Seismic Performance of L-Shape, U-Shape RC Buildings having Shear Wall and Bracing at Corner

Badri Adhikari[1], Tek Raj Gyawali[2], Rajendra Aryal[3]

[1]*Lecturer, School of Engineering, Pokhara University, Gandaki, Nepal*
[2]*Professor, School of Engineering, Pokhara University, Gandaki, Nepal*
[3]*Lecturer, School of Engineering, Pokhara University, Gandaki, Nepal*

---***---

Abstract: L-shape and U-shape buildings are more functional for natural light and fresh air, and the best architectural view[4]. Hospitals, schools, offices, and commercial buildings are normally made L-shape and U shape in Nepal [10]. As per the Indian and Nepal building code, it is mandatory to make the seismic joint in irregular buildings i.e. L-shape and U-shape buildings [1]. However, in this research work, the study was made for the effectiveness of shear walls and Reinforce concrete bracing systems in an irregular building in comparison with regular bare frames [7]. Response spectrum analysis and time history analysis were performed using ETABS software based on IS code for this study [1], [23], [19]. Eleven different models (Rectangular, L-shape, and U-shape building) having floor area constant were taken for this analysis. In an analysis, we assume that all model areas located in seismic zone V as per Indian code and soil type-II were taken. Finally, an earthquake load was for different cases of bare frame, shear wall, and bracing system. Lateral displacement; inter-story drift, Story stiffness, overturning moment, and base shear were calculated in all the cases. Finally, the result showed that L-shape and U-shape buildings with shear wall and bracing system at corners have 0.11 timeless displacement and 0.12 times drift than rectangular bare frame building structures. Similarly 1.78 times more story stiffness, story shear, over toning moment than rectangular bare frame building structure. Among this study, it is concluded that the U-shape having a shear wall at the corner has better seismic performance than other model buildings. L-Shape and U-shaped building having a Shear wall or Reinforce concrete bracing system at the corner has better seismic performance than the bare frame rectangular building.

Keywords: Seismic performance, Shear wall, Reinforce concrete Bracing, Irregular shape building.

1. INTRODUCTION

Nepal is a highly earthquake-prone zone. Therefore, it is difficult to make buildings in irregular shapes as per Indian [1] and Nepalese building cords [5]. The population is increasing at an alarming rate everywhere in Nepalese city so the available land space in such centers is limited to overcome this problem some time we need to build irregular plan building likewise L-shape plan or U-shape plan. Mainly Hospital School, University Office and multistory commercial building built in plan irregular shape Seismic join in L-shape and U-shape block is mandatory as per Indian stander building code [1]. To overcome this problem this study is most important. This sturdy help to overcome the above problem.

1.1 Objective of the Study

To determine seismic performance of RC frame regular and irregular plan building by using finite element method-based software.

2. Modeling of the Building

All models (i.e. Rectangular, L-shape, and U-shape buildings) have the same plinth area, beam size, column size, and story height. All models were made bear frame, shear lock at every corner, and RC bracing at every corner respectively. As shown in the below fig., the original size of the building ware taken 30mX25m floor area and a total 13.5 height in four-story. The entire model was modeling in ETABS 2017 Version 17.0.1. For this seismic analysis.

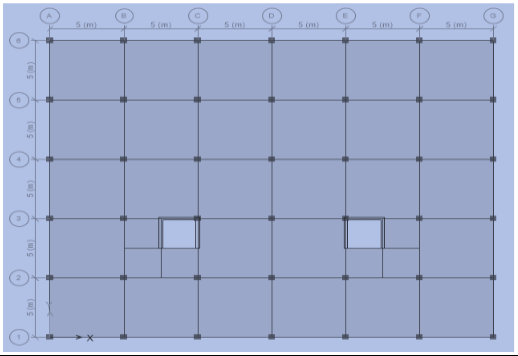
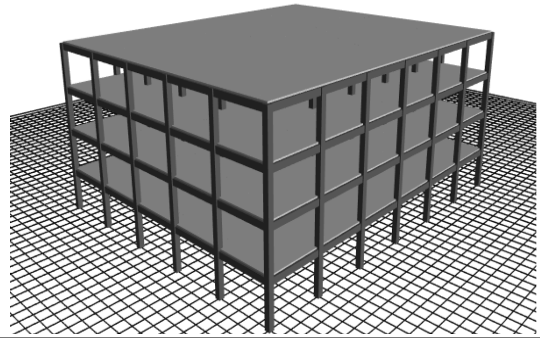
	

Fig. 1 Plan -Bare frame only in a rectangular building	Fig. 2 3-D of Bare frame only in a rectangular building

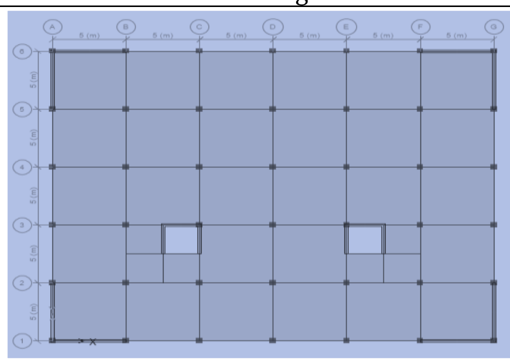
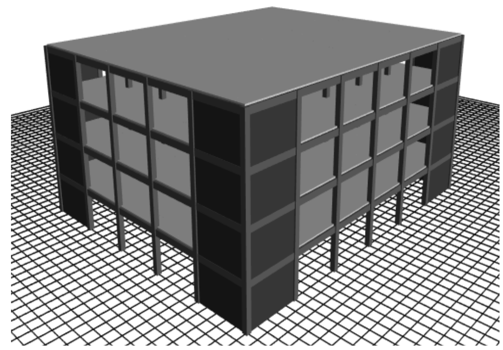

	

Fig. 3 Plan - Rectangular building with a corner shear wall	Fig. 4 3-D of Rectangular building with a corner shear wall

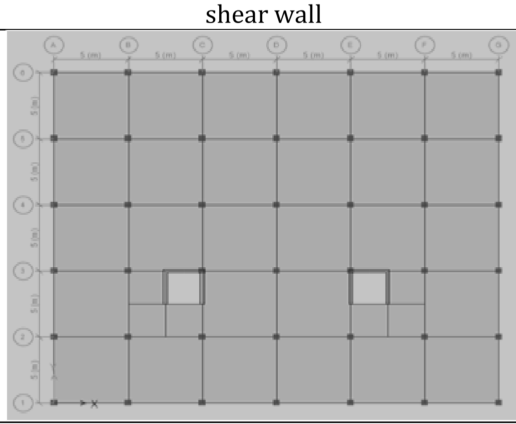
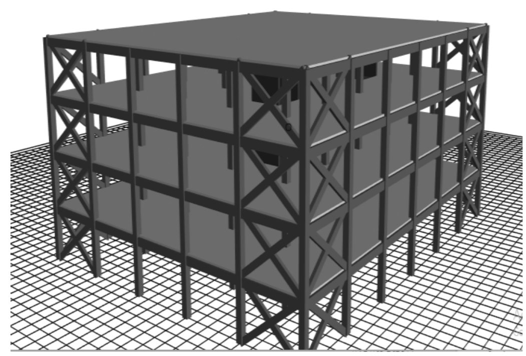

	

Fig. 5 Plan - Rectangular building with corner RC bracing	Fig. 6 3-D of Rectangular building with corner RC bracing

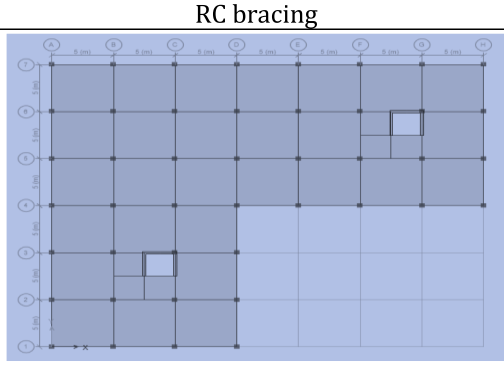
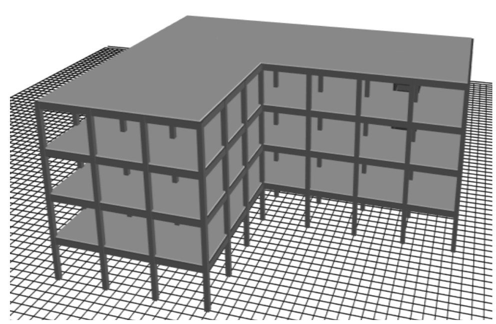

	

Fig. 7 Plan - L-shape bare frame only building	Fig. 8 3-D of L-shape bare frame only building

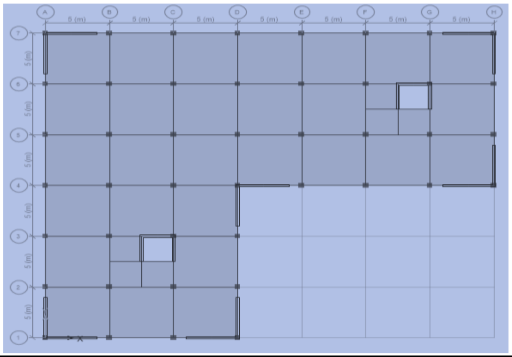


Fig. 9 Plan - L-shape building with the constant corner shear wall

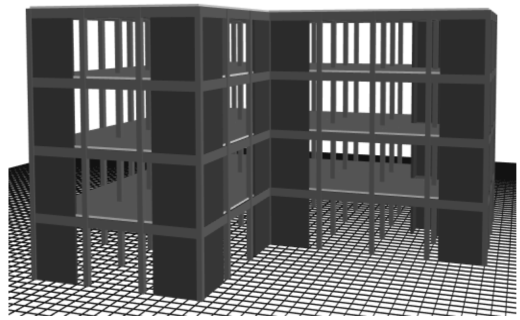


Fig. 10 3-D of L-shape building with the constant corner shear wall

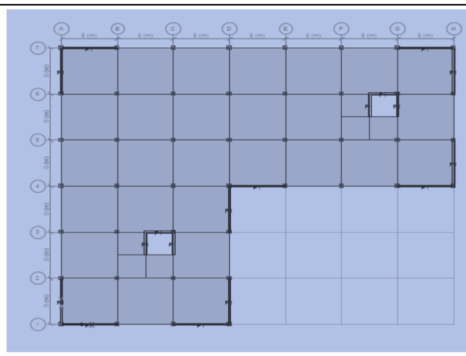


Fig. 11 Plan -L-shape building with the corner shear wall

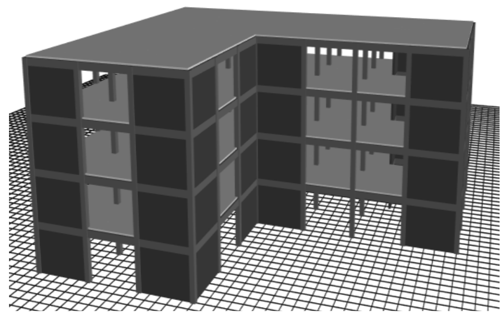


Fig. 12 3-D of L-shape building with the corner shear wall

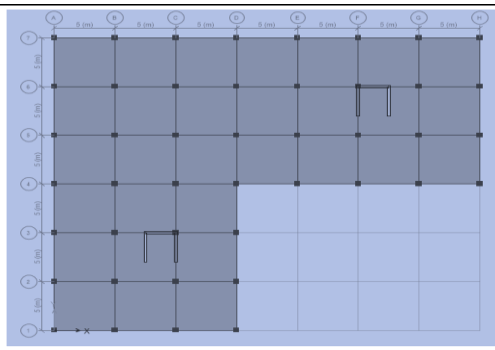


Fig. 13 Plan -L-shape building with bracing at the corner

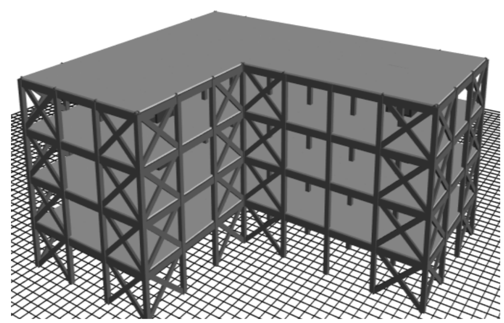


Fig. 14 3-D of L-shape building with bracing at the corner

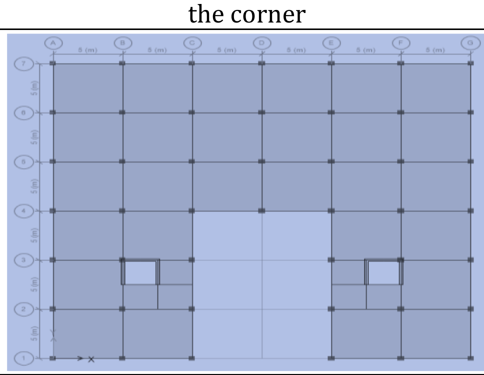


Fig. 15 Plan - U-shape building only bare

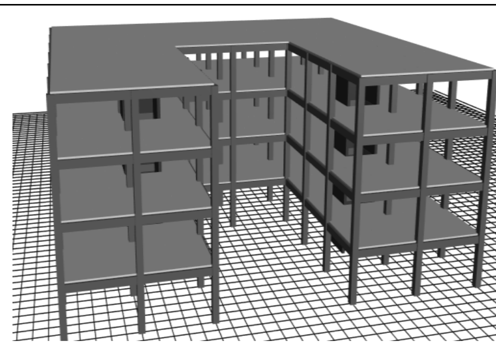


Fig. 16 3-D of U-shape building only bare

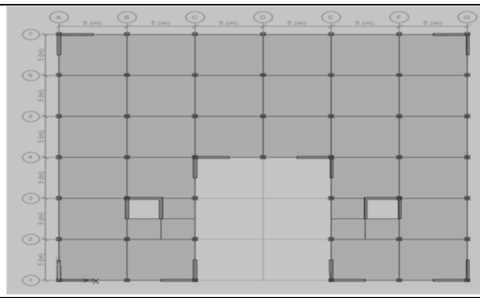
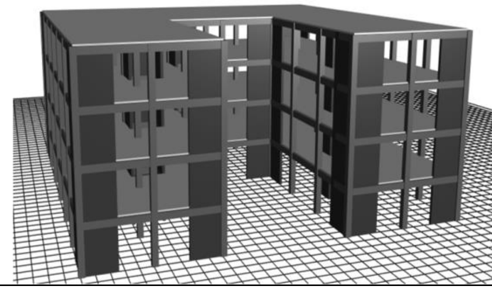
	

Fig. 17 Plan - U-shape building with constant shear lock	Fig. 18 3-D of U-shape building with constant shear lock

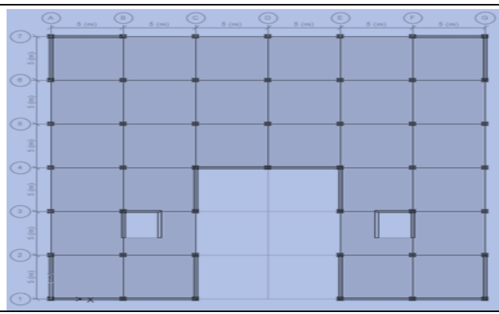
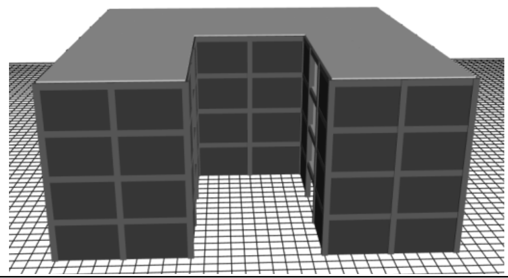

	

Fig. 19 Plan - U-shape building with shear	Fig. 20 3-D of U-shape building with shear

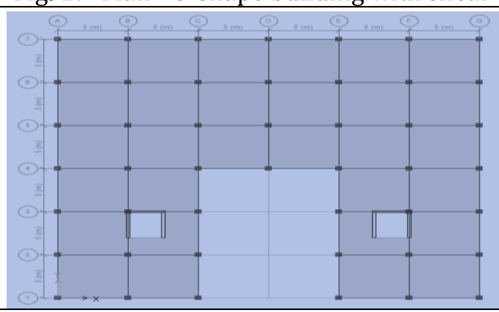
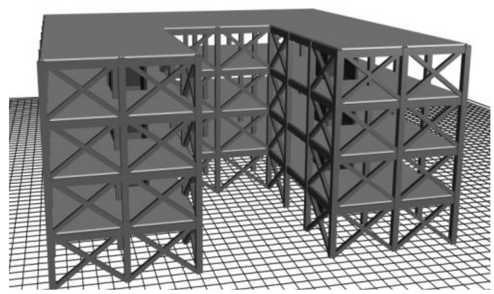

	

Fig. 21 Plan - U-shape building with bracing at the corner	Fig. 22 3-D of U-shape building with bracing at the corner

2.1 Assumptions of building design criteria

Assumptions

For this sturdy work, some important assumption made taken which mention below:

- Important Factor (I): 1.5
- Zone V, (Z): 0.36
- Response Reduction Factor (R) =5
- Damping = 0.05
- The structure was a special RC moment-resting frame (SMRF)
- IS code 1893-2002 considered, Limit state

Design Loads Considered (IS: 875 (Part 1) -1987, IS: 875 (Part 2) -1987, IS: 875 (Part 3) -1987). For all model.

3. Method of Analysis

To make a structure more earthquake-resistant we have to identify the weaker portion of a structure before the structure was built. Seismic analysis was dependent on the calculation of the response of building structures under an earthquake. Several types of analysis methods and tools were developed for the safety assessment of the building structure. In this sturdy work, the Response spectrum method and Time history analysis method were used for the analysis.

4. RESULT

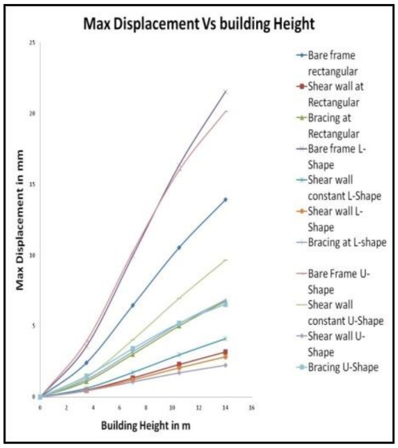


Figure 23 Sturdy of the maximum displacement due to response spectrum analysis.

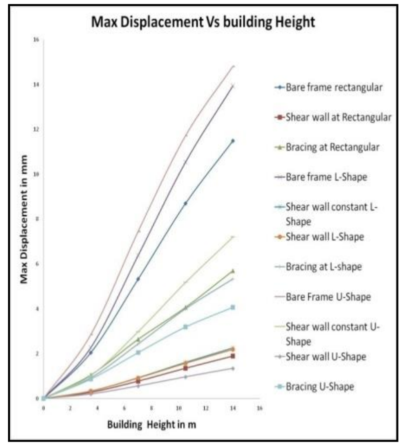


Figure 24 Sturdy of the maximum displacement due to time history analysis.

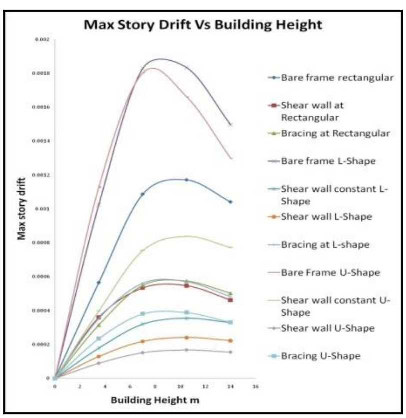


Figure 25 Study of maximum story drift due to Response spectrum analysis.

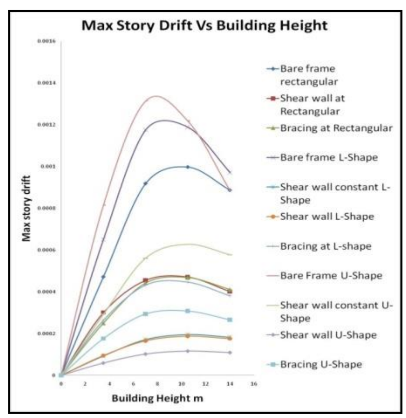
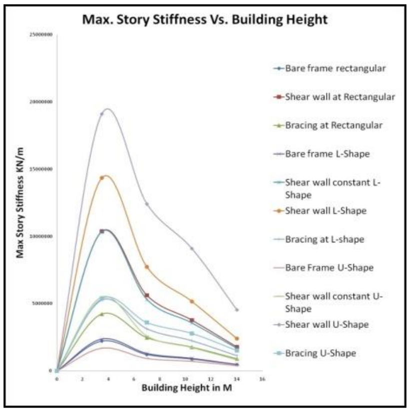


Figure 26 Study of maximum story drift due to time history analysis.



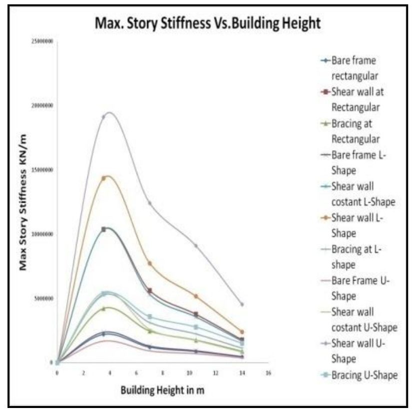
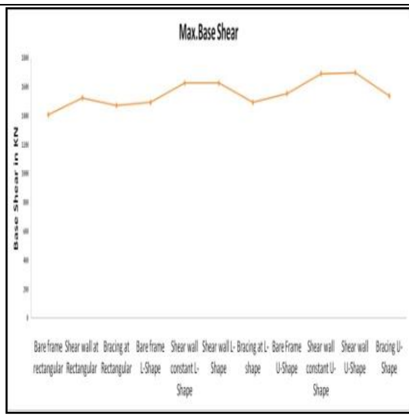


Figure 27 Study of maximum story drift due to Response spectrum analysis

Figure 28 Study of maximum story drift due to Time history analysis



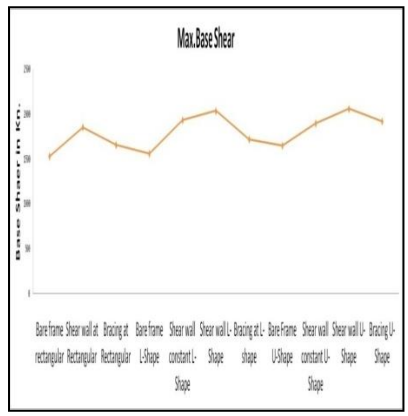
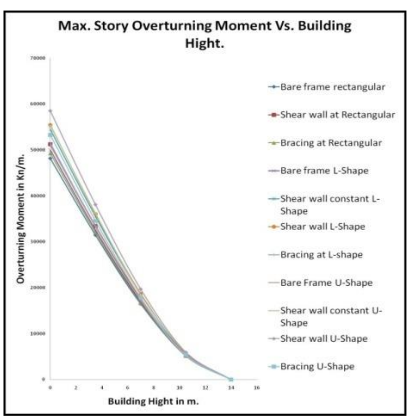


Figure 29 Study of maximum story shear due to static analysis.

Figure 30 Study of maximum story shear due to time history analysis.



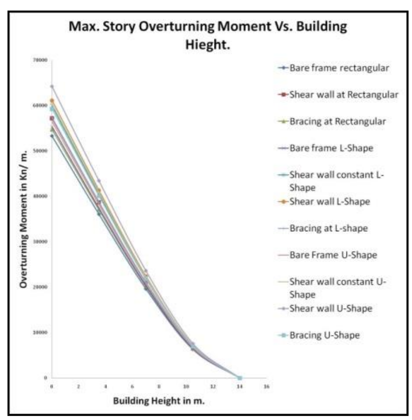


Figure 31 Study of maximum story overturning moment due to response spectrum analysis.

Figure 32 Study of maximum story overturning moment due to time history analysis.

Comparison of all building model

Table 5.4 Comparisons of all Rectangular, L-shape and U-shape Building Models

Analysis	BFR	SWR	X-BR	BFL	SWCL	SWL	X-BL	BFU	SWCU	SWU	X-BU
Displacement Comparisons with Rectangular Bare Frame Building.											
Response spectrum analysis	1	0.22	0.48	1.54	0.29	0.20	0.49	1.44	0.69	0.16	0.47
Time history analysis	1	0.16	0.49	1.21	0.19	0.19	0.46	1.20	0.62	0.11	0.35
Drift Comparisons with Rectangular Bare Frame building.											
Response spectrum analysis	1	0.44	0.48	1.40	0.31	0.21	0.46	1.24	0.74	0.14	0.31
Time history analysis	1	0.45	0.46	1.09	0.20	0.19	0.42	0.99	0.65	0.12	0.29
Stiffness Comparisons with Bare frame Rectangular Building											
Response spectrum analysis	1	3.82	1.94	1.03	3.63	5.17	2.44	0.83	1.71	1.78	3.20
Time history analysis	1	3.82	1.94	1.03	3.62	5.17	2.44	0.83	1.71	1.78	3.20
Base Shear Comparisons with rectangular Bare Frame Building											
Response spectrum analysis	1	1.08	1.05	1.06	1.15	1.15	1.06	1.10	1.20	1.20	1.09
Time history analysis	1	0.82	1.08	1.01	1.26	1.32	1.12	1.07	1.23	1.34	1.25
Overturning Moment Comparisons with Bare frame Building											
Response spectrum analysis	1	1.06	1.02	1.03	1.13	1.15	1.06	1.05	1.14	1.21	1.10
Time history analysis	1	1.11	1.04	1.03	1.16	1.20	1.09	1.06	1.17	1.25	1.14

5. CONCLUSION

Response spectrum analysis and time history analyses of the earthquake-resistant structure were performed satisfactorily. The study ware conducted for regular and irregular eleven different models.

From the above sturdy show, that the shear wall placed at every corner of the building shows the better seismic response to another model. Due to box action, all the corner walls interconnect and resist the force of each other.

- The displacement was 0.11 times less in the shear wall or bracing at the corner in L-shape and U-shape buildings than that of a rectangular bare frame building.
- The drift was 0.12 times less in the shear wall or bracing at the corner in L-shape and U-shape buildings than that of a rectangular bare frame building.

- The story stiffness was 1.78 times more in the shear wall or bracing at the corner in L-shape and U-shape buildings than that of a rectangular bare frame building.

- L-shape and U-shape buildings with the shear wall or bracing at the corner have 1.34 times increased story shear and 1.25 times increased overturning Moment than regular rectangular bare frame buildings. However, overall seismic performances of L-Shape and U-Shape buildings with the shear wall or bracing at every corner building have better than that of regular rectangular bare frame buildings.

5.1 Recommendations

Different assumptions and limitations have been adopted to simplify the modeling of the proposed structures. Thus, all the factors that may influence the behavior of the structures should consider in the modeling. The following recommendations made future studies to obtain the actual results.

For the present study, the analyses were performed for only rectangular; L-Shape, and U-shaped buildings with a constant floor area. Further investigation should make for different shapes and sizes of buildings.

- Since the analysis was performed for only one type of shear wall, further investigation should be made for different types of shear walls.
- Only the RC X-bracing type of braces was used in this analysis work, further investigation should make for different types of bracing systems.
- For the comprehensive design, the soil-structure interaction should not be ignored in high-rise buildings if underneath soil is soft. Hence, the study of dynamic analysis of high-rises should be carried out including soil interaction.

6. REFERENCES

[1] S. K. Jain, "Review of Indian seismic code, IS 1893 (Part 1): 2002," Indian concrete journal, vol. 77, pp. 1414-1422, 2003.

[2] A. D. R. Singh, P, "Analysis of High Raised Structures in Different Seismic Zones with Diagrid And Shear Walls Using E-Tabs."

[3] M. Atif, L. Vairagade, and V. Nair, "Comparative study on seismic analysis of multistory building stiffened with bracing and shear wall," International Research Journal of Engineering and Technology (IRJET), vol. 2, pp. 1158-1170, 2015.

[4] M. S. Azad and S. H. A. Gani, "Comparative study of seismic analysis of multistory buildings with shear walls and bracing systems," International Journal of Advanced Structures and Geotechnical Engineering (IJASGE), vol. 5, pp. 72-77, 2016.

[5] Q. Huang, Z. Guo, and J. Kuang, "Designing infilled reinforced concrete frames with the 'strong frame-weak infill'principle," Engineering Structures, vol. 123, pp. 341-353, 2016.

[6] C. Repapis, C. Zeris, and E. Vintzileou, "Evaluation of the seismic performance of existing RC buildings II: A case study for regular and irregular buildings," Journal of earthquake engineering, vol. 10, pp. 429-452, 2006.

[7] V. Abhinav, S. Reddy, V. Naidu, and M. Mohan, "Seismic analysis of multi-story RC building with shear wall using STAAD. Pro," International Journal of Innovative Technology and Research (IJITR), vol. 4, pp. 3776-3779, 2016.

[8] S. Kasat, S. Patil, A. Raut, and S. Bhuskade, "Comparative Study of Multi Storey Building Under Action of Shear Wall Using ETAB Software," in International Conference on Electrical, Electronics, and Optimization Techniques, 2016.

[9] V. R. Harne, "Comparative study of strength of RC shear wall at different location on Multi-storied residential building," International Journal of Civil Engineering Research, vol. 5, pp. 391-400, 2014.

[10] R. Kumar, E. S. S. Sidhu, S. Sidhu, and E. H. S. Gill, "Seismic Behavior Of Shear Wall Framed Buildings," International Journal of Engineering Technology, Management and Applied Sciences (IJETMAS), vol. 2, pp. 28-38, 2010.

[11] P. Chandurkar and D. P. Pajgade, "Seismic analysis of RCC building with and without shear wall," International journal of modern engineering research, vol. 3, pp. 1805-1810, 2013.

[12] A. Rahimi and M. R. Maheri, "The effects of retrofitting RC frames by X-bracing on the seismic performance of columns," Engineering Structures, vol. 173, pp. 813-830, 2018.

[13] V. S. Damam, "Comparative Study on Multistoried RCC Structure with and without Shear Wall by using SAP2000 v17," International Research Journal of Engineering and Technology, vol. 2, pp. 1261-1266, 2015.

[14] D. A. Narkhede, P. P. Padale, B. Jagadale, and P. J. Bhalerao, " Review Paper On Comparison of Seismic Behaviour of Shear Wall and Bracing System in Rc Frame Structure.."

[15] M. J. Thomas and R. Patel, " A Comparative Analysis of Structure With Inner and Outer Edge Shear Wall by Staad-Pro."

[16] H. S. Lee and S. W. Woo, "Effect of masonry infills on seismic performance of a 3-storey R/C frame with non-seismic detailing," Earthquake engineering & structural dynamics, vol. 31, pp. 353-378, 2002.

[17] R. Mohan and C. Prabha, "Dynamic analysis of RCC buildings with shear wall," International Journal of Earth Sciences and Engineering, vol. 4, pp. 659-662, 2011.

[18] W. Cao, S. Xue, and J. Zhang, "Seismic performance of RC shear walls with concealed bracing," Advances in Structural Engineering, vol. 6, pp. 1-13, 2003.

[19] S. Anshuman, D. Bhunia, and B. Ramjiyani, "Solution of shear wall location in Multi-storey building," International journal of civil and structural engineering, vol. 2, p. 493, 2011.

[20] M. Ashraf, Z. SEDIGHI, and M. Javed, "Configuration of a multistorey building subjected to Lateral Forces," 2008.

[21] G. Bhatt, A. Titiksh, and P. Rajepandhare, "Effect of Curtailment of Shear Walls for Medium Rise Structures," in 2nd International Conference on Sustainable Computing Techniques in Engineering, Science and Management (SCESM-2017)-27-28 January 2017, 2017, pp. 501-507.

[22] S. Monish and S. Karuna, "A study on seismic performance of high rise irregular RC framed buildings," International Journal of Research in Engineering and Technology (IJRET), vol. 4, pp. 340-346, 2015.

[23] S. Qiao, X. Han, and K. Zhou, "Bracing configuration and seismic performance of reinforced concrete frame with brace," The Structural Design of Tall and Special Buildings, vol. 26, p. e1381, 2017.

[24] H. A. Safarizki, S. Kristiawan, and A. Basuki, "Evaluation of the use of steel bracing to improve seismic performance of reinforced concrete building," Procedia Engineering, vol. 54, pp. 447-456, 2013.

[25] M. M. Ahmed, S. E. A. Raheem, M. M. Ahmed, and A. G. Abdel-Shafy, "Irregularity effects on the seismic performance of L-shaped multi-story buildings," Journal of Engineering Sciences Assiut University Faculty of Engineering, vol. 44, pp. 513-536, 2016.

[26] S. E. Abdel Raheem, M. M. Ahmed, M. M. Ahmed, and A. G. Abdel-Shafy, "Seismic performance of L-shaped multi-storey buildings with moment-resisting frames," Proceedings of the Institution of Civil Engineers–Structures and Buildings, vol. 171, pp. 395-408, 2018.