NONLINEAR FINITE ELEMENT ANALYSIS OF RC INFILLED FRAMES

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ABSTRACT

In this study, a nonlinear finite element model is used to assess the seismic response of RC infilled frames. The RC elements and the masonry panels are modeled as plane stress elements. The smeared cracking approach has been adopted to simulate the cracking behavior of both RC elements and masonry infills. To account for the interacting effect of infill wall-RC frame, two cases were considered; in the first case, the infill panels and the RC elements are supposed to be rigidly connected, whereas in the second one, interface elements are used as potential crack, slip and crushing planes to simulate the possible detachment between the frame and the infill .

Different structures have been studied. The results obtained will allow have an insight into the behavior of RC infilled frames and indicate that finite element models with interface elements are more appropriate to simulate the observed mode of failure of masonry panels subjected to seismic loading.

Keywords: Nonlinear analysis, RC frames, Infill panels, smeared cracking, interface elements.

1. INTRODUCTION

Bricks masonry infilled panels, which are used as interior/exterior partitions in framed structures situated in high seismicity areas are known to significantly affect the strength, stiffness and ductility of the composite structure. However, in most building codes around the world, infill masonry panels are considered as nonstructural components in the seismic analysis and design of RC frames. The contribution of the infill panels to the lateral strength and stiffness of a give structure is neglected. This is due to the fact the behavior of the composite structure is quite complex since it involves two distinct materials with totally different properties, especially the masonry which shows a great scatter in the material properties. This interaction may have a dual effect: it can affect positively or adversely the seismic performance of the structures and it is still an open issue within the structural community. The behavior of masonry-infilled reinforced concrete frames has been the subject of numerous investigations, experimentally, analytically and numerically. To date, two

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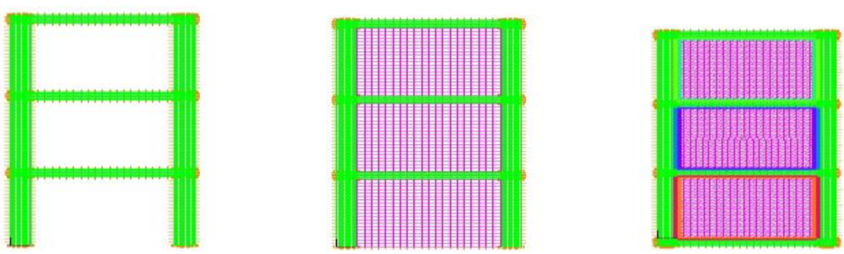
approaches have been used to model masonry panels: the macro-model (strut model) (Polykov (1960); Holmes (1961); Smith (1966); Smith and Carter (1969); Mainstone (1971); Reflak and Faijfar (1991); Saneinejad and Hobbs (1995), Buonopane and White (1999); Korkmaz et al.(2007), Madan and Hashmi (2008)) and the micro model (finite element model), (Dhanasekar and Page (1986); Liauw, and Lo(1988); Schmidt(1989); Mehrabi, and Shing (1997); Mehrabi et al. (1994) and Mosalam and Paulino (1997)).

2. FINITE ELEMENT MICRO-MODELLING

In the micro model approach adopted in this work, both the frame and the infill masonry panels are discredited by four nodded isoparametric plane stress solid elements. The base of the columns is supposed to be fully fixed while all other nodes have two degree of freedoms. 2D axisymmetric contact surface elements are used to model the frame-infill interaction. Each interface element consists of two contact surfaces that may come into contact during the seismic action. One of the two contact surfaces is chosen to the ‘‘contractor’’ surface while the other one is the ‘‘target surface’’. The main characteristics of these elements are that the nodes on the contactor surface cannot penetrate the target surface and that no tensile strength is associated with the joint, making the modelling of the detachment between the frame and the infill possible. The contact algorithm implemented in ADINA and based on the constraint function method is adopted for the surface contact element.

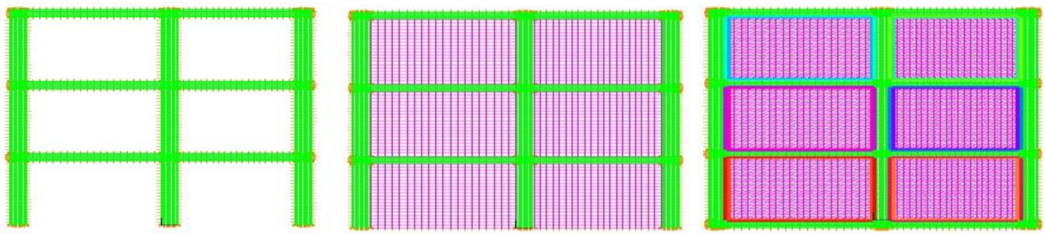
3. STRUCTURAL GEOMETRY AND FINITE ELEMENT MODELS

The structures used in this study are 2D frames, figure 1. Three different cases are used: bare frame, infilled frame with perfect bond and infilled frame with interface elements. The bay lengths are 3 m and the story height is 3 m. The finite element meshes consisting of 2D isoparametric plane stress elements are also shown in figure 1.



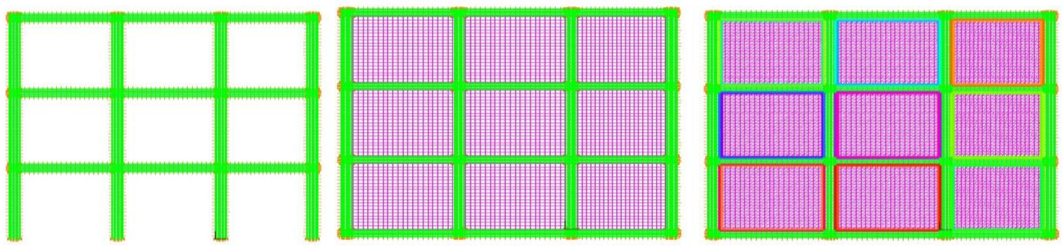
a) bare frame, b) infilled frame with rigid contact c) infilled frame with interface elements

Structure 1



a) bare frame, b) infilled frame with rigid contact c) infilled frame with interface elements

Structure 2



a) bare frame, b) infilled frame with rigid contact c) infilled frame with interface elements

Structure 3

Figure 1: Geometry and finite element meshes of the structures

3.1. Ground motion

The horizontal component of the New Hall earthquake record was used in this study, figure 2.

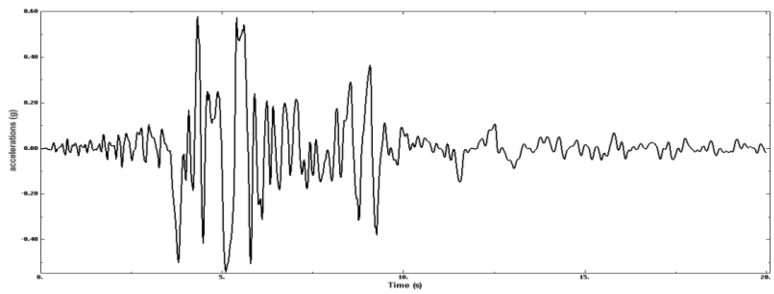
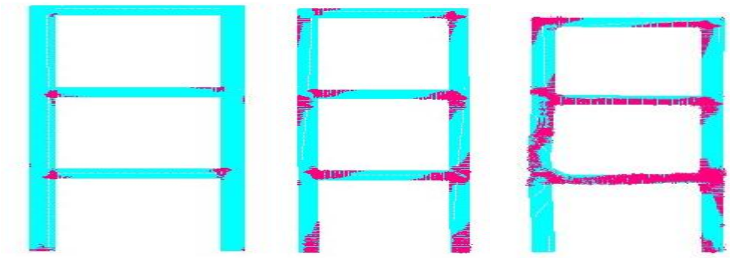


Figure 2 : Earthquake record used

4. RESULTS AND DISCUSSIONS

In the following figures 3-5, are shown the cracking patterns obtained from the dynamic analysis of each structure under the New hall earthquake record for the three cases. For structures 1 and 2, the inclusion of the infill masonry panels may reduce the density of cracking, thus enhancing the seismic performance of these structures. By neglecting the interface between the frame and the infill masonry panels and assuming perfect bond between them, the cracking profiles observed significantly deviates from the generally observed experimental and field evidence results. The inclusion of interface elements results in more realistic prediction of the response of the infilled frames since they can simulate the separation and detachment and the diagonal pattern observed in this type of structure. The main damage observed in infilled frames is concentrated in the ground level suggesting that in real earthquakes this zone must be given great attention. Different contact lengths between infill walls and the surrounding frames are observed.



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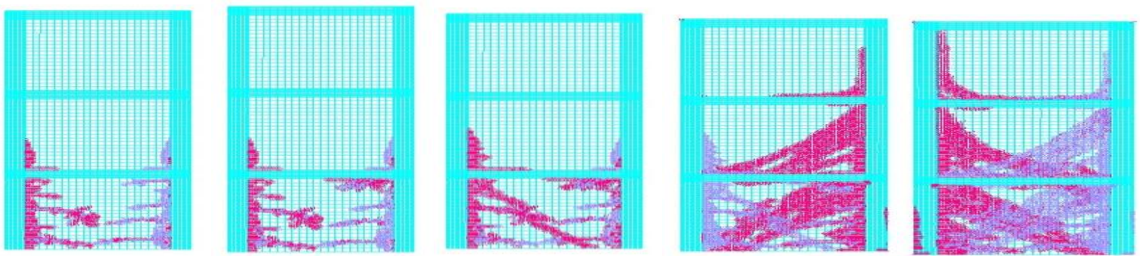

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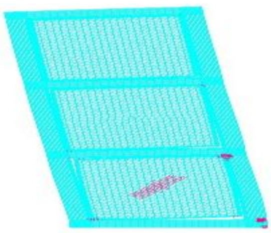

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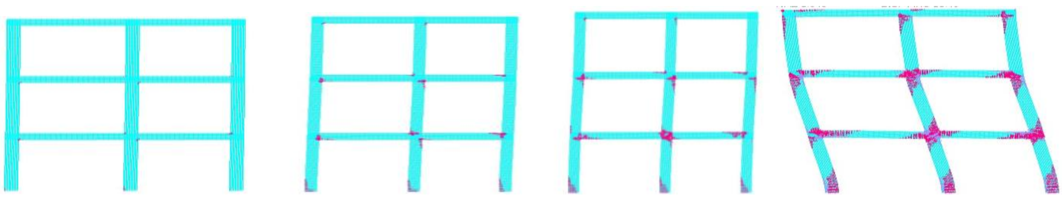
Figure 3 cracking patterns in structure 1 a) RC bare frame, b) RC infilled frame with contact, c) RC infilled frame with interface elements



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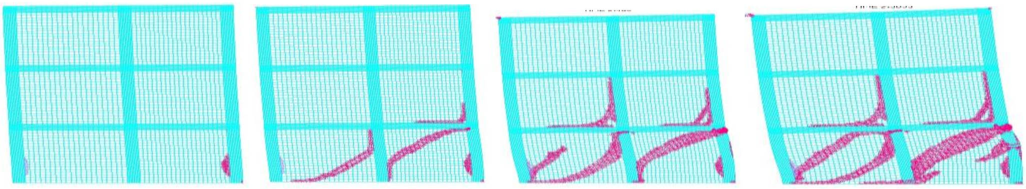

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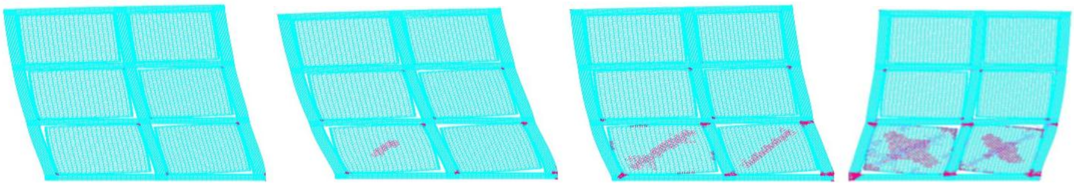

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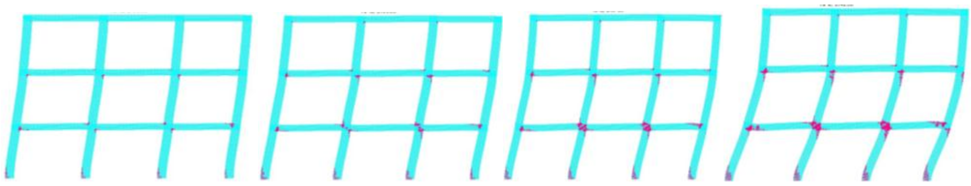
Figure 4 cracking patterns in structure 2



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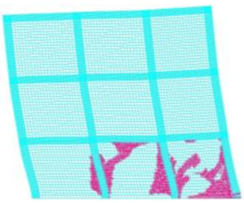

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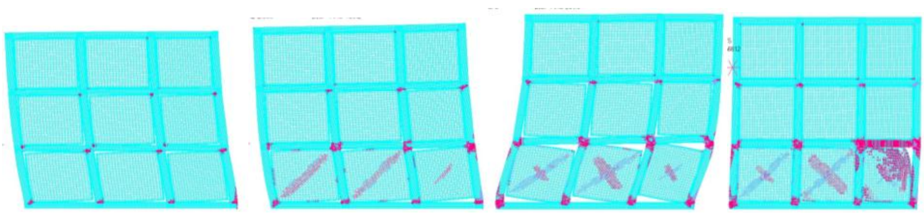

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Figure 5 cracking patterns in structure 3

5. CONCLUSIONS

The main objective of this study was to investigate the utilities and effectiveness of finite element models through a micro model to predict the seismic response of RC masonry infilled frames. Considering interface elements between the frame and surrounding infill is crucial to the realistic prediction of the overall behavior of the structures compared to that of perfect bond. The smeared cracking approach is found to be suitable for predicting the response of masonry when its failure mode is diagonal. The micro models are able to model the behavior of this type of structures in detail, even though they are computationally expensive.

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