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EFFECT OF INFILL IN EARTHQUAKE RESISTANT BUILDINGS

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Abstract: Infilled frame structures are commonly used in buildings. Masonry infilled RC frames are the most common type of structures used for multi-storey constructions in developing countries. But these infills are considering as the non-structural members. In the present study an attempt was made to highlight the effect of infill in the earthquake resistance buildings. A square, rectangular and L shaped buildings were considered with 25% openings and with full infill. Pushover analysis was carried out on bare frame, strut frame, strut frame with 25% central openings in X direction, by using computer aided software SAP2000 from which different parameters such as base shear, displacement and performance point were computed. Buildings with infill were observed to have more initial stiffness in elastic state and less drift than bare frame at the end of the analysis. In L shaped building(45m*45m*32m) the infill was placed in the direction of push up to 35m from the exterior end. The displacement observed at the exterior corner point of L shaped building using infill was found to 28% more than the displacement at interior point in bareframe.

Keywords: infill, pushover analysis, performance point , hinges , strut , openings.

I.INTRODUCTION

In reinforced concrete frame building, masonry walls are generally used in as infill's and specified by architects as partitions in such a way that they do not contribute to the vertical gravity load-bearing capacity of the structure. Infill walls protect the inside of the buildings from the environment hazards and create separation insides. In addition to this infill have a considerable strength and stiffness and they have significant effect on the seismic response of the structural systems RC framed buildings are generally designed without considering the structural action of masonry infill walls present. These walls are widely used as partitions and considered as non-structural elements. But they affect both the structural and non-structural performance of the RC buildings during earthquakes**.**

II. LITERATUREREVIEW

Agrawal, *et al*.(2013)Attempted to highlight the performance of masonry infill reinforced concrete (RC) frames including open first storey with and without opening. Found if the effect of infill wall is considered then the deflection has reduced drastically. Infill was modelled using the equivalent strut approach.(Davis, *et al.*2004) Static analysis, response spectrum analysis and non-linear pushover analysis were performed. Concluded that the lateral load resisting mechanism of the masonry infill frame essentially different from the bare frame. Dorji and Thambiratnam (2009) studied Seismic response of in-filled frame structures. the influence of infill strength, openings and soft storey phenomenon are investigated. Results in terms of tip deflection, fundamental period, inter-storey drift ratio and stresses are presented and they will be useful in the seismic design of in-filled frame structures. Irfanullah, et *al.* (2013) investigated the behaviour of RC frames with various arrangement of infill when subjected to earthquake loading. concluded that the lateral stiffness in different models under consideration are increasing with the addition of infill compared to situation when infill is notprovided.

III. MODELLING

SAP2000 has a fixed form inputs, like material properties, equilibrium and compatibility equation, energy and work principals boundary conditions, analysis methods and design principals. Also, the information about structure and site condition, soil condition, wind and seismicity condition are available.
Modeling done by SAP2000 software with the collected details with different cases of the infill.

DETAILS OF THE BUILDINGS

Shape = square
Storey=G
+3 3*3bay Storey height = 3.2m

Beam = 300mm x 300 mm
Column = 400mm x 350 mm
Bay width in X direction = 5 m
Bay width in Y direction = 5 m
Live load = 3kN/m^2
Dead load = 10 kN/m^2
typicalfloor
Grade of concrete = M25
Steel = Fe 415
Density of concrete = 25 kN/m^3
Density of brick wall = 20 kN/m^3
Modulus of elasticity of concrete, E_c = 27.386 x 10^6kN/m^2
Modulus of elasticity masonry, E_m = 1.294 x 10^6kN/m^2
Poisson's ratio of concrete = 0.2 Poisson's ratio of brick wall = 0.22

- For the other cases every property is same other than the plandimensions.
- Rectangular building dimensions = 15 m * 30m
- For L shaped building dimensions = 45 m*45 m,T_f=10m,T_w=**10m.**
- Calculation of seismic loads for each building as per IS 1893 partI-zone3
- Calculation of the width of the infill in both the cases when full infill consideringand25% openings are considering.
- By doing pushover analysis on all the buildings then by comparing the pushover curves and performance points, found the effective case in them.

3.1 CALCULATION OF STRUT WIDTH

There are many formulae were proposed for the calculation of the width of the strut

The simplest equivalent strut model includes a single pin-jointed strut. Holmes who replaced the infill by an equivalent pin-jointed diagonal strut made of the same material and having the same thickness as the infill panel suggest a width defined by,

Width of the strut =1/3(diagonal length of strut)=1.8m

This was proposed by *Sixth Revision of IS 1893 (Part 1)*

3.2 CALCULATION OF STRUT WIDTH WHEN OPENINGS ARE THERE IN INFILL

Here considered 25% of openings are there in the infill

As per Sixth Revision of IS 1893 (Part 1)

For URM infill walls with openings, width $\boldsymbol{w_{do}}$ *of* equivalent diagonal strut shall be taken as:

$$W_{do} = \alpha\, W_{ds}$$

Where

W_{do} = width of diagonal strut with openings

W_{ds} = width of diagonal strut

α= Reduction factor, which accounts for openings in infill. For walls with a central opening,

α shall be taken as

$$\alpha = \begin{cases} 1 & \text{if } A_r \le 0.05 \\ 1 - 2.5A_r & \text{if } 0.05 < A_r < 0.40 \\ 0 & \text{if } A_r \ge 0.40 \end{cases}$$

Where

A_r = Opening Area Ratio
= Area of Opening / Total Area of URM Infill Wall Panel

Here, strut width = 0.7m

3) Thickness of the equivalent diagonal strut shall be taken as thickness of original URM infill wall

IV. DISCUSSION OFRESULTS

SQUARE BUILDING (15m*15m*12.8m)

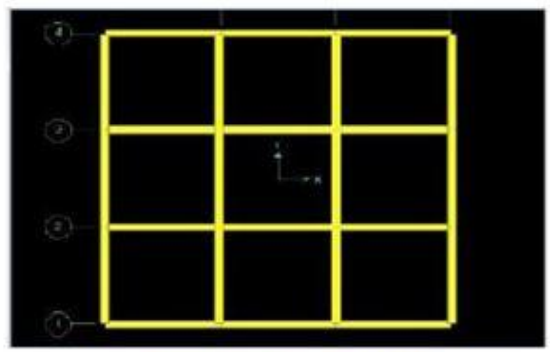

Fig 1: Square frame plan

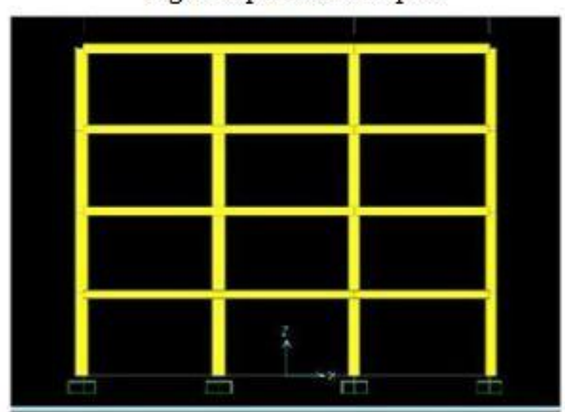

Fig 2: Square frame elevation

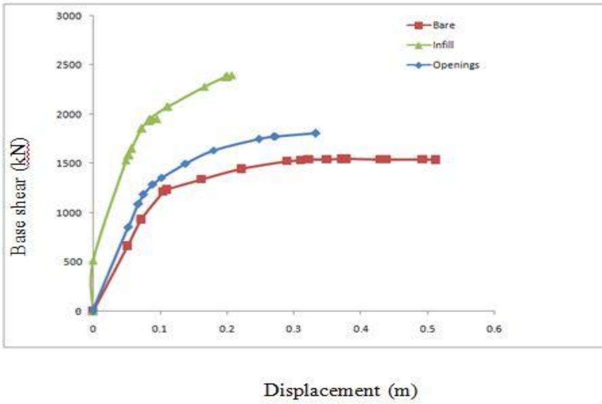

Fig 3: comparative pushover graph between the square building with different infill cases

Table 1 performance points of the square building with different cases

Case	Base shear (kN)	Displacement (m)
Bare frame	706.38	0.055
With 25% openings in infill	834.15	0.051
With full infill	901.42	0.029

HINGES

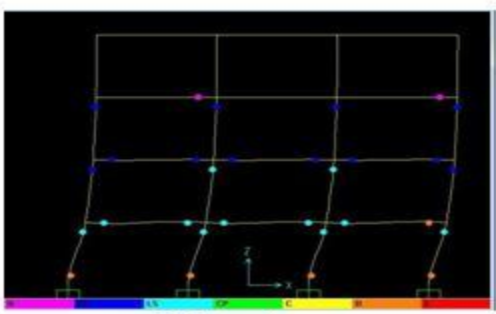

Fig.4 bare frame

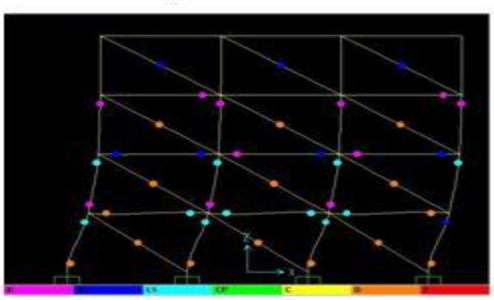

Fig.5 with 25% openings in infill

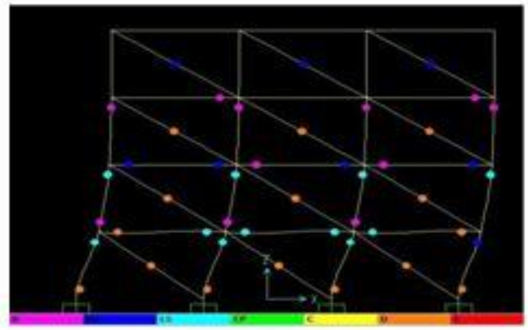

Fig.6 With full infill

From the above figures (4, 5, 6) 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 (15m * 30m * 12.8m)

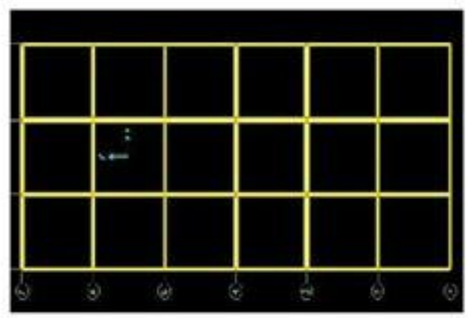

Fig. 7 Rectangular frame plan

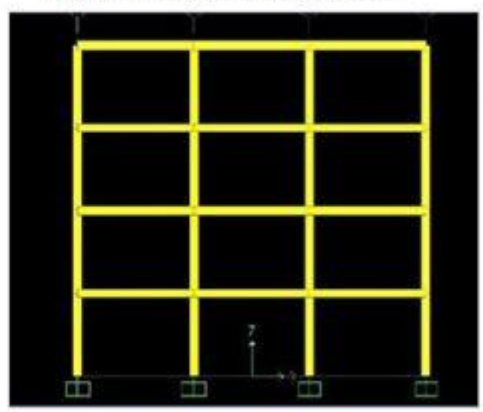

Fig. 8 Rectangular frame elevation

1

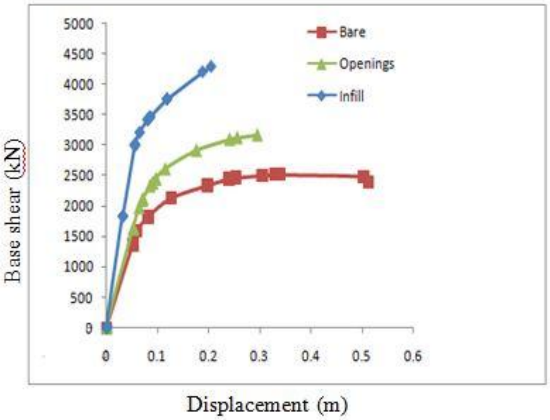

Fig 9*:* comparative pushover graph between the rectangular building with different infill cases

Table 2 performance points of the rectangular building with different cases

Case	Base shear (kN)	Displacement (m)
Bare frame	1362.82	0.055
With 25% openings in infill	1625.68	0.052
With full infill	1836.04	0.031

HINGES

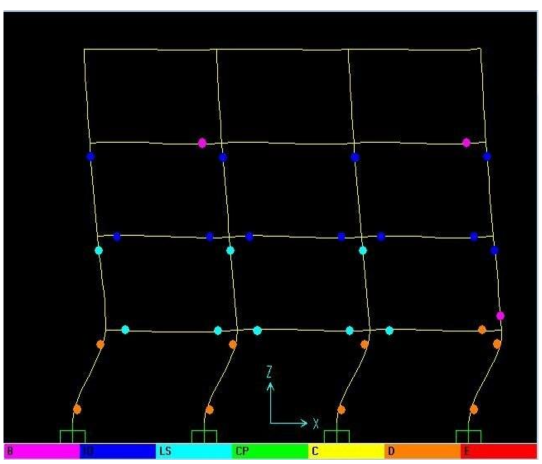

Fig.10 bare frame

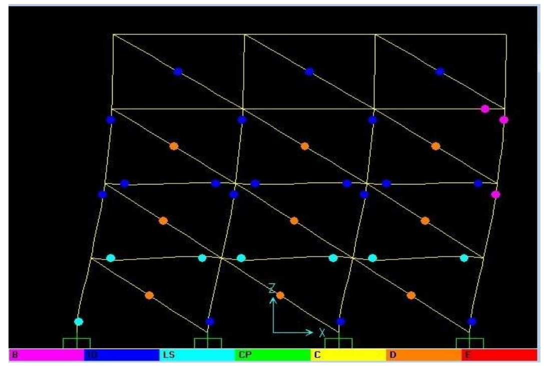

Fig.11 with 25% openings in infill

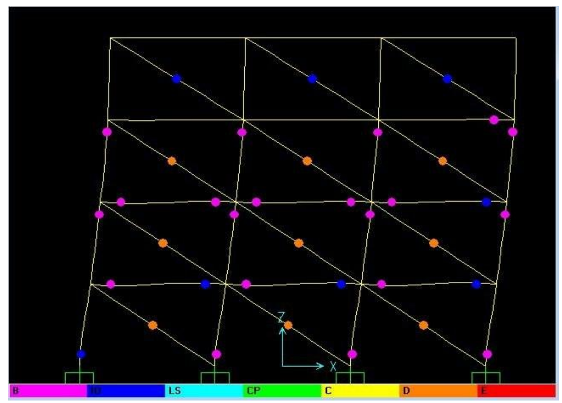

Fig.12 With full infill

From the above figures (10, 11, 12) 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.

In the ground storey the bare frame is affecting heavily by hinges but with infill it was reduced.

L SHAPED BUILDING (PLAN IRREGULARITY)

DIMENSIONS (45m*45m*12.8m)

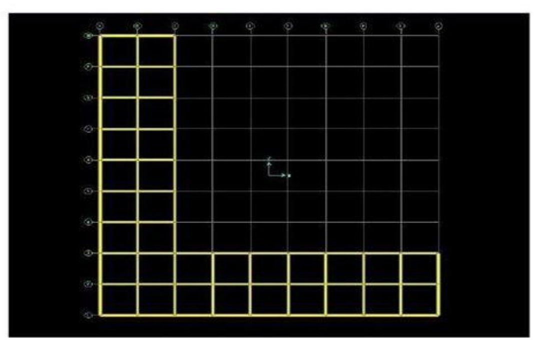

Fig.13 L shape plan

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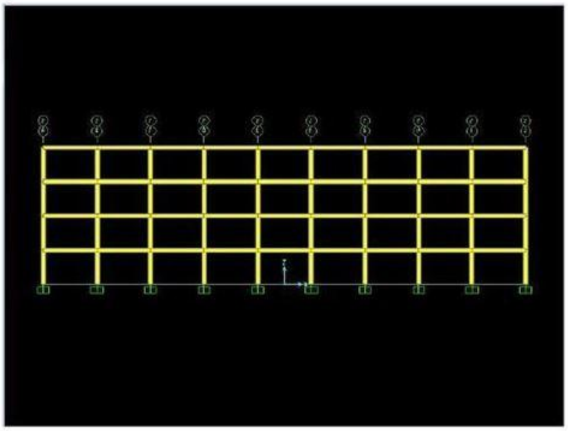


Fig.14 L shape elevation

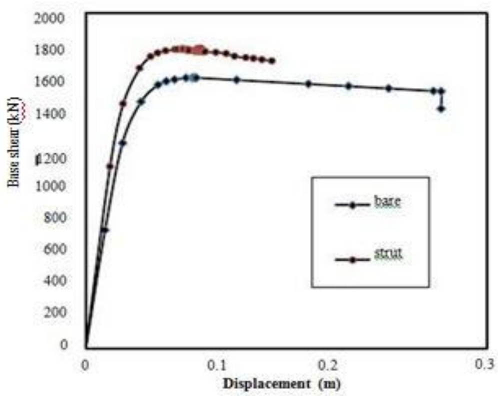


Fig.15 Comparative pushover graph at point 115 (Central interior joint)

Table 3 Performance points of the L shape building at joint 115 with different cases

case	Base shear (kN)	Displacement (m)
Bare frame	1599.81	0.066
With infill in shorter side	1757	0.062

From the above fig. 15 and table.3 showing that at interior joint the base shear bearing capacity is increasing but the displacement is reducing very less because of that joint have good stiffness before itself.

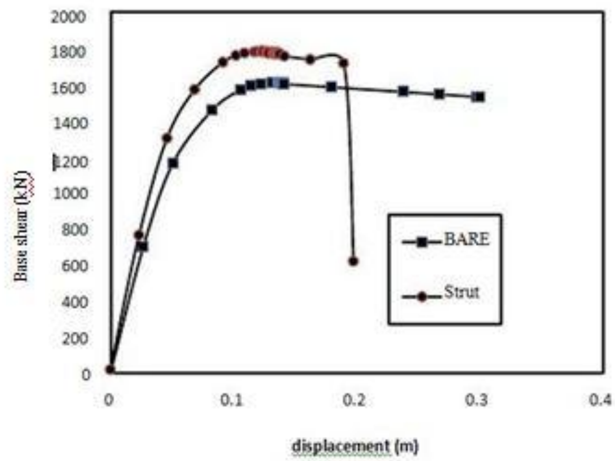
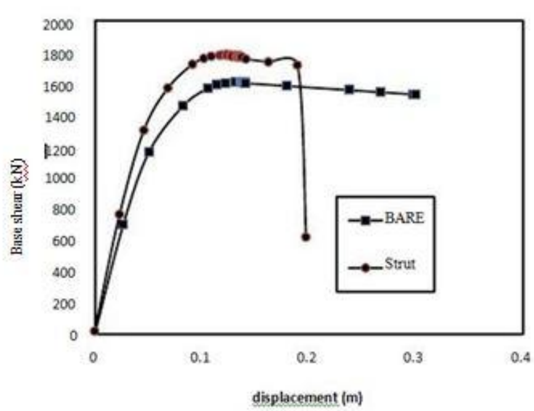


Fig. 16 comparative pushover graph at point 150 (external joint)

Table. 4 Performance points of the L shape building at joint 150 with different cases

case	Base shear (kN)	Displacement (m)
Bare frame	1599.81	0.122
With infill in shorter side	1720.8	0.091



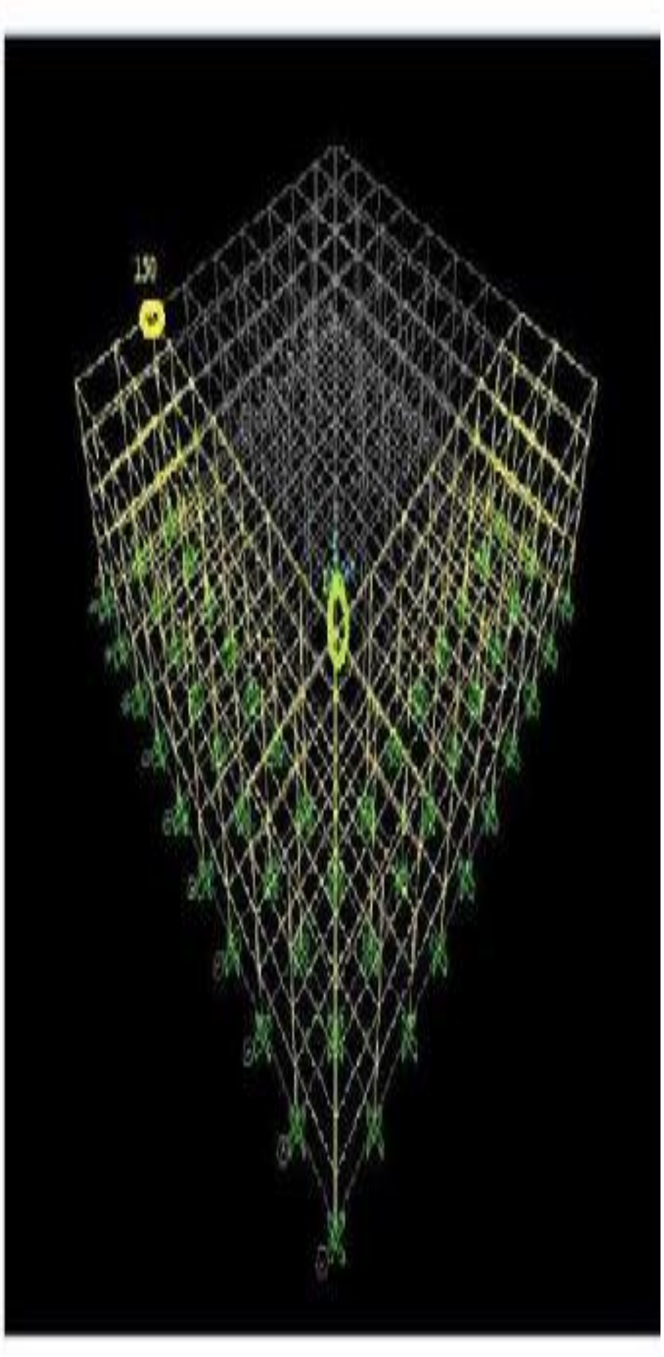


Fig 17 Location of central interior and exterior joints in the building

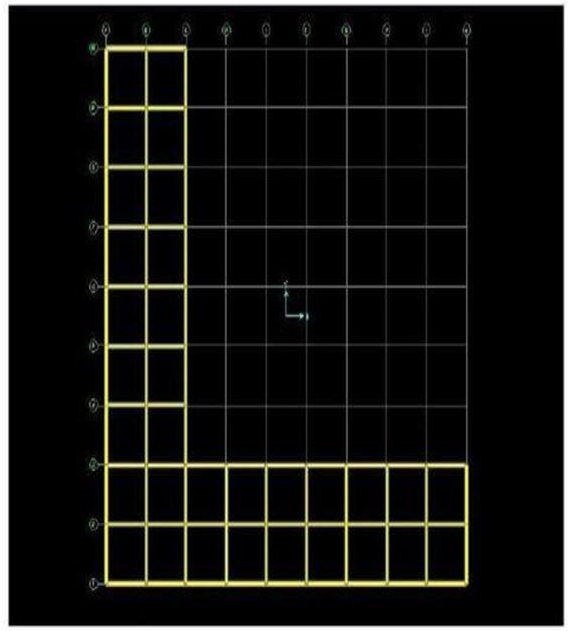


Fig 18 L shape plan

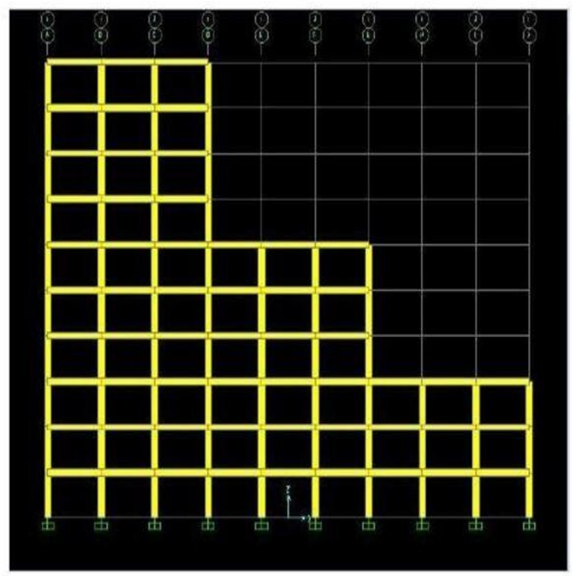


Fig 19 L shape elevation

L SHAPED IRREGULAR BUILDING
(VERTICAL IRREGULARITY)

DIMENSIONS (45m*45m*32m)

L SHAPED IRREGULAR BUILDING

(VERTICAL IRREGULARITY)

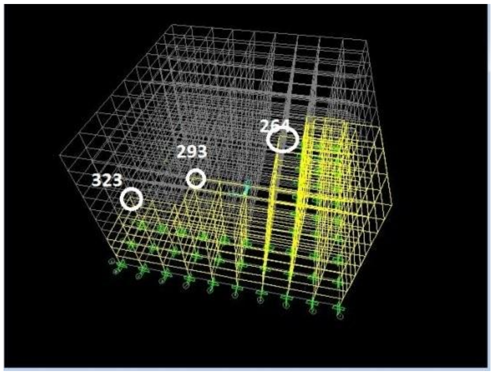


Fig. 11 Location of exterior joints at different heights in the building

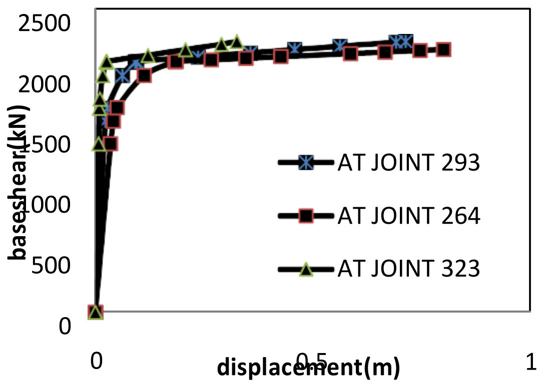


Fig. 12 comparative pushover graph at 3 joints of the frame

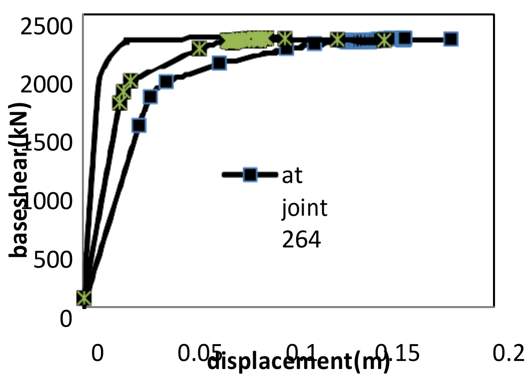


Fig. 13 comparative pushover graph at 3 joints of the frame with infill

Table. 5 Performance points of the bare frame at 3 exteriorjoints

joint	Base shear (kN)	Displacement (m)
264	1715.569	0.058
293	1714.12	0.032
323	1725.12	0.01

Table. 6 Performance points of the bare frame at 3 exterior joints

joint	Base shear (kN)	Displacement (m)
264	1968.55	0.05
293	1980.83	0.02
323	1997.53	0.006

HINGES

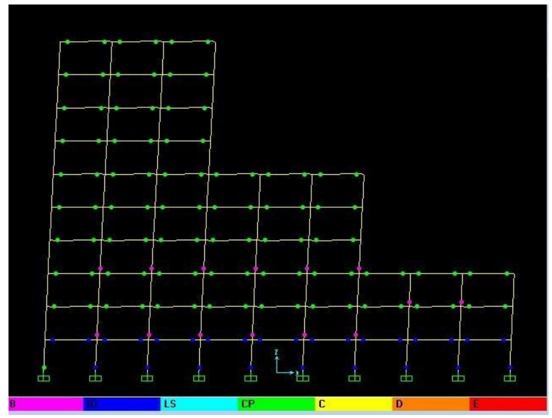


Fig. 14 hinge formation for bare frame

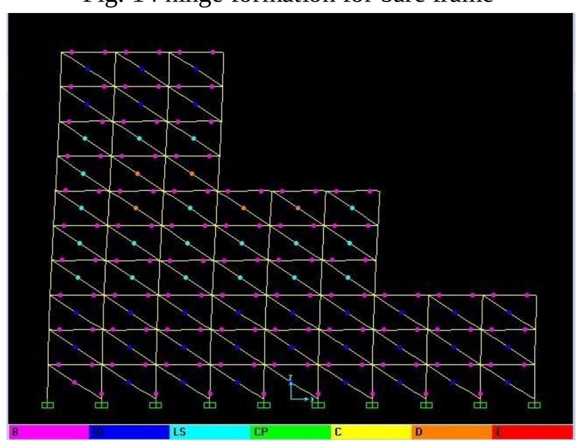


Fig. 15 hinge formation for infill frame

V. CONCLUSION

Four different building frames were investigated with different cases of plan, elevation and infill. Analytical research on behaviors of the building frames was done by performing pushover analysis onthem.

From the pushover analysis of buildings with different shapes 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 building 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.
- For irregular L shaped building, difference in displacement is observed between the internal joint and external joint. The displacement observed at the exterior corner joint of L shaped building with infill was found to be 28% higher than the interior joint in the bare framestructure.
- For L shaped 9 storey vertical irregular building , it is observed that the infill offer good resistance to the structure duringearthquake loads. The effect of infill is significantly higher in low rise buildings than the high risebuildings.

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