CHAPTER 6
SUMMARY and CONCLUSIONS

6.1 Summary

Numerical studies of infilled frames require proper modeling of the infill wall characteristics. In this thesis, the numerical study focused on developing numerical models to represent the load-displacement behavior and strength of the reinforced concrete infilled frames. Therefore, numerical study has been carried out to investigate the performance of masonry–infilled reinforced concrete frames under cyclic lateral loading.

The outcome of this research is a relative quantitative evaluation of the behavior of the reinforced concrete frames infilled with masonry infill panels.

The outcome of the first part of the numerical study is a development of a model represents the reinforced concrete infilled frames items (reinforced concrete frames, infill walls and interfaces between them). Nonlinear finite element method is employed to conduct this part of the numerical study. The second part of the numerical study is devoted to model the interaction of the frame and the wall under various loads. Design parameters and factors affecting the behavior of reinforced concrete infilled frames were studied to provide information needed for the development of a design methodology for infilled frame building.
Recommendations and guidelines for a simple design methodology are presented which can be used by engineers to design proper reinforced concrete infilled frames.

6.2 Conclusions

Analysis of the results leads to the following remarks and conclusions:

1. A smeared-crack finite element model is used to idealize the behavior of reinforced concrete infilled frames with masonry infill. A constitutive model for interface element has been used for modeling the interface behavior of reinforced concrete frames and infill. It is shown that the finite element models are able to simulate the failure mechanisms exhibited by infilled frames including crushing, cracking of concrete frames and masonry panels. Also, the lateral displacements and strengths obtained with these models are in good agreement with these obtained from experiments done by other researchers in this field.
2. The sophistication of the developed finite element models provides a unique capability for the analysis and performance evaluation of infilled structures, and the models eventually can be used for numerical parametric studies to extrapolated existing experimental results for the development of comprehensive design guidelines.
3. The results indicated the contribution of the infill in the strength, stiffness, and ductility of the system. Also, the numerical results indicate that infill panels can significantly improve the performance of reinforced concrete frames.
4. Presence of infill panel reduces significantly the frame lateral displacement to 80 % of the corresponding bare frame lateral displacement. This reduction becomes more pronounced with improve of the interface condition.
5. The presence of infill panel leads to a significant increase in the frame capacity compared to that of the bare frame by about at least three times depending on many factors. This clearly indicates the significance effect of the infill walls in attracting most of the lateral loads in frame structures and shows why infill walls with or without opening should be accounted for in design.

6. Load sharing of each component of the composite system depended on the drift level. At small drift levels the masonry shared as much as 85 % of the total lateral load. At large drifts, the total horizontal load shared by masonry reduced to 75 %, this is due to cracking in the infill.
7. Strong interfaces lead to considerably efficient performance of the infilled frame especially top and sides interfaces. From this study the optimum value of the interface normal stiffness (Kn) can be taken equal to 650 N/mm^3. Also, the optimum value of the interface shear stiffness (Ks) can be taken equal to 0.20 N/mm^3 in which this values are in agreement with the value given by other researchers.
8. Rough interface between the frame and infill leads to a remarkable increase of about 12.5 % in the lateral load resistance of the infilled frame, therefore it is recommended to use shear connectors between the frame and the infill.
9. The presence of shear connectors at the infill/frame interfaces leads to a 60 % reduction in the frame lateral displacement compared with the corresponding values of infilled frames without shear connectors. This is because separation and slip at the infill/frame interfaces are eliminated especially at early stages of loading.
10. The ultimate load capacity of the infilled frames with shear connectors increased by 51 % compared to infilled frames without shear connectors.
11. The presence of openings in the infill panel leads to a considerable increase in the frame lateral displacement, this increase is about 5.5 times that for solid infill. The ultimate load capacity of the frame reduced by about 32 % compared with the solid infilled frame.
12. The composite action between the frame and the infill is adversely affected as the opening position moved towards the side. Since in practical cases, lateral loads can be applied in either direction, the best location of the window opening is at the top or at the bottom of the middle third of the panel. Also the best solution is to locate the door opening at the center of the wall.

13. Increasing opening size significantly reduce the lateral load resistance. The reduction in the lateral load is about 38 % in case of increasing opening size from 14 % to 32 % of panel dimension.
14. The increasing of rectangularity ratio of the infill panel (L/H) leads to reduction of the lateral displacement by about 60 %.
15. The load capacity of the infilled frames is considerably affected by the compressive strength of the infill panel material. An increase of about 63 % in the lateral load capacity obtained by increasing the panel strength from 8 MPa to 15 MPa.
16. The effect of changing reinforcing steel yield stress on frame lateral displacement can be neglected specially at early stages of loading history until about 75% of peak load. However, after that load, the frame with reinforcing steel yield stress of 240 MPa shows 60 % increase in lateral displacement until failure.
17. The effects of increasing yield stress of reinforcing steel were slightly affecting the infilled frame behavior, specially ultimate load. The increase of the reinforcing steel yielding strength from 240 MPa to 400 MPa increases the ultimate load by 36 %.
18. The influence of changing the frame-beam stiffness insignificantly affects the ultimate capacity.
19. The ultimate load capacity of the infilled frame is significantly reduced due to the increasing of stories number. A reduction of 32.5 % and 60 % obtained from two stories and three stories respectively.
20. The ultimate load capacity of the two bays and three bays are about 1.80 and 3.20 times that of single bay respectively.
21. A rational approach for design of reinforced concrete infilled frames has been developed.