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Seismic Performance of Brick Infill in RCC Structure

Ms. Vaishnavi Battul, Mr. Rohit M. Shinde, Mr. Shivkumar Hallale, Ms. Tejashree Gulve
Dr. D. Y. Patil Institute of Engineering, Management and Research, Akurdi, Pune

ABSTRACT

Most common type of structures used in multi-storey construction a masonry infills which are considered as non-structural elements. In this paper an attempt has been made to highlight the effect of infill in earthquake resistant buildings. Two different type of structures, namely square, rectangular are considered with 25% openings and with full infill. Pushover analyses are carried out on bare frame, strut frame, strut frame with 25% central openings. From the analysis, it is found that the frame with infill have more initial stiffness and less drift in elastic state than bare frame. However in the plastic state, the base shear of the infill frame structure significantly reduces compared to bare frame. Infill is significantly effective in low rise building with compare to the high rise building.

KEYWORDS: infill, bare, pushover, regular

INTRODUCTION

The typical multi-storey construction in India comprises reinforced concrete (RC) frames with brick masonry infill. In reinforced concrete frame building, masonry walls are generally used in as infill's and specified by architects as partitions. Infill walls protect the buildings from the environment hazards and create separation insides. From the last few decades, the civil engineering researcher has been involved in the investigation about the interaction between infill masonry walls and RC frames in the seismic structural behaviour of the RC buildings. Unreinforced masonry infill wall panels may not contribute towards resisting gravity loads, but contribute significantly, in terms of enhanced stiffness and strength under earthquake (or wind) induced lateral loading. However, in practice, the infill stiffness is commonly ignored in frame analysis, resulting in an under-estimation of stiffness and natural frequency. These variations of rigidity and strength are dependent on the mechanical properties of the material used for the infill and also on the interaction existing between this infill and the frame. Several methods have been proposed in the literature for modelling masonry infill, such as, equivalent diagonal strut method, equivalent frame method, finite element method with masonry wall discretized into several elements, etc. The geometrical distribution within the building and the local interaction among the panel and the surrounding primary RC elements. An infill frame is defined as a dual system, which consists of bricks or concrete blocks filling the inter-planar voids between lower and upper beam and space between side columns of reinforced or steel frame. Despite the fact that infill enhances both strength and stiffness of the moment resisting frames; their role is ignored in the design due to insufficient knowledge of the composite behaviour of infill and frames. It is credible, that a major portion of the lateral load is shared by the infill. The effect of the infill in regular and irregular buildings may vary, So It is important to study the implications of the common practice of ignoring the infill stiffness with regard to performance under seismic loading.

BUILDING DATA AND GEOMETRY

In this a four- storey building model with different aspect ratios of lengths buildings has taken into consideration. The building is analyzed and is subjected to pushover analysis for all the buildings with infill and openings in the infill. The structural components are designed for various load and its combination, as per IS: 456(2000), IS 875 and IS: 1893(2016). In order to carry out analysis " SAP2000" software has been used. The structures are designed to resist specified static lateral force related to the properties of structures and zone seismicity. Based on location of building the zone factor, seismic coefficient values are taken. Here considered 2 buildings those are

1) Square building (15m x 15m)

2) Rectangular building (15m x 30m)

Table 1: Structural Data Of The Building (Square Building (15m X 15m))

Type of Structure	Ordinary moment resisting frame
Shape of the building	square
Type of building	Residential building
Total area of building	15x15=225m^2
Number of floors	G+3
Total height of the building	12.8m
Floor to floor height	3.2m
Grade of concrete	M25
Steel grade	Fe415
External brick wall thickness	230mm
Internal brick wall thickness	115mm
Size of column	350X400mm
Size of beam	300X300mm
Live load on roof and floors	1.5 kN/m2 and 4 kN/m2
Superimposed dead load on roof and floors	10 kN/m2 and 12 kN/m2
Density of concrete	25KN/m3
Density of masonry wall(light brick wall)	20KN/m3
Response reduction factor	5
Importance factor	1
Site located in Seismic zone 3	Z- 0.16

For the other case all properties are same except the plan dimensions.

- Rectangular building dimensions = 15 m x 30 m

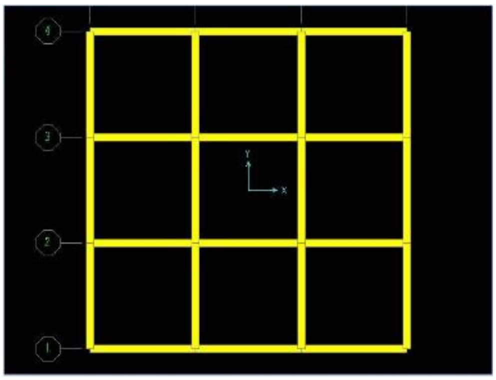
In buildings the infill members will not take any moments , these will act as truss members which will take only axial forces. So whenever considering the effect of infill in a building , the infill will be design as a strut member.

Table 2: Strut Design Summary

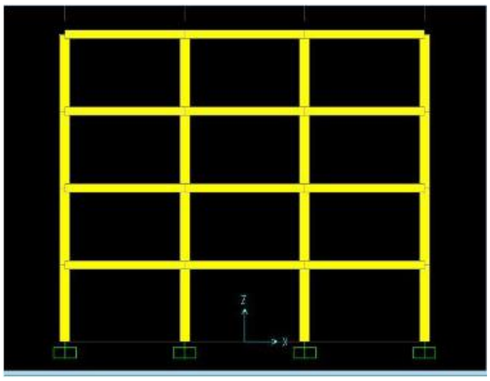
Infill	Width of the strut (m)
100%	1.81
With 25% openings	0.7

MODELLING

The modelling of the two buildings was done in SAP2000 software, and pushover analysis has been performed on them. The plan and elevation of every building as shown below

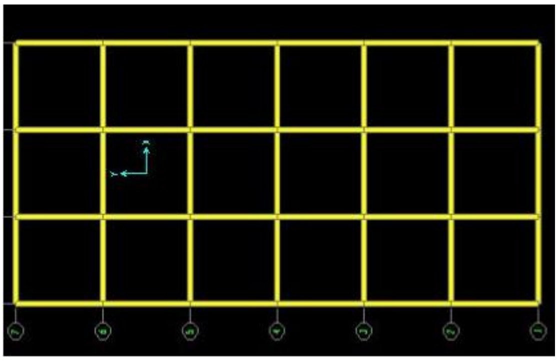


a. Plan

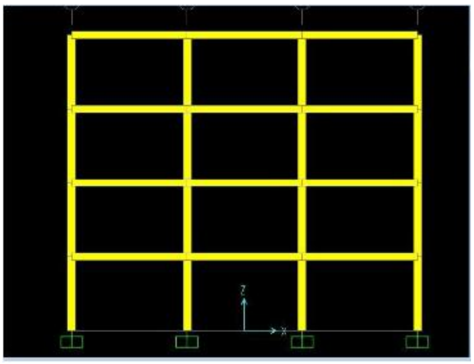


b. Elevation

Fig. 1: Square Building



a. Plan



b. Elevation

Fig.2: Rectangular Building

RESULTS AND DISCUSSION:

All the two building models with different infill cases are analysed for nonlinear static behaviour using SAP2000 (v14). The results are obtained from the pushover analysis. The results presented here are focussed on the effect of infill in each building. The comparison of the each building has been done by comparing pushover curve, performance point and hinge formation. Based upon these parameters found the effect of infill in these buildings.

Square Building:

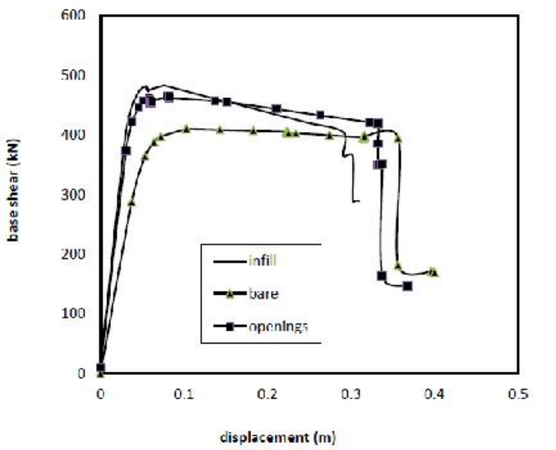


Fig. 3: Comparative Pushover Graph Between The Square Building With Different Infill Cases

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It is observe that for the pushover curves comparison of square building frame with bare frame, with infill and with 25% of openings in infill. From the comparison it is showing that infill giving more initial stiffness to the frame. But after the elastic stage because of the infill effect the mechanism of the beams and columns getting affected and the base shear bearing capacity decreasing.

Performance Points:

Table 3: Performance Points Of The Square Building With Different Infill Cases

case	Base shear (kN)	Displacement (mm)
Bare frame	402.55	85
With 25% openings in infill	463.61	76
With full infill	485.7	69

Hinge Formation:

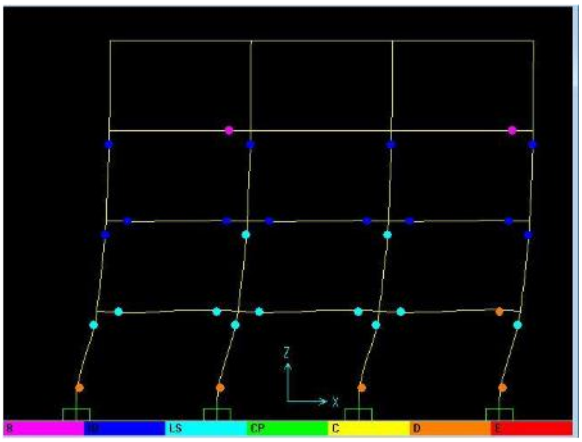

Fig. 4 : Hinge Formation For Bare Frame

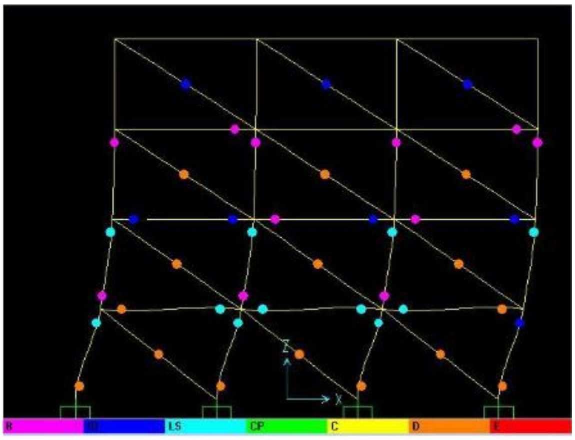

Fig. 5 Hinge Formation For Frame With 25% Of Openings In Infill

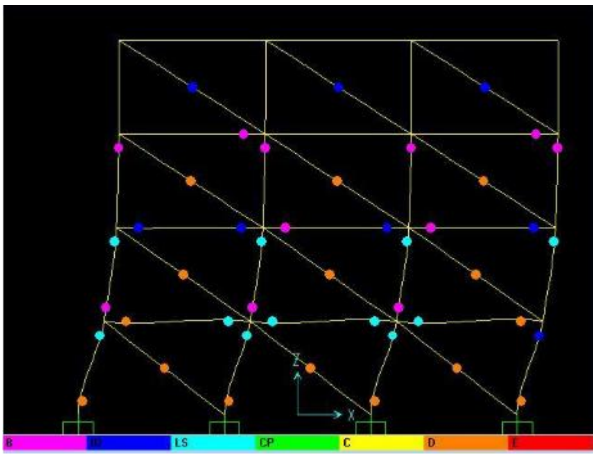

Fig. 6 Hinge Formation For Frame With Full Infill

From the above figures observed the hinges formation in each case, in the bare frame the hinge formation is less with compare to the other cases. It is because of the infill which is giving higher initial stiffness in elastic state. However after going to the plastic state because of these infill the load carrying mechanism of the frames is getting affected and forming the hinges**.**

Rectangular Building:

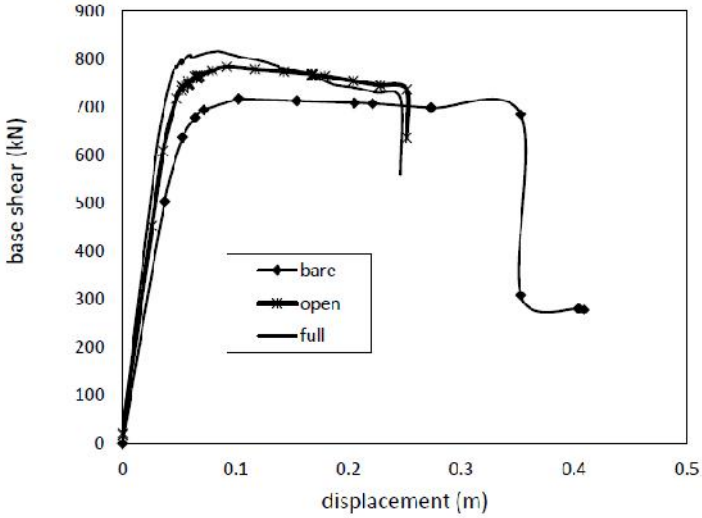

Fig. 7: Comparative Pushover Graph Between The Rectangular Building With Different Infill Cases

It is observe that for the pushover curves comparison of rectangular building frame with bare frame, with infill and with 25% of openings in infill. From the comparison it is also showing that infill giving more initial stiffness to the frame. But after the elastic stage because of the infill effect the mechanism of the beams and columns getting affected and the base shear bearing capacity decreasing. So for regular buildings like square and rectangular the performance and the effect of infill on them is same.

Performance Points

Table 4: Performance Points Of The Square Building With Different Infill Cases

Case	Base shear (kN)	Displacement (mm)
Bare frame	716.971	107
With 25% openings in infill	776.07	79.8
With full infill	811.46	72.9

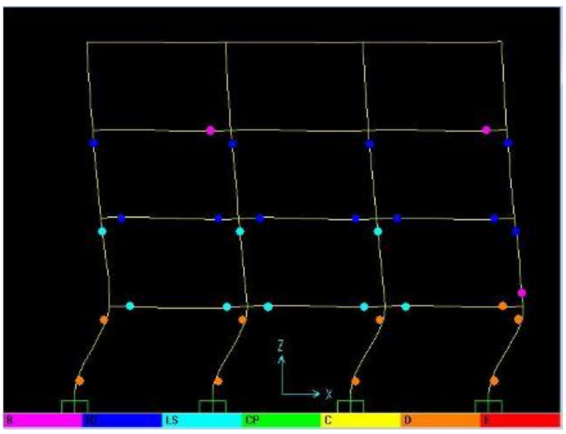

Fig. 8 : Hinge Formation For Bare Frame

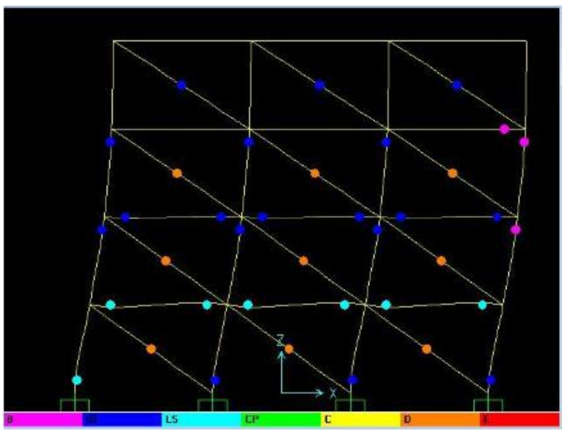

Fig. 9 Hinge Formation For Frame With 25% Of Openings In Infill

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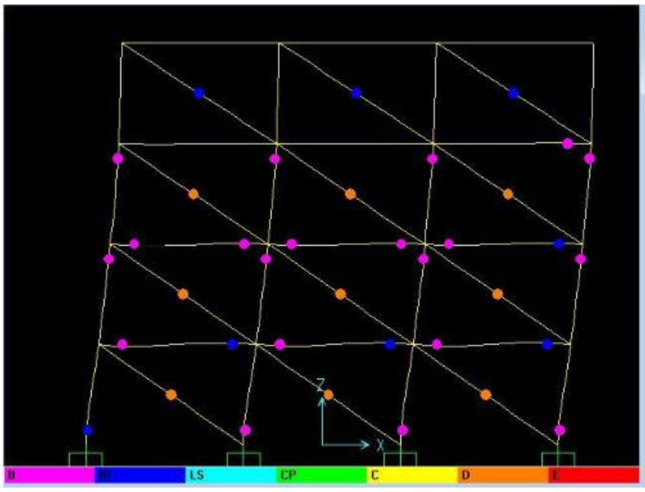

Fig. 10 Hinge Formation For Frame With Full Infill

From the above figures observed the hinges formation in each case , with compare to the square frame the effect of infill is changing here in rectangular frame. In the ground storey the bare frame is affecting heavily by hinges but with infill it was reduced.

CONCLUSION

Two different building frames were investigated with different cases of plan and infill. Analytical research on behaviours of the building frames was done by performing pushover analysis on them. From the pushover analysis of buildings with different infill cases. Following generalized conclusions are made

- In the case of regular buildings, initial stiffness of the building increases with the infill material. In the elastic state, the buildings with infill are able to bear more base shear than the buildings with bare frame.
- In the case of regular buildings, least number of hinges at the top floor is formed in the bare frame compared to the buildings with infill. However in the plastic state, the base shear of the infilled frame structure significantly reduces compared to bare frame.

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