzing the structures. Some results are as follow:

1- The values of base shears are increased. This effect is more sensitive in low buildings.
2- The influence of infill walls on dynamic behavior of the structures causes an decrease on inters storey drifts.
3- The locations of plastic hinges are changes and generally the damage contributions in different storey are changed and the infill walls prevents the damages concentrated in top storeys and has a positive effect on damage contributions in vertical directions in all storeys.
4- The lateral stiffness of structures with open spaces in first storey has changed inconveniently and higher displacement and damages concentrated in this storey. This had behavior is more considered in low structures.

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