Comparative Analysis of Irregular RC Buildings with and Without Shear Wall in Lateral Loading

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ABSTRACT

Ten-story buildings are taken into consideration in this study. In ETABS-2018, the building is modelled with a shear wall, but the analysis does not take this into account. Different loads, such as dead, live, and seismic loads in the X and Y directions, are taken into consideration for analytical purposes. As per NBC 105:2020, different combinations of loads are taken into consideration. An attempt is made in this thesis to comprehend the seismic performance of buildings with and without shear walls. This project's primary goal is to determine if a building with or without a shear wall will fare better during earthquakes. The current study examines RCC building models that have G+9 stories and either a shear wall or no shear wall taken into account for analysis. The dynamic approach in the ETABS programme is used to analyse the model. Various seismic parameter categories, including base shear, drift, displacements, story stiffness, torsion, and forces in beams and columns in each model. In the end, the seismic behaviour of the structures is compared in terms of time interval, member forces, base shear, storey shear, overturning moment, displacement, stiffness, and drifts. It is found that model 1 performs better than model 2. The research also indicated that buildings with vertical irregularities have more venerable outcomes.

Keywords: ***Irregular building, drift, displacement, Storey shear, RC buildings.***

INTRODUCTION

Since many of the buildings in use today have various layouts and elevations that could be affected by destructive earthquakes in the future, it is important to assess how well the structures are performing in terms of their ability to endure disasters, particularly those caused by earthquakes. Shear walls are unavoidable when creating a structure, but in order to take the necessary safety measures, it is important to understand how structures—with or without these shear walls—behave during earthquakes. For the purpose of earthquake behaviour and design, a thorough analysis of the structural behaviour of structures with shear walls is necessary.

When building, shear walls are an unavoidable necessity. It is necessary to research how these shear wall structures behave during earthquakes. The primary goal of earthquake engineering is to design and construct a structure so that the damage to the structure and its structural components during an earthquake is minimised by implementing appropriate safeguards. The size, form, and positioning of beam columns as well as building layouts all have an impact on a structure's seismic resistance. Unusual buildings have a higher risk of structural member failure and earthquake vulnerability. A abrupt shift in mass, stiffness, geometry, and strength along a height is referred to as vertical irregularity. Structures with discontinuities in the horizontal plan, such as cutouts, large openings, and asymmetrical plan shapes (T, E, F, H, L, etc.), are referred to as horizontally irregular structures. The Indian Standard Code depicts the vertically uneven buildings in Figure 1.

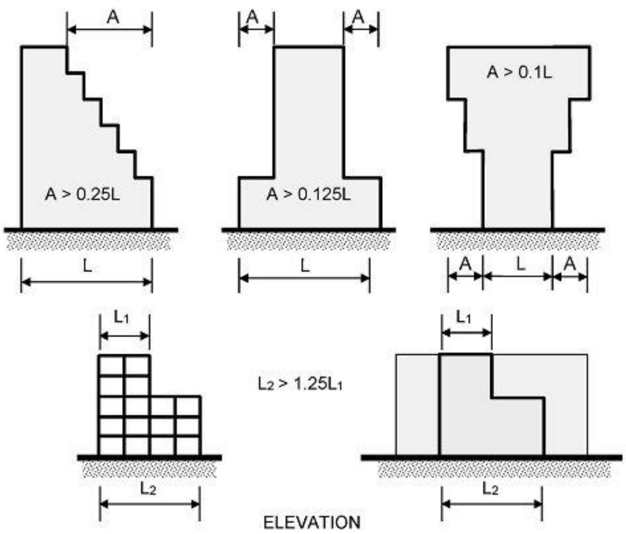

Figure 1. Vertical irregular buildings.

There are several researches on the impact of shear wall on high-rise buildings. Most research is conducted for regular buildings. Although the research on the irregular buildings is done, the irregularity of the plan considered in this study, the building such as set back buildings which is mostly constructed as a vertical irregular shaped buildings in Nepal, limited number of research were conducted by the researcher. Many studies only focused on either regular RC buildings or vertically irregular buildings with shear wall. There is lack of the research were obtained in position of the shear wall in different position and its effect in the vertical irregular buildings with soft story in the lower portion of the structure. These irregularities are responsible for the structural collapse of buildings under the action of dynamic loads. Hence, extensive research is required for achieving ultimate performance even with a poor configuration. Therefore, this study aims to enhance the understanding and evaluation of seismic behavior for horizontal irregular buildings with different positioned shear wall.

In this study, the seismic behavior of the vertical irregular RC buildings with and without shear wall with different positioned are investigated with the help of seismic parameter. The comparative study is presented different positioned shear wall structure based on the seismic performance. The seismic performance such as displacement, drift, shear force, fundamental time period, stiffness, torsional irregularity ratio are studied and compared. The level of torsional effects observed when the shear wall provided in different positions mainly focused in this study.

Earthquake resistant buildings should possess, at least a minimum lateral stiffness, so that they do no swing too much during small levels of shaking. Moment frame buildings may not be able to offer this always. When lateral displacement is large in a building with moment frames only, structural walls, often commonly called shear walls, can be introduced to help reduce overall displacement of buildings, because these vertical plate-like structural elements have large in-plane stiffness and strength. Therefore, the structural system of the building consists of moment frames with specific bays in each direction having structural walls. Structural walls resist lateral forces through combined axial-flexure-shear action. Also, structural walls help reduce shear and moment demands on beams and columns in the moment frames of the building, when provided along with moment frames as lateral load resisting system.

Pardeshi Sameer et.al (2016) : Basically They adopted 4 types of models Regular, L-Shape, T shape, Plus Shape and they analyze the Structure on the Method of Time History Analysis They found results that Plan configuration has Good Response in Seismic Analysis, Shear force was found to be max. at first Storey. Whereas the Displacement will be observed large in T-Shape. Prof. Vedantee Prasad Shukla et.al (2018) The study point out that time period of the regular building is more than irregular. Mr. S.Mahesh et.al (2014) Comparison of analysis and design of regular and irregular configuration of multi-Story building in various seismic zones using STADD PRO, They were followed by Time History Analysis Method, They adopted seismic Zone 4found Drift is weak in Regular building. Dr.S.K. Dubey & P.D. Sangamnerkar (2015) The building is assumed as commercial complex. Geometry of building is ‘T’ in shape consisting of open ground storey parking. They analyzed for Zone IV. Abhay Guleria (2016) : The modeling and analysis has done by using finite element based software ETABS In addition, this study suggests that L shape and S shape structure gives almost similar response against overturning moment, story drift, and Story displacement. Sanhik Kar Majumder and Priyabrata Guha(2015) Presented the comparison between wind and seismic load on different types of structures. Magliulo G., Maddaloni G. & Petrone C (2017): They are respectively a Rectangular Plan Shape, L-Plan Shape & a Rectangular Plan Shape with Courtyard building. There sult the modeling and analysis of (G+5) structures are done by using STAAD Pro. Shreyasvi. C and B. Shivakumara swamy (2015) :compared the behaviour of regular and re-entrant structures for the regular and irregular models, storey displacements, time periods and storey shears were compared. Prajapati P.B and Prof. Mayur G Vanza (2014) : in this study, the comparison of seismic response between a rectangular, C shape and L shape was done. Arunava Das and Priyabrata Guha (2016) : in this paper, behaviour of four storey irregular and regular building subjected to earthquake loads were compared. Time history analysis and pushover analysis was performed using SAP2000. Arvindreddy and R.J.Fernandes (2015) : investigated the response of regular and plan irregular structures under zone V.

METHODOLOGY

Earthquakes are perhaps the most unpredictable and devastating of all natural disasters. They not only cause great destruction in terms of human casualties, but also have a tremendous economic impact on the affected area. The concern about seismic hazards has led to an increasing awareness and demand for structural design to withstand seismic forces. In such a scenario, the onus of making buildings and structures safe in the earthquake prone areas lies on the designers, architects and engineers who conceptualized these structures.

Factors that should be considered in the designing of an earthquake resistant structure includes understanding of the physics of earthquake, the properties and configuration of the structure, study of the behavior of structures in past earthquakes and also recommendations and codes provided by relevant authorities.

Nepal Building Code Provision

Nepal National Building Code NBC 105: Seismic Design of Buildings document is the outcome of the revision of the earlier version of NBC 105: 1994 Seismic Design of Buildings in Nepal. This code covers the requirements for seismic analysis and design of various building structures to be constructed in the territory of the Federal Republic of Nepal. This code is applicable to all buildings, low to high rise buildings, in general. Requirements of the provisions of this standard shall be applicable to buildings made of reinforced concrete, structural steel, steel concrete composite, timber and masonry. For Base-isolated buildings as well as for buildings equipped and treated with structural control can be designed in reference with specialist literatures. Minimum design earthquake forces for buildings, structures or components thereof shall be determined in accordance with the provisions of this standard.

In this study following models are prepared for the study:

Model1. Building with Regular shape

Model2.Building with irregular shape.

Model Assumption

Equivalent static method is used to calculate the lateral forces at each storey level as per NBC: 105:2020and time period of the modes is calculated by using ETABS 2016 software. Different types of loads are assumptions such as brick masonry which is 19.2 kN/m^3, floor finishing is 1 kN/m^2, live load is 3 kN/m^2 on all floors except roof. The zone factor is 0.3, importance factors is 1 and R factors is 5 are also assumed for seismic analysis. 150mm thick slab is considered for all building models. Exterior wall thickness is taken as 250mm and interior wall thickness as 125mm and all beams were taken as model 1:-355.6mm x 609.6mm, model2:-355.5x 609.6mm. the assumed models are as shown in figure 2 and 3.

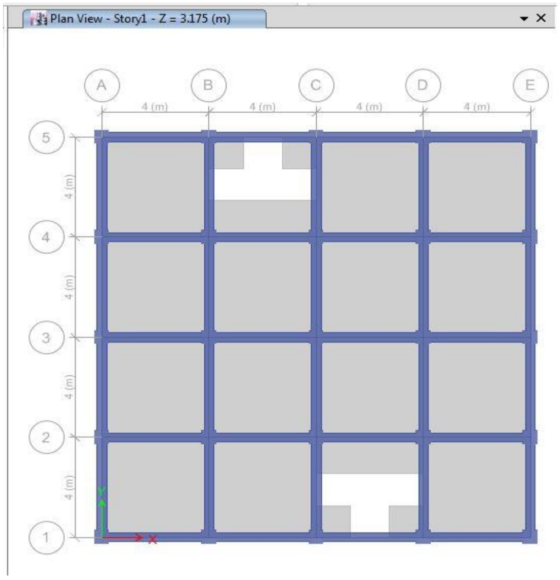

Figure 2. Plan of building for with our shear wall

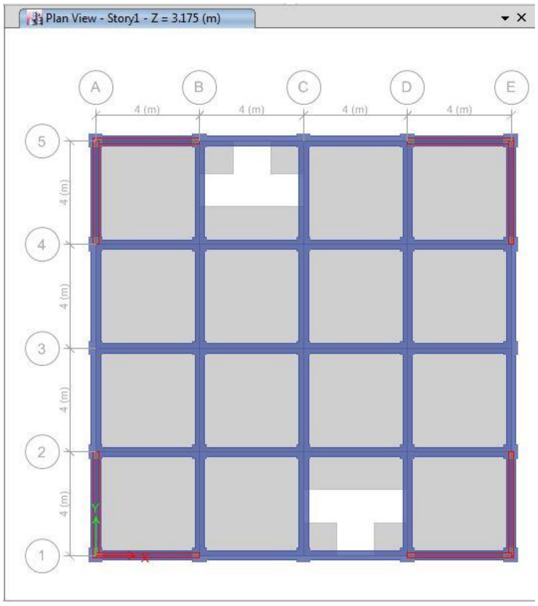

Figure 3. Plan of building for with shear wall

RESULTS AND DISCUSSION

To understand the vertical irregular buildings with and without shear wall different seismic parameter such as drift, displacements, story shear, shear forces and maximum bending moments etc. and compared each others.

Maximum displacement

Table 4.2 shows the maximum displacements along y directions. It is observed that in the top story along the x direction model 2 shows maximum value of displacements almost 69.8mm. however the enormous difference is observed in displacements along the y directions as shown in table 1. In the model 1 the displacements is 68.05mm and in model 2 it is increased and observed 85.7mm it means almost 25% displacements more as compared to model 1.

Table 1. Comparison of maximum top storey displacement of each models considered.

Models	**Displacement in mm**	
	EQX(ULS)	**EQY(ULS)**
Model 1	61.002	68.051
Model 2	69.869	85.72

Inter story drift ratio

The inter-story drift (ISD) is the more reliable parameter to observe the structural and nonstructural damage as compared to the displacements. Table 2 shows the maximum story drift in each story each models. Comparison of maximum drift of each models are shown in Table 2. It need further analysis to observe failure pattern and dynamic analysis for venerability observation. However model 1 shows safe in drift for earthquake loading. Also along the y directions the models 2 shows the 0.0044 story drift which is exceed the standard value. It means vertical irregular buildings are more venerable under earthquake load.

Table 2. Comparison of maximum drift of each models considered.

Models	**Drift**	
	EQX(ULS)	**EQY(ULS)**
Model 1	0.002674	0.002868
Model 2	0.00391	0.004477

Storey shear

The base shear is the lateral total force at the base of the structures induced due to the earthquake ground motions. The base shear of the structures depends upon the plan shape of the structures, fundamental time periods and soil types of the sites. Table 3 show that comparison between two models.

Table 3. Comparison storey shear each models considered

Models	**Storey shear in kN**	
	Rx	**Ry**
Model 1	-3323.19	-3323.19
Model 2	-3436.44	-3436.44

Overturning moment

In the both direction it is clear that the maximum overturning moments values are observed in the models 2. Comparison of maximum overturning moment of each models are shown in Table 4. From the Figure 4 it is observed that the model 2 have more overturning moment than model1 in both longitudinal and transverse direction.

Table 4. Comparison of overturning moment storey of each models considered

Models	**Overturning moment in kN-m**	
	EQX(ULS)	**EQY(ULS)**
Model 1	-67362.46	67362.46
Model 2	-69127.12	69127.12

Stiffness

The size, shape, and length of the columns, shear walls, and bracings determine how rigid the stories are in the buildings. Stiffness is a crucial structural engineering characteristic that controls how a reinforced concrete (RC) building or shear wall responds to several kinds of loads, including gravity, wind, and seismic pressures. In essence, stiffness is a structure's ability to resist deformation in response to an applied load. Stiffness and the capacity of RC buildings and shear walls to bear lateral loads—like those brought on by wind or earthquakes—are intimately associated. Comparison of the stiffness of all models are shown in the Table 5. The table shows that stiffness of model 1 is greater than model 2.

Table 5. Comparison of stiffness of each models considered.

Models	**Stiffness in kN/m**	
	EQX(ULS)	**EQY(ULS)**
Model 1	788386.848	710709.547
Model 2	6936182.609	6799551.367

Time period

The fundamental time period (FTP) of a structure determines its worldwide seismic requirements. The majority of the codes reference an empirical formula that depends on the height of the building. In the direction of the design lateral force, a building's translational natural periods determine its design horizontal base shear coefficient. The vibration periods calculated by ETAB's finite element software for various model shapes. The data shows the as increases in mode in models the values also increased. The mode 1 and 3 represents the x and y directional fundamental time periods. It shows that the models 2 have high time periods as compared to the model 1. Figure 4 shows that the three mode form of time periods of two models and observed that mode 2 have similar results and in other mode the modal 2 have quite more values as compared to model 1.

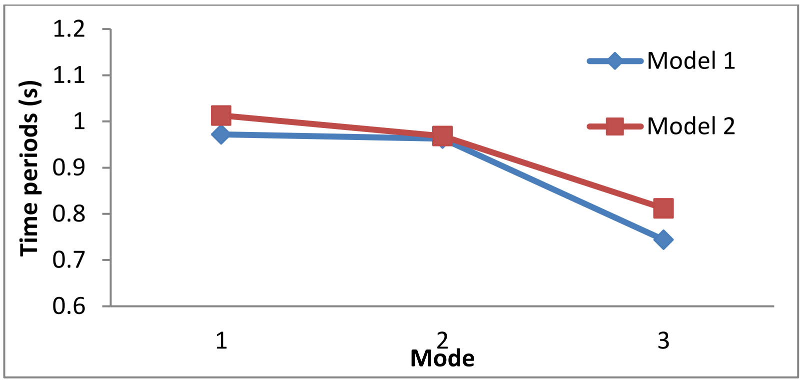

Figure 4. Comparative analysis of fundamental time periods.

CONCLUSIONS

From the analysis carried out following conclusion are drawn:

a) When compared to a building without a shear wall, the 10-story building with a shear wall has less displacement.
b) A 10-story building with a shear wall has a 78% reduction in displacement compared to a building without one.
c) A building with a shear wall has a lower storey drift than one without one. In the instance of the shear wall erection, the drift has dropped by 19.35%.
d) The fundamental time period of the building with shear wall is less than without shear wall.
e) The model's base shear increases with a shear wall compared to a scenario without one.
f) A building with a shear wall has a 23% greater overturning moment than a building without one.
g) Buildings with shear walls have increased structural rigidity.

REFERENCES

1. Milind V. Mohod "Effect Of Shape And Plan Configuration On Seismic response Of Structure"International Journal Of Scientific & Technology Research Volume 4.2015.
2. Mohammed yousuf, P.M. shimpale(2013). Dynamic Analysis of Reinforced Concrete Building with Plan Irregularities. International Journal of Emerging Technology and Advanced Engineering, Volume 3, Issue 9, September 2013
3. Mohammed Rizwan Sultan and D. Gouse Peera(2015)"Dynamic Analysis Of Multi-Storey Building ForDifferent Shapes" International Journal of Innovative Research in Advanced Engineering (IJIRAE).ISSN:2349-2163,Issue 8, volume 2 (August 2015)
4. Arvindreddy, R.J.Fernandes, "Seismic Analysis of RC Regular and Irregular Frame Structures", IJERT, Vol.2, Issue: 5, Aug-2015.
5. Prof. S.S. Patil, ,Miss. S.A. Ghadge, ,Prof. C.G. Konapure, , Prof. Mrs. C.A. Ghadge. " Seismic Analysis of High-Rise Building by Response Spectrum Method" International Journal Of Computational Engineering Research (Ijceronline.Com) Vol. 3 Issue. 3,march 2013
6. S.Mahesh and Dr.B.Panduranga Rao" Comparison of analysis and design of regular and irregular configuration of multi Story building in various seismic zones and various types of soils using ETABS and STAAD" IOSR Journal of Mechanical and Civil Engineering (IOSRJMCE) , Volume 11, Issue
7. S.K. Ahirwar, S.K. Jain and M. M. Pande (2008)"Earthquake loads on multistorey buildings as per is:1893-1984 and is: 1893-2002: a comparative study" The 14thWorld Conference on Earthquake Engineering October 12-17, 2008, Beijing, China.
8. Sarkar P, Prasad A Meher, Menon Devdas, 2010, Vertical geometric irregularity in stepped building frames, Engineering Structures 32 (2010) 2175–2182
9. Dnyaneshkumar H. Lanjewar, Prof. Ameya Khedikar(2017) "Seismic Analysis of Unsymmetrical RCC Structures'' International Journal of Innovative Research in Science,Engineering and Technology Vol. 6, Special Issue 11.
10. Ramanujam I V and Dr H Sudarsana Rao." COMPARATIVE STUDY OF SEISMIC FORCES BASED ON STATIC AND DYNAMIC ANALYSIS AS PER IS: 1893 -2002" ISSN 2319 – 6009 WWW.IJSCER.COM VOL. 4, NO. 1, FEBRUARY 2015
11. Gaurav Kumar , Prof. V.K. Singh Comparison of Seismic Performance of MultiStoried RCC Buildings with Plan Irregularity Volume3 ,May 2018.