CHAPTER 7

CONCLUSIONS

The principal aim of introducing steel in the masonry infill in this study is to make it ductile and to enable it to resist tensile forces. The reinforced masonry ensured sufficient ductility by permitting redistribution of lateral load and by providing good energy dissipation characteristics for cyclic loading. The horizontal reinforcement provided in the reinforced brick masonry infill prevents the separation of joints due to diagonal shear cracking. This improves the resistance and energy dissipation capacity of the wall when subjected to cyclic lateral load. In un-reinforced masonry infill frames, a diagonal crack causes shear deterioration in strength and subsequent brittle collapse. However, in the reinforced brick masonry infill frame due to the provision of horizontal reinforcement the cracks distributed over the entire surface of the walls.

At ultimate state, crushing of masonry due to a combination of bending and shear was observed indicating that the load bearing capacity of masonry units is fully utilized. Shear resistance of reinforced masonry infill depends on different mechanism such as tension of horizontal steel and dowel action of vertical steel. Moreover, the combinations of truss and arch-beam action of vertical and horizontal reinforcement with masonry improve the performance of infilled frames. Hence, horizontal bed joint reinforcement is efficient in the case of shear mode of failure and vertical reinforcement is needed for the bending mode of failure. Infills have a significant beneficial effect on the strength, ductility and energy dissipation capacity of frames.
Based on this study, the conclusions derived for different combinations of frames are discussed below:

### 7.1 BF, BMF and RBMF

- The load carrying capacity of the RBMF is 2.38 times that of BF and 1.56 times that of BMF
- The initial stiffness of the BMF is 1.62 times that of BF and final stiffness is 1.39 times that of BF.
- The initial stiffness of the RBMF is 4.68 times that of BF and final stiffness is 5.19 times that of BF.
- The cumulative ductility factor for RBMF is 1.23 times that of BMF and 0.96 times that of BF.
- The cumulative energy dissipation capacity of RBMF is 1.3 times that of BMF and 2.49 times that of BF.
- The RBMF has more favorable failure mechanism than BF and BMF.
- The RBMF has the highest load carrying capacity, stiffness and energy dissipation capacity.
- The damage to the brick masonry infill during the final stages of loading was considerable than reinforced masonry infill and hence there is a danger of cracking and spalling of bricks that may endanger the occupants.

### 7.2 BF, HMF and RHMF

- The load carrying capacity of the RHMF is 1.18 times that of HMF and 2.53 times that of BF.
• The initial stiffness of the HMF is 5.47 times and for RHMF is 9.09 times that of BF.

• The cumulative ductility factor for RHMF is 2 times that of HMF and more or less equal to BF.

• The cumulative energy dissipation capacity of HMF is 1.8 times that of BF and for RHMF is 2.46 times that of BF.

• The RHMF has the highest load carrying capacity, stiffness, ductility and energy dissipation capacity.

• The damage like spall of infill and cracking is very less in RHMF when compared to HMF and hence it avoids danger to the occupants.

7.3 BF and RABMF

• The ultimate load carrying capacity of RABMF is 1.9 times that of BF.

• The initial stiffness of the RABMF is 2.62 times that of BF and final stiffness is 1.31 times more than that of BF.

• The cumulative ductility factor of RABMF is more or less equal to BF.

• The cumulative energy dissipation capacity of RABMF is 3.04 times that of BF.

• The damage to the RABMF during the final stages of loading was more in bottom three storeys than top two storeys.
7.4 RBMF, RHMF and RABMF

- The load carrying capacity of RHMF is more or less equal to RBMF and 1.33 times that of RABMF.
- The initial stiffness of the RHMF is 1.94 times that of RBMF and 3.48 times that of RABMF.
- The cumulative ductility factor for the above three reinforced masonry frames is more or less equal.
- The cumulative energy dissipation capacity of the RBMF and RHMF is more or less equal.
- The cumulative energy dissipation capacity of RABMF is 1.22 times that of other two reinforced masonry infill frames.
- The RHMF has better performance than other two reinforced masonry infill frames.

7.5 GENERAL

- The presence of reinforcement in the infill reduces the stresses in beams and in general increases the ductility of the infilled frame.
- The reinforced hollow block masonry infill provides superior performance than other frames.
- Masonry infill acts as a structural member imparting additional stiffness to the bounding frame.
- The ANSYS model is able to represent different behaviors of infilled frames subjected to lateral loading. With a good
knowledge of the material properties of the infill panels, the load-deflection relationship and the distribution of stress can be predicted with accuracy.

- In finite element analysis of the infill frame, there is good agreement with the test results for the first few readings, but the results show variations in the later stages.

- The presence of infill in frames increases the load carrying capacity and decreases the deflection of frames. Hence, the effect of infill has to be incorporated while designing the framed structures.

7.6 RECOMMENDATIONS FOR FUTURE WORK

Reinforced masonry infill has been proven as an effective infill for increasing the strength, ductility and energy dissipation capacity of multistory reinforced concrete frames. The behaviour of infilled frames under lateral loads has been investigated by a number of researchers. There are several factors such as geometry, material properties, boundary conditions, aspect ratio etc., involve in their behaviour. In order to continue to understand further the behaviour of the infilled frames the future research works can be conducted as follows.

- This investigation was done for plane frames. But the actual frame structures are having three dimensional structural elements. Hence, this work can be extended to study the behaviour of space frames.

- In this investigation, the reinforced concrete infill frames have been considered. But in high rise buildings steel frames
are normally used. Hence, the study of steel frames with different infills can be done.

- In this work, the infill panels were considered without door and windows openings. But these openings will change the behaviour of infill frame. Hence, the effect of openings can be considered.

- In reinforced masonry infill, the reinforcements were provided without any connection with beams or columns. If reinforcements are connected, that will improve the overall performance of the frame. Hence, this study can be extended.

- The infilled frames were tested with equivalent static cyclic loads. The frames can be tested under dynamic loading to study the actual wind or earthquake loads.

- In all infilled frames, the severe damage occurred at the bottom storey leeward side columns. So, the load carrying capacity can be increased by providing proper strengthening techniques in bottom columns.

- In reinforced masonry infill either horizontal or vertical reinforcement was used. But, the reinforcement inclined to $45^\circ$ may prevent the formation of diagonal cracks in the infill. Hence, the work can be modified by using inclined reinforcements.

- In the modeling of infill frames instead of free meshing, mapped meshing can be used in which merging of nodes from reinforcement to frames then to infill can be done accurately.