Analysis of Plan Symmetric and Asymmetric Buildings Subjected to Seismic Load using Pushover Analysis

B G Nareshkumar
Professor
Department of Civil Engineering
Maharaja Institute of Technology Mysore,
Mandya, India

Punith N
Assistant Professor
Department of Civil Engineering
Maharaja Institute of Technology Mysore,
Mandya, India

Thejashwini G
UG Student
Department of Civil Engineering
Maharaja Institute of Technology Mysore,
Mandya, India

Lakshmi P B
UG Student
Department of Civil Engineering
Maharaja Institute of Technology Mysore,
Mandya, India

***Abstract*—Earthquakes are one of the most hazardous natural disasters which cause major loss in the field of construction industries Hence seismic analysis has become the most important analysis to be carried out in the design of a building. In this paper a six storey plan regular (box shape) and plan irregular (L-shape) buildings have been analyzed using Pushover analysis in ETABS (V15.2.2). The floor diaphragms considered were rigid and semi-rigid in membrane and shell and the diaphragm which yielded comparatively better results for lateral displacement and storey shear at End of Projection and at Re-Entrant corner was recommended for earthquake prone areas.**

Keywords*—Plan symmetry, Plan asymmetry, center of mass, center of rigidity, lateral displacement, storey shear, pushover analysis, ETABS-2015

I. INTRODUCTION

Now a days, the modern urban infrastructure demands uniqueness, which is often leading to irregular buildings. These irregular buildings are more often prone to earthquakes hence it is very essential to consider earthquake loads while designing these buildings. The IS 1893 (part 1) 2002 for earthquake resistant design of structures classifies the irregularities into 2 types namely:

1) Plan Irregularity
2) Vertical Irregularity

1.Plan Irregularity

Plan Irregularity refers to asymmetrical plan shapes or discontinuities in horizontal resisting elements such as cut-outs, large openings etc., resulting to torsion, diaphragm deformation and stress concentration. Plan irregularity is further classified as torsional irregularity, re-entrant corner, diaphragm discontinuity, out of plane offsets and non parallel systems.

2.Vertical Irregularity

Vertical irregularity is the vertical discontinuities in the distribution of mass, stiffness and strength.

Vertical irregularity is further divided into stiffness irregularity, mass irregularity and vertical geometric irregularity.

A. Centre of Mass

The centre of mass is a portion defined relative to an objector system of objects. It is the average position of all the parts of a system weighted according to their masses. For single rigid body having uniform density the centre of mass shall be located at its centroid.

B. Centre of Rigidity

Centre of rigidity is the point where the whole body have fully resisting rotation. Hence, it is the point where the force is applied but the body does not rotate instead translates in space.

C. Torsional Irregularity

Torsional Irregularity is defined to exist where the maximum storey drift computed including accidental torsion, at one end of the transverse to an axis is more than 1.2 times the average storey drifts at the two ends of the structure (Fig. 1.)

Torsional irregularity shall be considered when the floor diaphragm is rigid in their own plan in relation to the vertical structural elements that resist lateral forces.

i) Inherent Torsion

For diaphragms that are not flexible, the distribution of lateral force at each level can be considered the effect of Inherent Torsional Moment M_t, resulting from eccentricity between the locations of centre of mass and centre of rigidity.

ii) Accidental Torsion

Where the diaphragms are not flexible. Accidental Torsional Moment M_{ta} caused by the assumed displacement of the centre of mass each way from its actual location by a distance equal to 5 percent of the dimension of the structure perpendicular to the direction of applied force is considered.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 05, May-2018

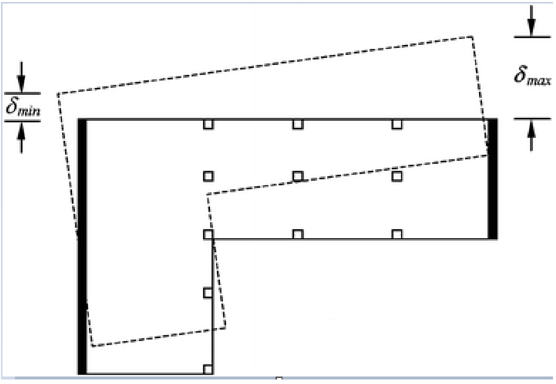

Fig. 1. Torsional irregularity

D. Re-Entrant corner Irregularity

Re-Entrant corner irrgularity is defined to exist where both plan projections of a building beyond a re-entrant corner is greater than 15 percent of the plan dimension of the building in given direction (Fig. 2.)

Presence of Re-Entrant corner in a building mainly causes torsion and sterss concentration in the corners of the building.

In this study, it is mainly concentrated on the torsional irregularity of the building in the re-entrant corner and at the end of projection.

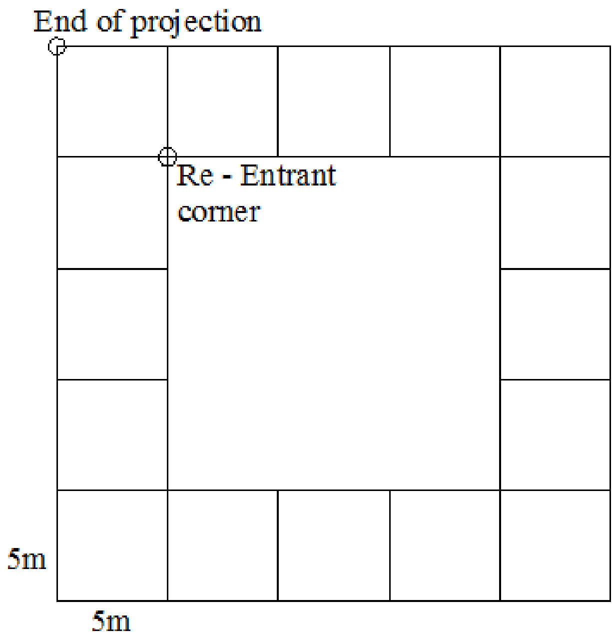

Fig. 2. Plan regular building

E. End of projection

End of Projection is the external or outside corner of the structure where the two wings of the structure meets as shown in the Fig. 3. Generally, the concentration of stress is a bit less than that of the stress at re-entrant corner. In a building, the end of projection and the re-entrant corner are considered as the most critical points.

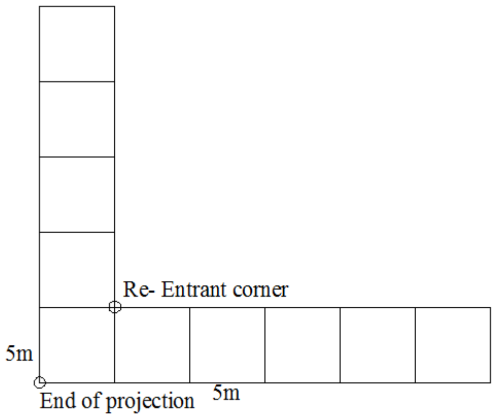

Fig. 3. Plan irregular building

II. METHODOLOGY

In this paper, the buildings have been analysed under Pushover analysis in ETABS (Extended Three dimensional Analysis of Building System). ETABS is software used for analysis and design of building. The version that has been used is ETABS 2015(V15.2.2). Both linear and nonlinear analysis can be done using ETABS.

Here, nonlinear static analysis has been used for analysing the building. It is also called as Pushover Analysis. For the study, a regular (box shape) and an irregular (L-shape) building with (G+5) storeys has been considered. There are 5 number of bays in both X and Y directions and each bay is 5m. The typical storey height is 3.2m. The RC structural members are designed as per code provisions (IS 456-2000). The size of the beam is 230X450mm and that of column is 230X600mm. The slab is 150mm thick. The floor diaphragm is designed for both Rigid and Semi-Rigid conditions under Membrane and Shell cases.

III. ANALYSIS

The buildings were modelled in ETABS-2015 with the parameters from Table I. The buildings were analysed and designed by applying dead load and live load before applying the lateral loads to check the safety of the structure. The structural members were revised as per requirement if found unsafe. Once the building is safe, Lateral loads were applied using pushover analysis.

The floor diaphragms were defined for rigid and semi rigid in membrane and later on in shell. The pushover analysis was carried out by defining the load cases in both X and Y directions as non linear static force. The load type was selected as acceleration. The load application pattern was selected as displacement. Later, the plastic hinges were assigned for beams and columns at 5% and 95% of the lengths of beam and column as per ASCE 41-13 table. Later, the defined diaphragm was assigned and the model was checked for errors. After confirming zero errors, the model was analysed for the seismic loads.

Table below shows the parameters that are considered in this study.

TABLE I: PARAMETERS CONSIDERED IN THIS STUDY

1	Structure Type	Ordinary Moment Resisting Frame
2	No. of Storey	G+5
3	Typical Storey Height	3.2m
Material Properties		
1	Grade of Concrete	M20
2	Grade of Steel	Fe-500
3	Density of Concrete	25kN/m3
Member Properties		
1	Slab Thickness	0.15m
2	Beam size	0.23mX0.45m
3	Column size	0.23mX0.6m
Loads considered		
1	Live Load	3.5 kN/m^2
2	Reduced Live Load	2.5kN/m^2
3	Floor Finish	1kN/m^2

IV. RESULTS AND DISCUSSIONS

The obtained results from the analysis were tabulated and the lateral displacements and storey shear at Re- entrant Corner and at End of Projections were noted down.

Graphs of Lateral displacement v/s number of storeys and Storey Shear v/s Number of storeys were plotted for PushX and PushY at Re-Entrant corner and End of Projection separately for both box and L-shape buildings and is shown in Fig. 4 to Fig. 15.

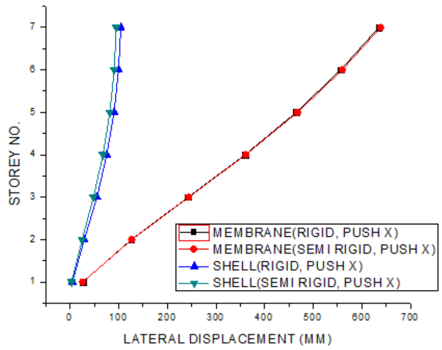

Fig. 4. Lateral Displacement of box shape building at End of Projection due to Push X.

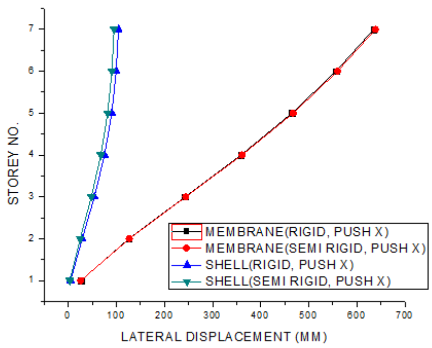

Fig. 5. Lateral Displacement of box shape building at Re-Entrant Corner due to Push X.

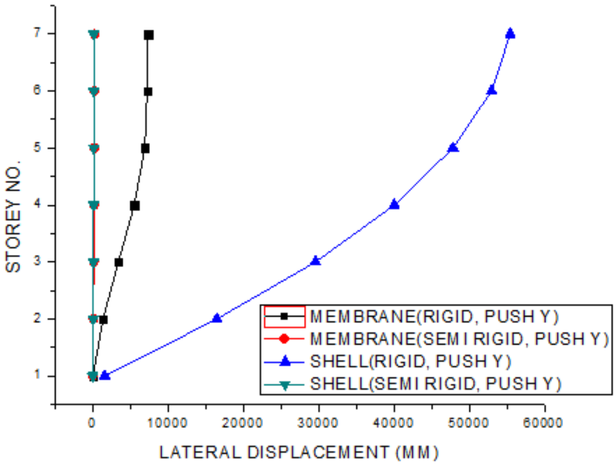

Fig. 6. Lateral Displacement of box shape building at End of Projection due to Push Y.

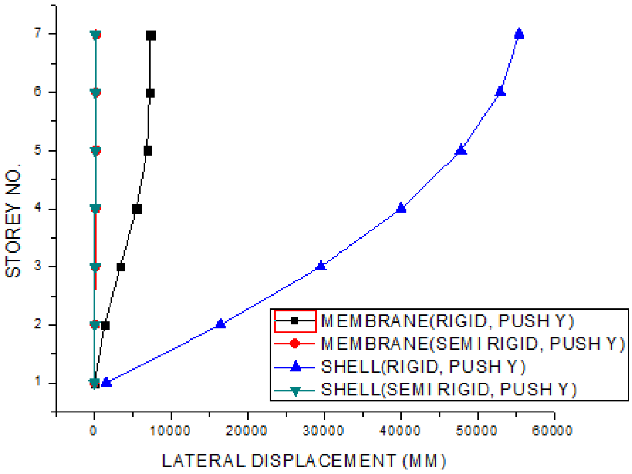

Fig. 7. Lateral Displacement of box shape building at Re-Entrant Corner due to Push Y.

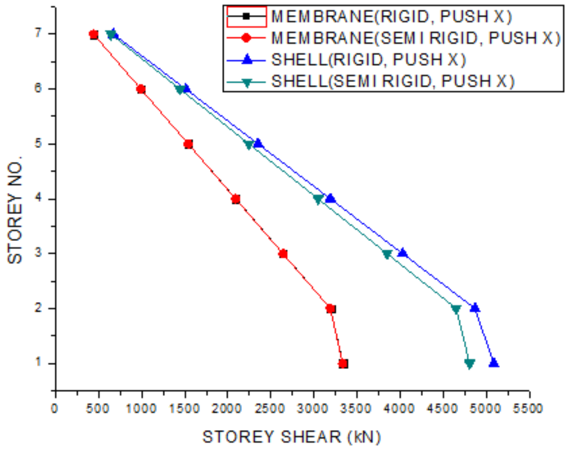

Fig. 8. Storey Shear of box shape building due to Push X.

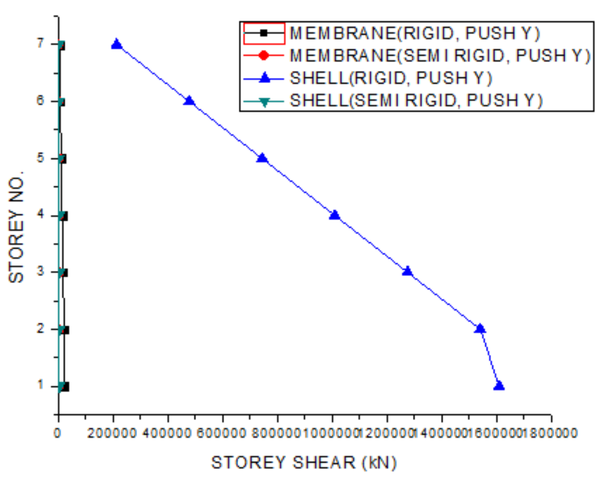

Fig. 9. Storey Shear of box shape building due to Push Y.

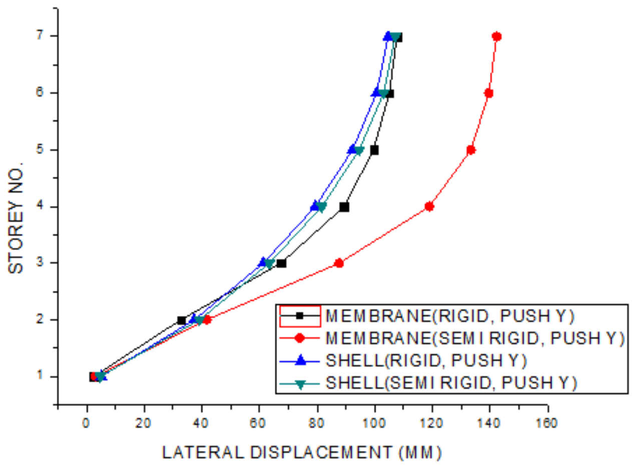

Fig. 12. Lateral Displacement of L- shape building at End of Projection due to Push Y.

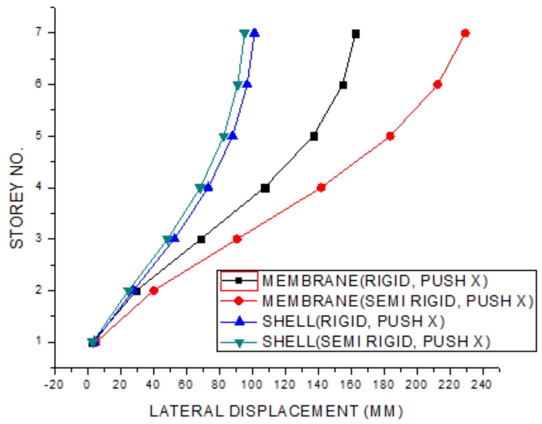

Fig. 10. Lateral Displacement of L-shape building at End of Projection due to Push X.

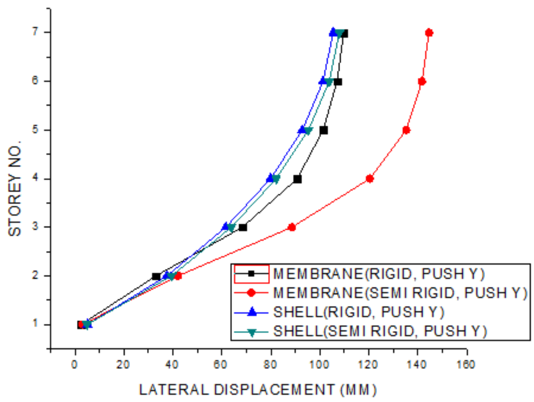

Fig. 13. Lateral Displacement of L- shape building at Re-Entrant Corner due to Push Y.

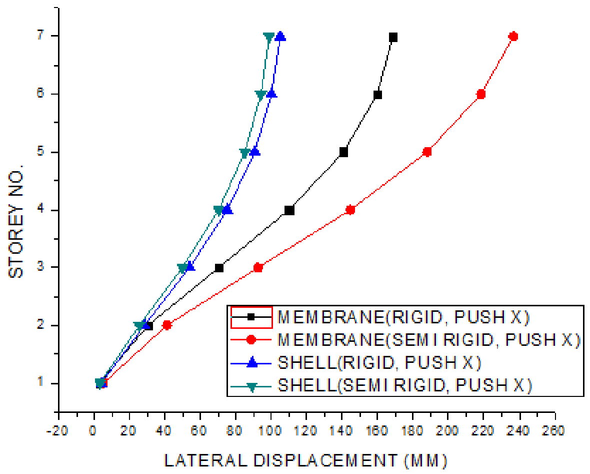

Fig. 11 .Lateral Displacement of L-shape building at Re-Entrant Corner due to Push X.

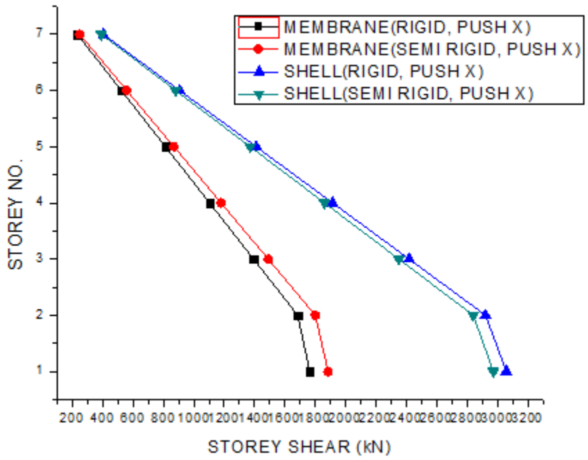

Fig. 14 .Storey Shear of L-shape building due to Push X

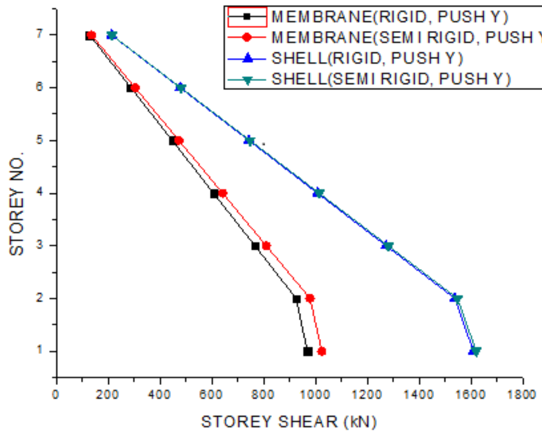

Fig. 15. Storey Shear of L- shape building due to Push Y.

V. CONCLUSION

Now a days, due to architectural consideration and the requirement of the clients, the buildings are becoming more irregular than regular. So in the present study, it can be seen that, the membrane with semi-rigid diaphragm and shell with semi-rigid diaphragm are performing better in the seismic area when compared to membrane rigid diaphragm and shell rigid diaphragm. Also, it can be concluded that the storey shear goes on decreases with the increase in height of the building. Similarly, the lateral displacement increases as the height of the building increases.

REFERENCES

[1] Ashish R. Akhare, Abhijeet A. Maske, "Performance Based Seismic Design of R.C.C. Buildings with Plan Irregularity", Journal of Civil Engineering and Environmental Technology, Vol. 2, Number 10, April-June 2015.

[2] IS 1893 (Part 1), "Criteria for Earthquake Resistant Design of Structures",2002.

[3] Milind V. Mohod, "Pushover Analysis of Structures with Plan Irregularity", IOSR-JMCE, Volume 12, Issue 4 Ver. VII, July-August 2015

[4] Naresh kumar B.G., Punith N., et al."Assessment of Location of Centre of Mass and Centre of Rigidity for Different Setback Buildings" IJERT,Vol. 6 Issue 05, May-2017. (*references*)

[5] Rahila Thaskeen, Shinu Shajee, "Torsional Irregularity of Multi-Storey Structures", IJIRSET, Vol. 5, Issue 9, September 2016.

[6] Shreyasvi C., B.Shivakumaraswamy, "A Case Study on Seismic Response of Buildings with Re-Entrant Corners", IJERT, Vol. 4 Issue 05, May-2015.

[7] 2009 NEHRP Recommended Seismic Provisions, FEMA P-752 CD,June 2013.

ACKNOWLEDGMENT

We acknowledge the principal and head of the department of our college, Maharaja Institute of Technology Mysore for providing an opportunity to publish an international journal. We also acknowledge International journal of Engineering Research and Technology for helping in sharing the knowledge of author with other parts of the world through their journal. Also, we acknowledge each and every author of our paper without which the paper would not have completed according to prescribed manner and according to the technical perspective.