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Comparison of Response of The Structures Against Seismic Force

D. Vinod, P. Kodanda Ramarao

Abstract: ***The study of this paper is to assess the seismic vulnerability and response of regular and irregular shaped multi-storey building of same floor area 825 square meters. The regular building of rectangle shape is considered and irregular building of L shape structure is considered for the analysis. 11 storeyed regular (rectangular) shaped and irregular (L-shape) shaped buildings have been modeled using computer program ETABS 2016. Firstly the both rectangle and L shape buildings are analyzed with bare frame without any infill walls, later the rectangle and L shape buildings are analyzed by providing external infill walls around the plan of 10m×15m respectively. The analysis is done by Response spectrum method according to IS 1893(part 1): 2002. Comparative study on the maximum storey displacement, maximum storey drift and time periods of L and rectangular shaped building due to dynamic response spectrum has been explored. . From the results it is inferred that building with severe irregularity produces more deformation than regular building.***

Keywords: ***Irregularities, Response Spectrum Method, Infill Walls, ETABS.***

I. INTRODUCTION

Earthquakes are one of the most devastating natural hazards that cause great loss of life and livelihood. An earthquake is a spasm of ground shaking caused by a sudden release of energy in earth's lithosphere. This energy arises mainly from stresses built up during tectonic processes, which consists of interaction between the crust and the interior of the earth. In actual practice, the structures will usually be built in having one of the irregularities i.e. stiffness, diaphragm, mass, re-entrant corner, and torsion irregularity. In the multistory buildings damages due to earthquake are usually at the weak points. This weakness may occur due to strength, variation in stiffness, plan irregularities etc. So if a structure possess adequate strength, stiffness, ductility and simple configuration it can give better performance during earthquake. In this paper, L and rectangular shaped buildings are analyzed with bare frame and by adding infill walls. Framed structure of L and rectangular shape gives vulnerable results, later by providing stiffness to the both structures it gives better results. This is due to adding infill walls in the second case. Therefore these types of structures with infill walls should be considered under earthquake so that they can sustain moderate to strong earthquakes. Structure with infill walls gives good performance when compared to bare frame. Rectangular shape building gives best performance with infill walls when compared to L shaped building.

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II. MATERIAL PROPERTIES

Unit weight of concrete is 25 kN/m^3, unit weight of brick masonry is 19 kN/m^3, compressive strength of brick masonry is 10 N/mm^2, young's modulus of brick masonry is 2650 N/mm^2, shear modulus of brick masonry is 1104.17 N/mm^2, Poisson's ratio of brick masonry is 0.2, grade of concrete is M30, Grade of steel is Fe415, slab thickness is 0.15m, exterior masonry wall thickness is 0.23m.

III. LOAD CONSIDERATIONS

Loads considered on each floor as per IS 875: 1987

Dead load with floor finishing is 4.75 kN/m^2, live load is 3 kN/m^2 and masonry load of exterior walls is 11.15 kN/m (approx....).

Load on terrace floor as per IS 875: 1987

Dead load with terrace finishing is 5.25 kN/m^2, live load is 1.5 kN/m^2 and parapet wall load is 4.37kN/m

Seismic load consideration

The seismic loads are given for following seismic parameters as per IS: 1893: 2002.

Seismic Zone is Zone III (Moderate), Zone Factor is 0.16, and Type of soil is Type I (Hard Soil), Importance factor is 1, Response reduction factor is 3, and Damping is 5%.

IV. PLAN DETAILS

Total area of each shape of the building (i.e., L shape and rectangular shape) are equal to 825.m^2, Beam Dimensions including plinth beam is 0.23m×0.45m, Column Dimensions from 1-4 storey 0.3m×0.6m, Column Dimensions from 5-8 storey 0.3m×0.45m, Column Dimensions from 9-11 storey 0.3m×0.3m, Openings dimensions for all windows 1m×1.2m, Openings dimensions for all doors 1m×2.1m, Support conditions are Fixed.

V. LOAD COMBINATIONS

The load combinations with partial safety factor satisfying the Indian standard code provision i.e. IS 1893(Part 1):2002, are as follows:

1. 1.5[DL + LL], 2. 1.2[DL + LL+ EQ X], 3. 1.2[DL + LL+ EQ Y], 4. 1.2[DL + LL- EQ X], 5.1.2[DL + LL- EQ Y], 6. 1.5[DL + EQ X], 7. 1.5[DL + EQ Y], 8. 1.5[DL - EQ X], 9.1.5[DL - EQ Y], 10. 0.9[DL] + 1.5[EQ X], 11. 0.9[DL] +

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1.5[EQ Y], 12. 0.9[DL] - 1.5[EQ X], 13. 0.9[DL] -1.5[EQ Y].

The following load combinations are all considered for the analysis of high rise building, total 13 load combinations are considered.

VI. RESPONSE SPECTRUM METHOD

A response spectrum is simply a plot of the peak or steady-state response (displacement, velocity or acceleration) of a series of oscillators of varying natural frequency that are forced into motion by the same base vibration or shock. The resulting plot can then be used to pick off the response of any linear system, given its natural frequency of oscillation. One such use is in assessing the peak response of buildings to earthquakes.

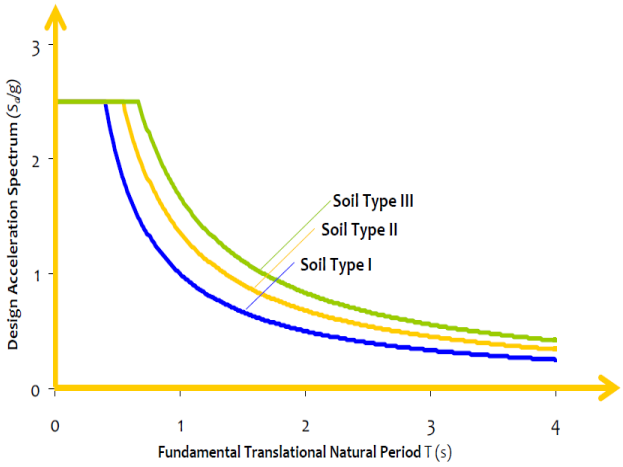

Fig.1 Response Spectra for Rock and Soil Sites for 5 Percent Damping

VII. PLAN OF BUILDINGS

The plan of the two buildings are same in floor area, the irregular building L shape is shown below, fig 2(a) shows the plan view and fig 2(b) shows the 3D view of L shape building.

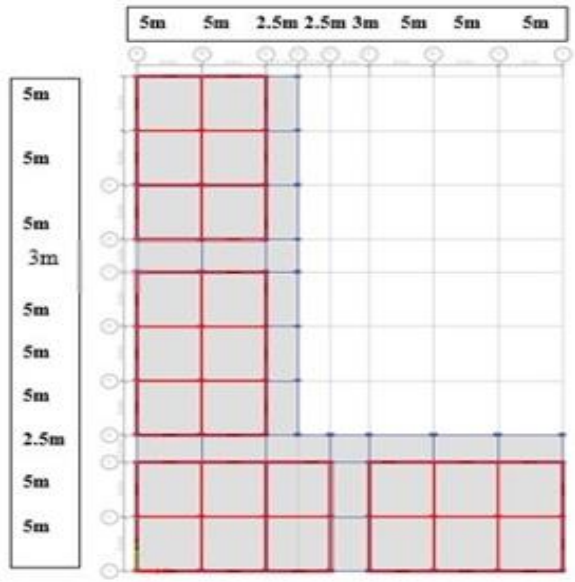

Fig 2(a) Plan View of L Shape Building with Infill Walls.

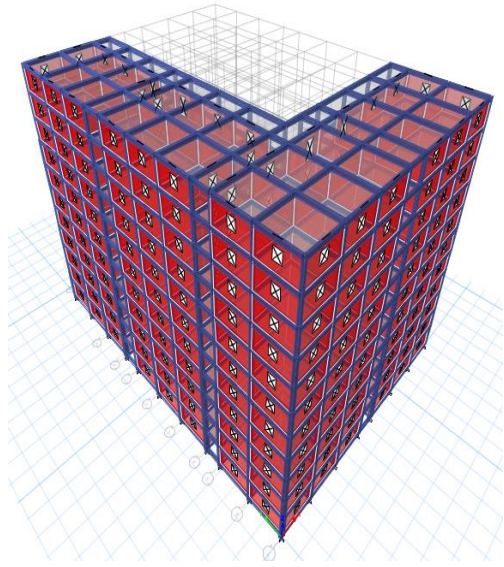

Fig 2(b) 3D View of L Shape Building with Infill Walls.

The rectangular shape building is symmetrical and the plan view is shown in fig 3(a), Fig 3(b) represents 3D view of rectangle building.

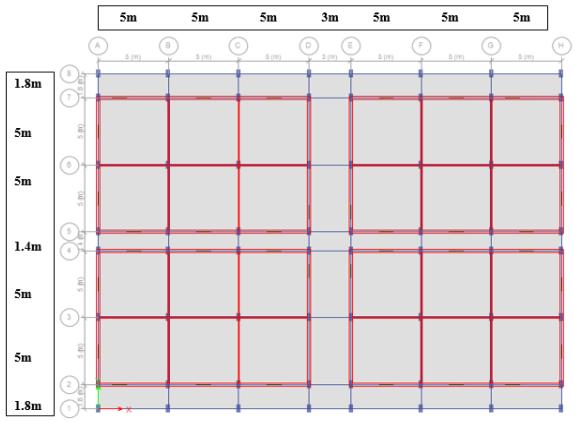

Fig.3 (a) Plan View of Rectangular Building with Infill Walls

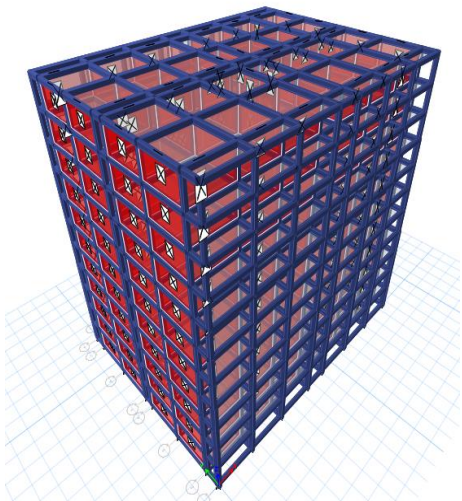

Fig 3(b) 3D View of Rectangular Building with Infill Walls

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VIII. METHODOLOGY

In this investigation the 11 storied buildings with different plans of regular and irregular configuration containing re-entrant corners are modeled and analyzed by ETABS 2016 and the results are compared with that of the regular plan building. All building plans have same floor areas and lateral strengths the storey height of 3 meters for each model. The cross sectional dimensions of beams, columns and slabs are the same in the three models. And also, the material properties, loading and seismic forces are the same in the two models. In this work, the models are constructed with contribution of infill walls. Brick masonry properties of infill walls are taken and assigned as a wall in every model.

IX. RESULTS AND DISCUSSION

A. Comparison of Time Periods

The Time periods for two buildings gets decrease in case of infill wall provided. The difference can be seen in the bar chart. Rectangular building got less time period as it is regular in shape. The maximum result can be obtained from the first three modes of time periods only. Table 1 shows the time periods and fig 4 represents the bar chart of time period.

Table I Comparison of Time Periods

S. No	Shape of the building	Time periods with bare frame (sec)	Time periods with infill walls (sec)
1	L shape	2.456	0.766
2	Rectangle	2.305	0.709

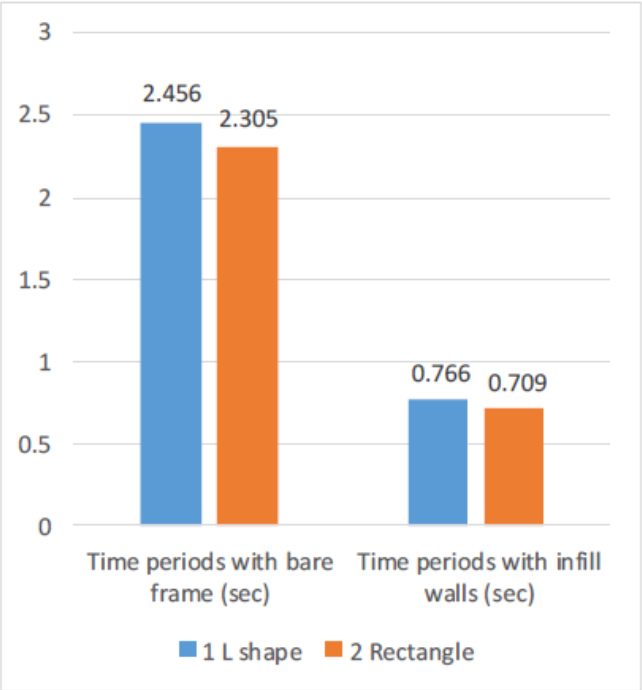

Fig.4 Comparison of Time Periods with and Without Infill Walls

B. Comparison of Natural Frequencies

Frequency is the number of cycles/second denoted as Hertz (Hz). Frequency is inversely proportional to time period. Inverse because if the frequency is high, then the time period is low. Here, the frequency of each building gets increased after adding infill walls as the time period gets decreased. Table 2 shows natural frequencies and fig 5 represents the bar chart of time period.

Table II Comparison of Natural Frequencies

S. No	Shape of the building	Frequencies with bare frame (cyc/sec)	Frequencies with infill walls (cyc/sec)
1	L shape	0.407	1.306
2	Rectangle	0.434	1.41

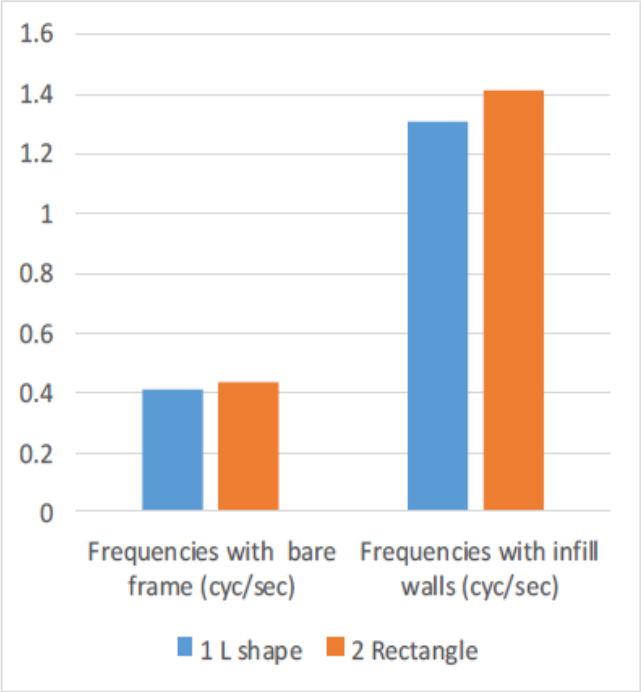

Fig.5 Comparison of Natural Frequency with and Without Infill Walls

C. Comparison of base shear

Base shear between three buildings in two cases are compared in the below bar chart. The base shear of the building gets increased in the second case after adding infill walls. Table 3 indicates maximum base shear and fig 6 represents bar chart of base shear.

Table III Comparison of Maximum Base Shear

S. No	Shape of the building	Base shear with bare frame in kN	Base shear with infill walls in kN
1	L shape	1400.66	5885.76
2	Rectangle	1526.53	6701

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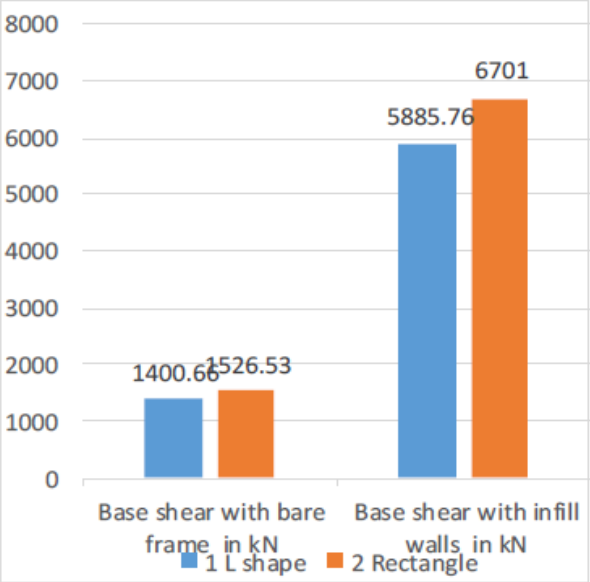

Fig 6 Base Shear With and Without Infill Walls

D. Comparison of Maximum Storey Displacements

The displacement of the building gets reduced by increasing stiffness of the building by providing infill walls. The maximum displacement occurred in the combination of loads are presented in the table 4. The maximum displacement occurs at top storey 11. The difference between the displacement before and after adding infill walls can be observed from the below fig 7 and fig 8.

Table IV Comparison of Maximum Storey Displacements

S. No	Shape of the building	Storey displacements with bare frame	Storey displacements with infill walls
1	L shape	99.28 mm	37.38 mm
2	Rectangle	87.58 mm	28.41 mm

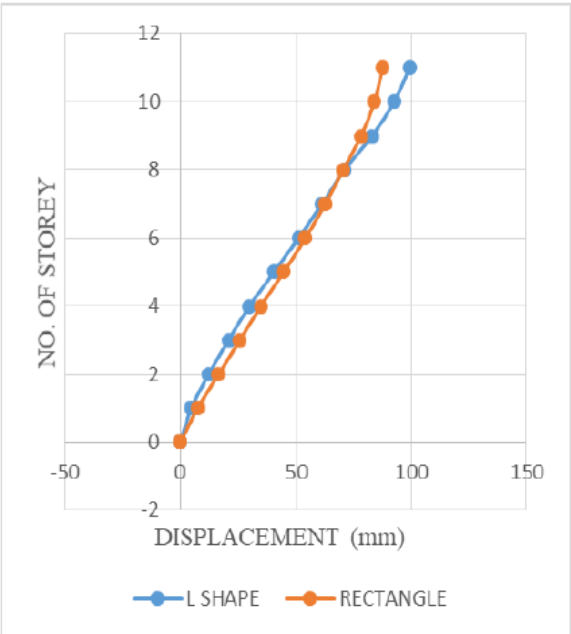

Fig. 7 Maximum Storey Displacement without Infill Walls

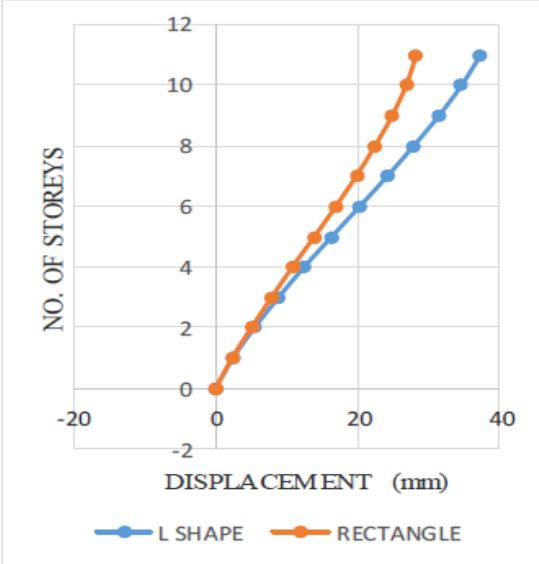

Fig. 8 Maximum Storey Displacement with Infill Walls

E. Comparison of Maximum Storey Drift

Drift is considered as the difference between the displacements of two storey's.

Maximum drift shall not exceed the 0.004 times the storey height according to IS 1893 (Part 1): 2002. The obtained values satisfies the IS code.

0.004×3000 = 12mm

The values in the below table are less than 12mm.

Table 5 shows the maximum storey drift. The drift before and after adding infill walls can be observed from the below graphs, Fig 9 and Fig 10.

Table V Comparison of Maximum Storey Drift

S. No	Shape of the building	Storey drift with bare frame	Storey drift with infill walls
1	L shape	11 mm (storey 9)	3.925 mm (storey 6)
2	Rectangle	10.48 mm (storey 9)	3.091 mm (storey 5)

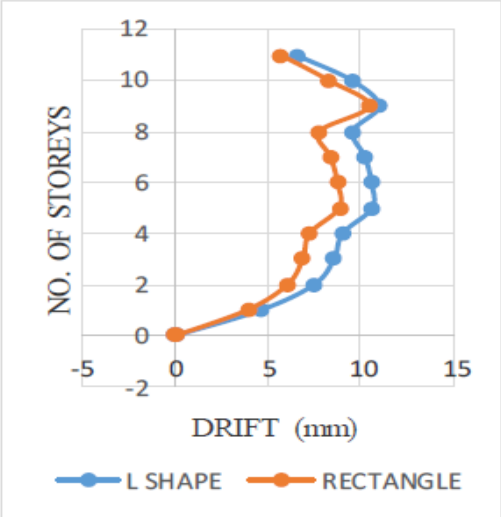

Fig. 9 Maximum Storey Drift Without Infill Walls

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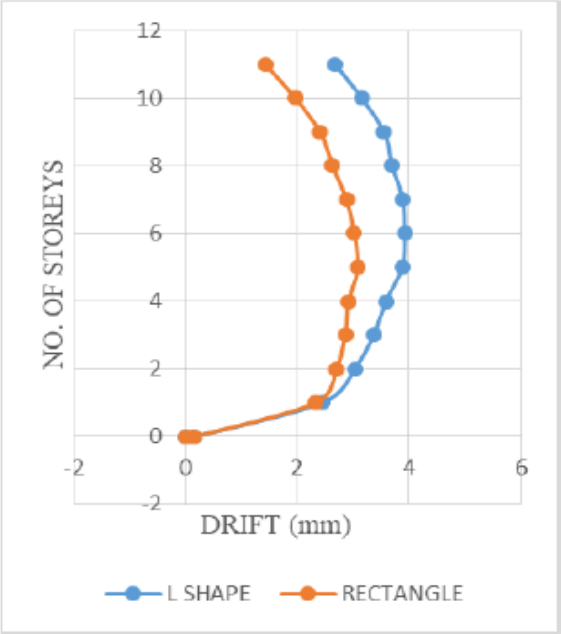

Fig. 10 Maximum Storey Drift With Infill Walls

X. CONCLUSION

1. Buildings with infill walls gives the better performance than the building without infill walls for the two shapes.
2. Displacement and Drift values get decreased when we add infill walls due to increase in stiffness of the building.
3. Base shear gets increased when we add infill walls due to increase in weight of the building.
4. Rectangular shape building gives the better performance as it is regular shape when compared to L shape building.
5. L shape building is irregular and gives poor performance.

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