Effect of Infill Walls on Seismic Performance of RC Frames

Mohd Abdul Malik[1], M A Azeem[2], Mohd Nazim Raza[3]

[1]*Post Graduate Student (Structures), Department of Civil Engineering, DCET, Hyderabad, India*
[2]*Assistant Professor, Department of Civil Engineering, DCET, Hyderabad, India*
[3]*Assistant Professor, Department of Civil Engineering, MJCET, Hyderabad, India*

Abstract: **For this study, three different shape buildings are considered which are both regular and irregular in plan. Three different storey conditions are applied to all the three buildings. A regular Rectangular shape, L shape and C shape buildings are studied having all 11 storey, 16 storey, 21 storey conditions. The Nonlinear static analysis is performed for all the models. The Seismic performance of Bare frame is compared with Infill frame, and for each shape models with different storey combination the effect change in number of bays with infill is studied. The Seismic performance of frame with soft storey is compared with frame having no soft storey conditions. The parameters studied are Storey Drifts, Time Period, Base Shear, Roof displacement, Performance points, and Hinge formation mechanism. From the study of all the thirty models it is found that the presence of Infill wall increases the load carrying capacity of the structure by 8 to 10 times than that of bare frame and the time period is decreased ranging from 188% to 325%.**

Keywords: **regular, irregular, nonlinear static analysis, infilled frames performance points.**

I. INTRODUCTION

Reinforced concrete frames are one of the most common constructions for low to medium rise buildings in all kinds of seismic hazardous regions. Brick masonry infill wall acts as a separation between the rooms with different functionalities and also provides additional stiffness to the RC frames enclosing it. The aspect that masonry infill wall provides additional stiffness to the moment resisting frame is usually neglected. The stiffness, strength and ductility are the major properties of a structure to estimate its capacity. For a complete understanding of the capacity of the frame, these three parameters are needed to be analyzed properly and the factors affecting them must be studied in detail. One such component that alters the stiffness, strength and ductility of the structure is the infill wall in the RC moment resisting frame. Due to this, it becomes necessary to understand the behaviour of the infill wall in terms of these three parameters. The effect of infill walls on the RC frames is well noted in many earthquake scenarios from the past.

II. PROCEDURE

Pushover analysis or non-liner static analysis has been developed over the past two to three decades and has become the preferred analysis procedure for design and seismic performance evaluation purpose, as the procedure is relatively simpler and also considers post elastic behaviour.

1.1 Non linear Static Analysis

Pushover analysis is nonlinear static analysis which provide 'capacity curve' of the structure, it is a plot of total base force vs. roof displacement. The analysis is carried out up to failure. It helps determination of collapse load and ductility capacity of the structure. The pushover analysis is a method to observe the successive damage state of the building. In pushover analysis structure is subjected to monotonically increasing lateral load until the peak response of the structure is obtained.

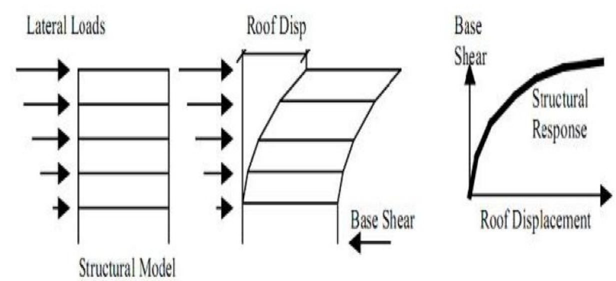

Figure 1 Application of lateral load and a graph showing relationship between Base Shear and Displacement.

1.2 Force vs Deformation Curve

Plastic hinge hypothesis was used to capture the nonlinear behavior according to which plastic deformations are lumped on plastic hinges and rest of them shows linear elastic behavior. Location of hinges in various stages can be obtained from pushover curve. The range AB is elastic range, B to IO is the range of immediate occupancy, IO to LS is the range of life safety, and LS TO CP is the range of collapse prevention. If all the hinges are within the CP limit then the structure is said to be safe. However, depending upon the importance of structure the hinges after IO range may also need to be retrofitted.

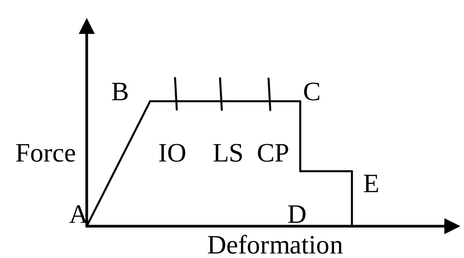

Fig.2 Force VS Deformation curve

III. CASE STUDY

The layout of rectangular, L shape and C shape consist of 6x6, 8x6 , 8x8 bays and bay width in each direction is 5m .The storey height is kept uniform of 3m for all kind of building models and the configurations of different models are given below.

Case A: Bare frame Vs Infill frame

Model 1: 6x6 21 storey bare frame
Model 2: 6x6 21 storey infill frame
Model 3: 6x6 16 storey C shape bare frame
Model 4: 6x6 16 storey C shape infill frame
Model 5: 6x6 11 storey L shape bare frame
Model 6: 6x6 11 storey L shape infill frame

Case B: Change in number of bays rectangular models

Model 1: 6x6 21 storey infill frame
Model 2: 8x6 21 storey infill frame
Model 3: 8x8 21 storey infill frame
Model 4: 8x6 16 storey infill frame
Model 5: 8x8 16 storey infill frame
Model 6: 8x6 11 storey infill frame
Model 7: 8x8 11 storey infill frame

Case C: Change in number of bays L shape models

Model 1: 8x6 21 storey L shape infill frame
Model 2: 8x8 21 storey L shape infill frame
Model 3: 8x6 16 storey L shape infill frame
Model 4: 8x8 16 storey L shape infill frame
Model 5: 6x6 11 storey L shape infill frame
Model 6: 8x6 11 storey L shape infill frame
Model 7: 8x8 11 storey L shape infill frame

Case D: Change in number of bays C shape models

Model 1: 8x6 21 storey C shape infill frame
Model 2: 8x8 21 storey C shape infill frame
Model 3: 6x6 16 storey C shape infill frame
Model 4: 8x6 16 storey C shape infill frame
Model 5: 8x8 16 storey C shape infill frame
Model 6: 8x6 11 storey C shape infill frame
Model 7: 8x8 11 storey C shape infill frame

Case E: Soft story effect

Model 1: 6x6 21storey rectangular infill frame soft storey
Model 2: 6x6 16 storey C shape infill frame with soft storey
Model 3: 6x6 11 storey L shape infill frame with soft storey

The models with soft story are compared with same models without soft storey and the effect of soft storey is studied.

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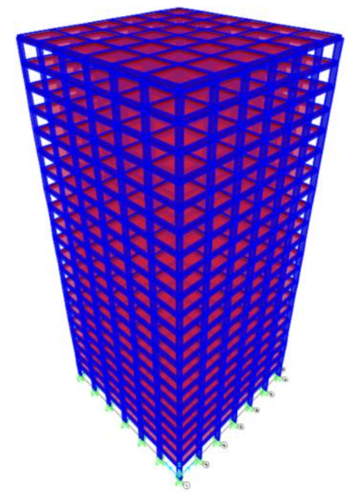

Fig.3 Isometric view of 6x6 21 storey rectangular bare frame

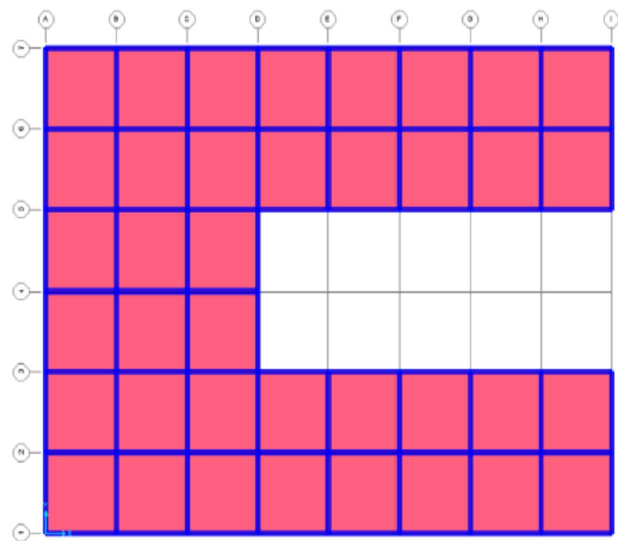

Fig.4 Plan of 8X6 C Shaped Infilled Frame Building

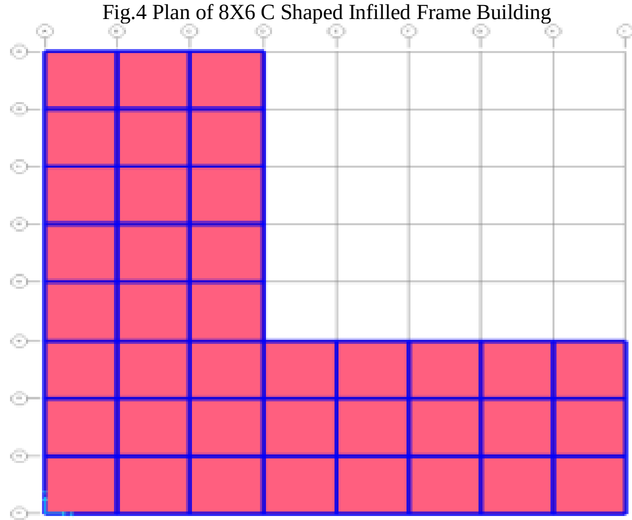

Fig.5 Plan of L Shaped 8X8 Infilled Frame Building

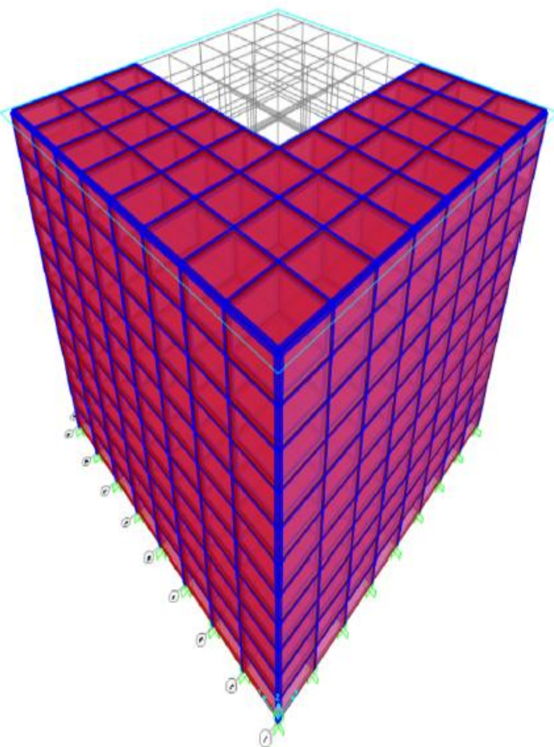

Fig.6 Isometric view 8x8 11 storey L shape infill frame

IV. RESULTS

The results obtained are of different parameters like fundamental time period, lateral displacement, storey drift etc. The results are obtained by running nonlinear static analysis and response for G+11, G+16 and G+21 storey symmetric and asymmetric building in plan with and without infill and their results are compared accordingly with SAP2000. The results obtained are compared in terms of base shear, displacement, story drift etc., in accordance with ATC-40 and FEMA 440.

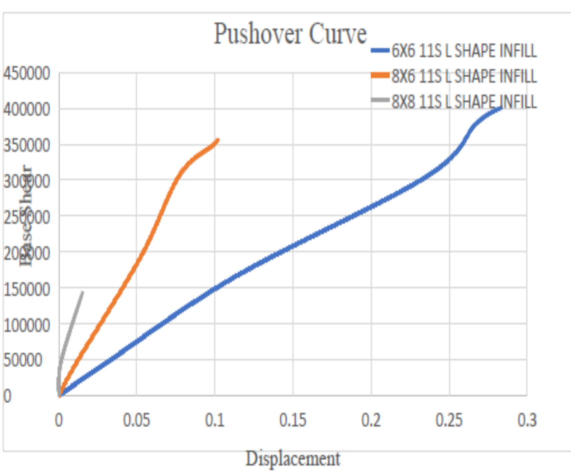

Fig 7 Pushover curve for G+21 L Shaped with and without infill

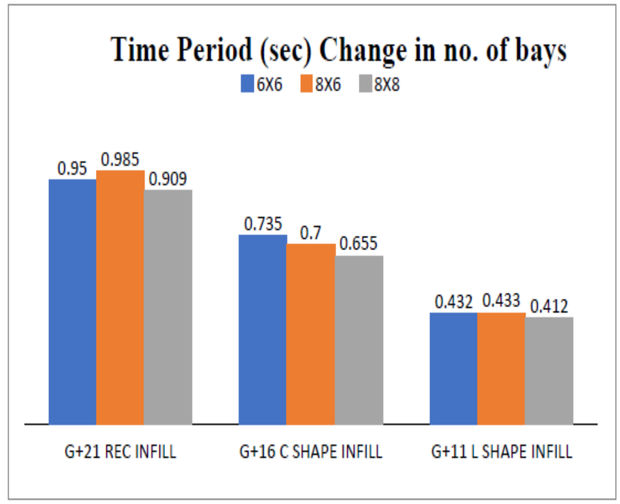

Fig.8 Time period comparison of infill frames considering change in bays

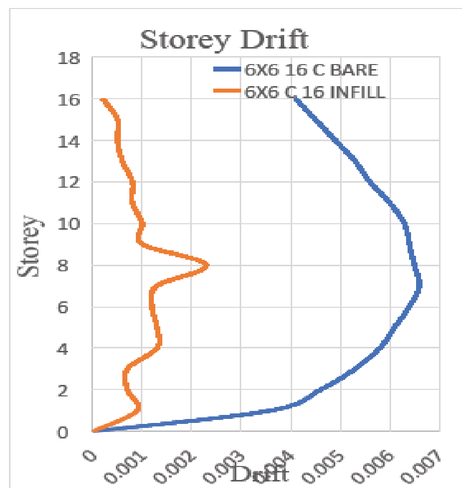

Fig.9 Storey Drift 6X6 16 Storey C Shaped with and without infill

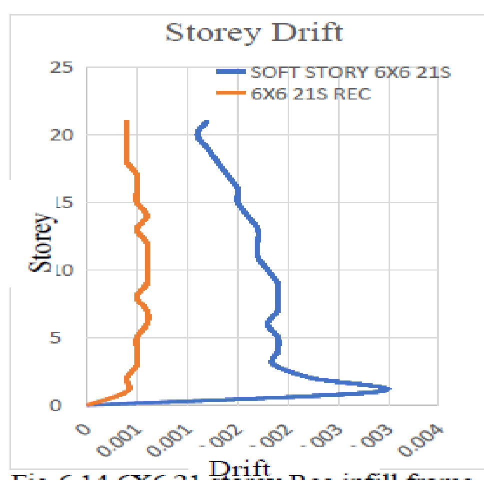

Fig.10 6X6 21 storey Rectangular infill frame without and with soft storey.

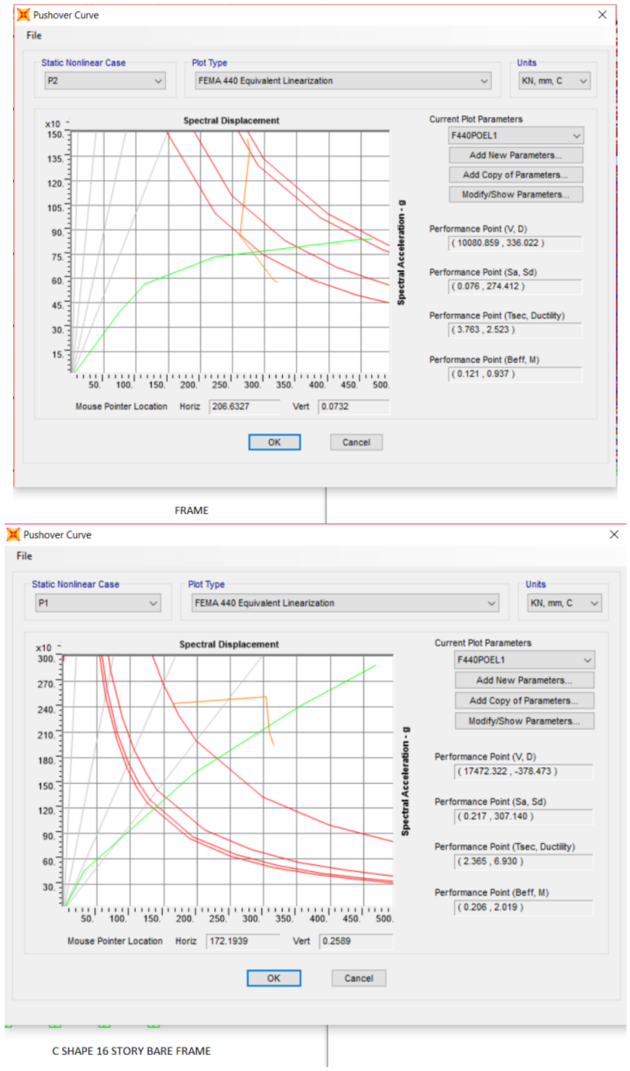

Fig.11&12 Performance point for C Shaped 16 Story Bare Frame

V. CONCLUSIONS

- Due to the inclusion of infill wall the time period of the structure decreases by 188%, 245% & 325% for G+21, G+16 & G+11 building respectively.
- With change in the number of bays in one and two directions the time period of structure with infill when compared to that building without infill frame of 6X6 bay are 3.3% & 4.3% for G+21 rectangular shaped building, 4.7% & 10.8% for G+16 C shaped building and 0.1% & 4.3% for G+11 L shaped building..
- Base shear of the G+21 rectangular infill frame building increases by 42% & 81% for 8X6 & 8X8 bay when compared to that of 6X6 bay. For G+16 C shaped building it increases by 55% & 105% for 8X6 & 8X8 bay. And for G+11 L shaped building it increase observed is 136 % and 199% for 8X6 & 8X8 respectively.
- Roof displacement for soft story building increases when compared to building with infill by 25.5%, 62.6% & 39.5% for G+21 rectangular, G+16 C shaped & G+11 L shaped building.
- Story drift for infill frame is less when compared to bare frame building and for soft story building the drift is maximum at the level of soft story. Maximum story drifts were observed at the lower stories for all the building including all infill frame buildings.
- Hinges were formed mostly throughout the structure for rectangular and C shaped building but for L shaped building hinges were largely formed at the junction i.e. at the re-entrant corner. But hinges were mostly in the immediate occupancy range.
- On comparison of all the configurations of buildings L shaped building behaviour was observed to be peculiar with sudden change in the values of base shear and time period and even with the hinge formation occurring mostly at the re-entrant corner.

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