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# Seismic Analysis of RC Buildings with and without Shear Wall using NBC

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**Abstract -** Shear wall are not avoidable in construction of buildings. However, the behavior of structures with these Shear wall during earthquake needs to be studied. By taking adequate precautions, the main objective of Earthquake Engineering is to design and build a structure in such a way that the damage to the structure and its structural components during an earthquake is minimized. Constructions can suffer diverse damages when they are put under seismic excitations. Although for a same structural configuration, region& earthquake, damages in the system are neither equal nor homogenous. So, there are several factors for these like – Structural system, Earthquake characteristics, the quality of construction, soil of location and its maintenance that define the seismic behavior of the structure. Present study represents the behavior with shear wall and not with shear wall of building. In this present study ten storey building is considered. The building is modeled in ETABS-2018 with shear wall and not with shear wall considered for analysis. For analysis purpose various loads are considered like dead load, live load and earthquake load in X and Y-direction. Various loads combinations are considered according to NBC 105:2020. The main objective of this project is to find out which will have better seismic performance either building with shear wall or without shear wall. The analysis of model is done using dynamic method in ETABS software. Finally the results of seismic behavior of buildings are compared with respect to time period, base shear, storey shear, member forces, overturning moment, displacement, stiffness and drifts.

Keyword: Shear wall, RC buildings, NBC, Displacements, Drift.

## INTRODUCTION

Many buildings in the present scenario have different configurations both in plan and elevation, which in future may subject to devastating earthquakes hence it is necessary to identify the performance of the structures to withstand against disaster primarily due to earthquake. Shear walls are not avoidable in construction of buildings; however, the behavior of structures with or without these shear wall during earthquake needs to be studied so that adequate precautions can be taken. A detailed study of structural behavior of the buildings with shear wall is essential for design and behavior in earthquake.

To perform well in an earthquake a building should possess four main attributes namely simple and regular configuration and adequate lateral Strength, stiffness and ductility. Buildings having simple regular geometry and uniformly distributed mass and stiffness in plan as well as elevation, suffer much less damage than buildings with irregular configuration.

A Building with shear wall is structure which performs against the earthquake. This structure must possess the simple, regular configuration, minimum lateral strength and also stiffness of the structure. Setback buildings are a subset of vertically irregular buildings where there are discontinuities with respect to geometry. The process to determine the response or behavior of a structure under some specified loads or combinations of loads is known as structural analysis. Shear walls are not avoidable in construction of Buildings. However, the behavior of structures with these shear wall during earthquake needs to be studied. By taking adequate precautions, the main objective of Earthquake Engineering is to design and build a structure in such a way that the damage to the structure and its structural components during an earthquake is minimized.

### Objectives of the study

The main objective of this study is to analyze multi-storey R.C. building models with shear wall and without shear wall of same pausing new building code of Nepal (NBC:105:2020).The following are the objectives of the study:

i. To model G+9 building with shear wall and without shear wall using ETABS.
ii. To analyze the models by shear wall and without shear wall by compare the values.
iii. To make notable observations from the outputs of analysis (storey shears, drifts, displacements, storey stiffness, reinforcements) so as to understand in detail the effects of earthquake loads on the behavior of building with shear wall and without shear wall.
iv. To review the result and hence derive the conclusions and discuss on the results obtained.

## LITERATURE REVIEW

A brief review of previous studies on the seismic analysis of multi storey RCC framed building with shear wall and without shear wall are presented in this section and past effort most closely related to the needs of the present work. The study of different research article help to get the suitable methodology and previous study area to get new relevant idea on this field.

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. VedanteePrasadShukla et.al (2018) This Topic Based onDesign of Irregular Building &Regular building at Different Earthquake Zone where as Slope is Greater than 3 Degree in the Which Regular and Irregular Building are Being Provided with Or without Shear wall, the Analysis is Performed By the Response Spectrum Method, Results in the form of storey displacement, storey drift, base shear and time period. Time period of the regular building is more than irregular. Seismic activities. They adopted Push over analysis method. While in the Results Comparison of base shear & Roof displacement can be seen, Base Shear for Regular Structure is more than that of Irregular Structure.

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) "Seismic behavior of Asymmetric R.C. buildings", they had modeled & analyzed a five storey framed structure using STAADPRO. 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) : Presented the analysis of multistory RC building for different plan configuration. The analysis has performed for the earthquake loads. The specification of lateral loads has been taken from IS 1893 (Part 1)2002. 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. In this study, the effect of wind and seismic both will be considered and compared them according to IS 875(Part 3)1987 and IS 1893(Part 1)2002 considering site with medium soil. They concluded that the proposed buildings with irregularities are more prone to earthquake damage & torsion is the most critical factor leading to major damage or complete collapse of building.

MagliuloG., MaddaloniG. & PetroneC (2017):"Influence of Earthquake direction on the Seismic Response of Irregular Plan R.C. Frame buildings", they used three multi storey R.C. building, representing a very common structural topology in Italy for the evaluation. 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.Shivakumaraswamy (2015) :compared the behaviour of regular and re-entrant structures in various seismic zones. Both response spectrum method and time history method was performed using ETABS. Accelerograms of Bhuj and Elecentro earthquake was used for time history method. For the regular and irregular models, storey displacements, time periods and storey shears were compared. The drift and storey displacement were more for irregular building

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. SAP 2000 software was used for the static and dynamic analysis. In case of time history method, the accelerograms of Uttarkhasi, Bhuj and Chamoli was considered. Parameters such as deflections at the joints, storey shears were compared for different models.

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. Elecentro acceleration details were used for time history method. From the results, it was observed that in case of irregular model, the displacements from pushover analysis was greater than that of time history analysis.

Arvindreddy and R.J.Fernandes (2015) : investigated the response of regular and plan irregular structures under zone V. Static and dynamic methods were conducted using ETABS. The displacements of both regular and irregular models were compared for the different methods and it was concluded that static method gave higher displacements compared to dynamic method.

METHODOLOGY AND MODELING

Earthquake design philosophy

The earthquake design philosophy may be summarized as follows:

i. Under minor but frequent shaking, the main members of the building that carry vertical and horizontal forces should not be damaged; however building parts that do not carry load may sustain repairable damage.
ii. Under moderate but occasional shaking, the main members may sustain repairable damage, while the other parts of the building may be damaged such that they may even have to be replaced after the earthquake; and
iii. Under strong but rare shaking, the main members may sustain severe (even irreparable) damage, but the building should not collapse.

Thus, after minor shaking, the building will be fully operational within a short time and the repair costs will be small. And, after moderate shaking, the building will be operational once the repair and strengthening of the damaged main members is completed. But, after a strong earthquake, the building may become dysfunctional for further use, but will stand so that people can be evacuated and property recovered. The consequences of damage have to be kept in view in the design philosophy. For example, important buildings, like hospitals and fire stations, play a critical role in post-earthquake activities and must remain functional immediately after the earthquake. These structures must sustain very little damage and should be designed for a higher level of earthquake protection. Collapse of dams during earthquakes can cause flooding in the downstream reaches, which itself can be a secondary disaster. Therefore, dams (and similarly, nuclear power plants) should be designed for still higher level of earthquake motion.

**Importance of seismic design codes**

Ground vibrations during earthquakes cause forces and deformations in structures. Structures need to be designed to withstand such forces and deformations. Seismic codes help to improve the behavior of structures so that they may withstand the earthquake effects without significant loss of life and property. Countries around the world have procedures outlined in seismic codes to help design engineers in the planning, designing, detailing and constructing of structures. An earthquake-resistant building has four virtues in it, namely:

i. Good Structural Configuration: Its size, shape and structural system carrying loads are such that they ensure a direct and smooth flow of inertia forces to the ground.
ii. Lateral Strength: The maximum lateral (horizontal) force that it can resist is such that the damage induced in it does not result in collapse.
iii. Adequate Stiffness: Its lateral load resisting system is such that the earthquake-induced deformations in it do not damage its contents under low-to moderate shaking.
iv. Good Ductility: Its capacity to undergo large deformations under severe earthquake shaking even after yielding is improved by favorable design and detailing strategies. Seismic codes coverall these aspects.

**Seismic methods of analysis**

Seismic Methods of Analysis After selecting the structural model, it is possible to perform analysis to determine the seismically induced forces in the structures. The analysis can be performed on the basis of the external action, the behavior of the structure or structural materials, and the type of structural model selected. The analysis process can be classified. Depending on the nature of the considered variables, the method of analysis can be classified. Based on the type of external action and behavior of structure, the analysis can be further classified as linear static analysis, linear dynamic analysis, non-linear static analysis, or non-linear dynamic analysis. Linear static analysis or equivalent static analysis can be used for regular structures with limited height. Linear dynamic analysis can be performed in two ways, either by the response spectrum method or by the elastic time-history method. The significant difference between linear static and linear dynamic analyses is the level of the forces and their distribution along the height of the structure. Non-linear static analysis is an improvement over linear static or dynamic analysis in the sense that it allows inelastic behavior of the structure. The method is simple to implement and provides information on the strength, deformation, and ductility of the structure, as well as the distribution of demands. This permits the identification of the critical members that are likely to reach limit states during the earthquake, to which attention should be paid during the design and detailing process. But the non-linear static method is based on many assumptions, which neglect the variation of loading patterns, the influence of higher modes of vibration, and the effect of resonance. In spite of the deficiencies, this method, known as push-over analysis, provides a reasonable estimation of the global deformation capacity, especially for structures that primarily respond according to the first mode.

A non-linear dynamic analysis or inelastic time-history analysis is the only method to describe the actual behavior of a structure during an earthquake. The method is based on the direct numerical integration of the differential equations of motion by considering the elasto-plastic deformation of the structural element. The scope of this book limits the discussion to only methods of elastic analysis; namely, the seismic coefficient method, dynamic analysis, and a brief description of the time-history method. These are explained in the sections that follow.

**Response spectrum analysis**

This method is also known as modal method or mode superposition method. The method is applicable to those structures where modes other than the fundamental one significantly affect the response of the structure. This method is based on the fact that, for certain forms of damping which are reasonable models for many buildings the response in each natural mode of vibration can be computed independently of the others, and the modal responses can be combined to determine the total response. Each mode responds with its own particular pattern of deformation (mode shape), with its own frequency (the modal frequency), and with its own modal damping. The time history of each modal response can be computed by analysis of an SDOF oscillator with properties chosen to be representative of the particular mode and the degree to which it is excited by the earthquake motion. In general, the responses need to be determined only in the first few modes because response to earthquake is primarily due to lower modes of vibration. A complete modal analysis provides the history of response forces, displacements, and deformations of a structure to a specified ground acceleration history. However, the complete response history is rarely needed for design; the maximum values of response over the duration of the earthquake usually suffice. Because the response in each vibration mode can be modeled by the response of an SDOF oscillator, the maximum response in the mode can be directly computed from the earthquake response spectrum. Procedures for combining the modal maxima to obtain estimates (but not the exact value) of the maximum of total response are available. In its most general form, the modal method for linear response analysis is applicable to arbitrary three-dimensional structural systems. However, for the purpose of design of buildings, it can often be simplified from the general case by restricting its application to the lateral motion in a plane. Planar models appropriate for each of two orthogonal lateral directions are analyzed separately and the results of the two analyses and the effects of torsional motions of the structures are combined. Generally, the method is applicable to analysis of the dynamic response of structures, which are asymmetrical or have areas of discontinuity or irregularity, in their linear range of behavior. In particular, it is applicable to analysis of forces and deformations in multi-storey buildings due to medium-intensity ground shaking, which causes a moderately large but essentially linear response in the structure.

**Concept of regular and irregular plan**

A. Plan Irregularity Asymmetric or plan irregular structures are those in which seismic response is not only translational but also tensional, and is a result of stiffness and/or mass eccentricity in the structure. Asymmetry may in fact exist in a nominally symmetric structure because of uncertainty in the evaluation of center of mass and stiffness, inaccuracy in the measurement of the dimensions of structural elements.

B. Torsion Irregularity: To be considered when floor diaphragms are rigid in their own plan in relation to the vertical structural elements that resist the lateral forces. Tensional irregularity to be considered to exist when the maximum storey drift, computed with design eccentricity, at one end of the structures transverse to an axis is more than 1.2 times the average of the storey drifts at the two ends of the structure as shown in figure 1.

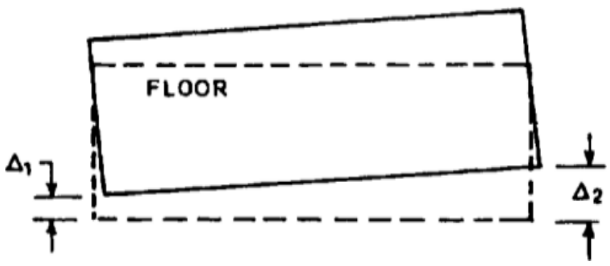


Figure 1. Torsion irregularity

C. Re-entrant Corners Plan configurations of a structure and its lateral force resisting system contain re-entrant corners, where both projections of the structure beyond the re-entrant corner are greater than 15 % of its plan dimension in the given direction.

The response spectrum technique is really a simplified special case of modal analysis. The modes of vibration are determined in period and shape in the usual way and the maximum response magnitudes corresponding to each mode are found by reference to a response spectrum. The response spectrum method has the great virtues of speed and cheapness.

**3.5 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.

**Details**

For the study, building with 10-storey with regular and irregular plan is modeled in ETABS. The building models are having plan area of 16mx16m.Forallmodelsstorey height is taken 3.175m.There are varying bays in X-direction and Y-direction. The depth of footing is taken 1.5 m. In these models beams and columns size are taken constant in all storey.

In this study following models are prepared for the study:

Model1. Building with Regular shape

Model2.Building with irregular shape.

**Loads**

Dead loads

Brick masonry :Unit Weight 19.2KN/$m^3$

Finishes (Floor Finishes) : 1 KN/$m^2$

Reinforced Concrete Elements: Unit Weight 25KN/$m^3$

Live load : 3 KN/$m^2$ on all floors except roof.

Lateral loads : Earthquake Loads as per NBC:105:2020

**Lateral load**

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. Following parameters were considered in calculating the lateral forces in the structures.

i. Zone factor (Z) = 0.3
ii. Importance factor (I) = 1
iii. Response Reduction Factor (R)= 5(SMRF)
iv. Soil Type=C

Load Combination considered in the analysis are mentioned above and for Dynamic Analysis addition combination is considered.

**Material properties**

i. Concrete grade: M25 for beam and Slab 25for Column
ii. Steel grade: Fe 500
iii. Modulus of Elasticity of concrete (Ec) ;5000√fck N/$mm^2$
**iv.** Modulus of Elasticity of Steel (Es) :2x$10^5$ N/$mm^2$

**Model description**

The figure 2 to 7 shows the different models and their 2d and 3D figure with shear wall.

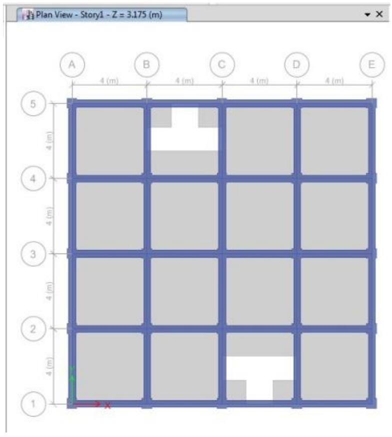

Figure 2. Plan of building For with our shear wall

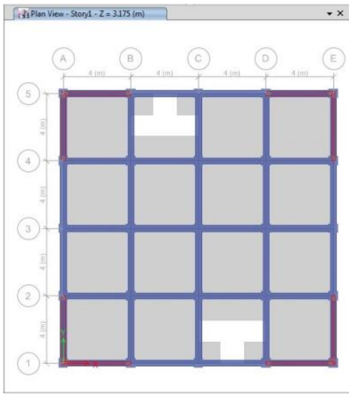

Figure 3 Plan of building For with shear wall

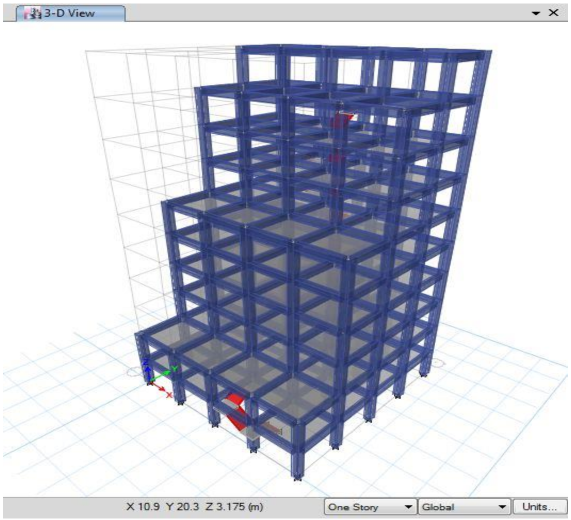

Figure 4. 3D view of building for without shear wall

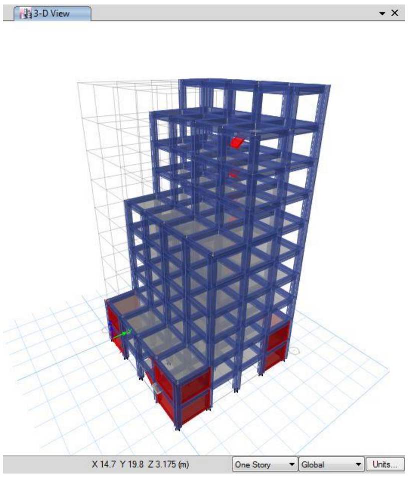

Figure 5 3D view of building for with shear wall

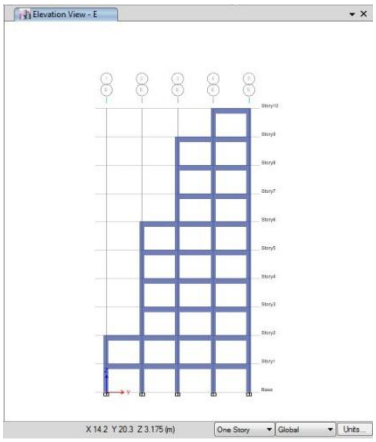

Figure 6 Elevation view of with out shear wall

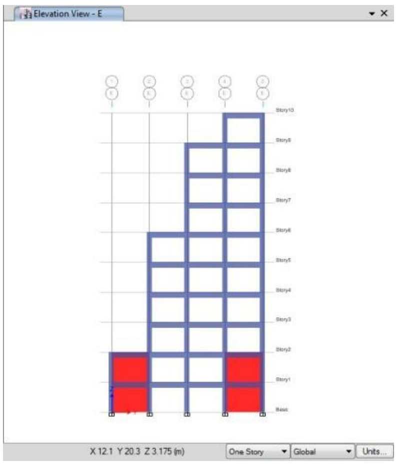

Figure 7. Elevation view of with shear wall

**RESULTS AND DISCUSSIONS**

In the present study, reinforced concrete building models i.e. G+9 with both static & Dynamic are analyzed using following NBC 105:2020.

In these models parameters maximum storey displacement, drift, storey shear, time period, base shear, overturning moment, stiffness, member forces were computed and represented graphically.

**Displacement**

The variation of displacement of different stories for all models when a response spectrum is along longitudinal direction is show in the Table 5.1.

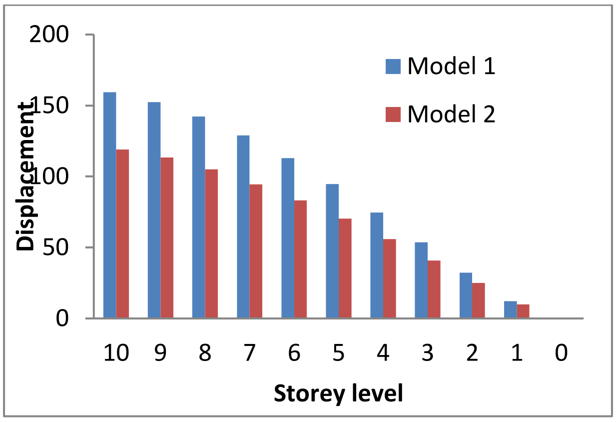


Figure 8 Displacement of models along longitudinal direction.

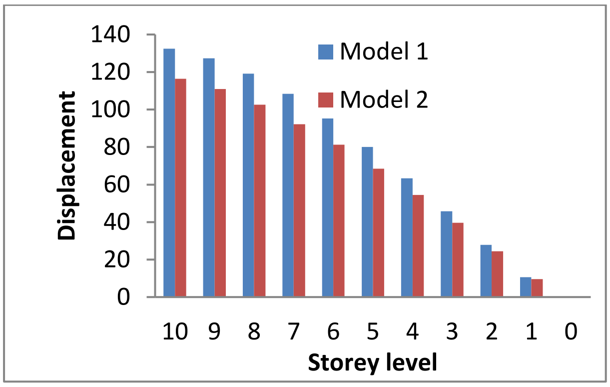


Figure 9 Displacement of models along transverse direction.

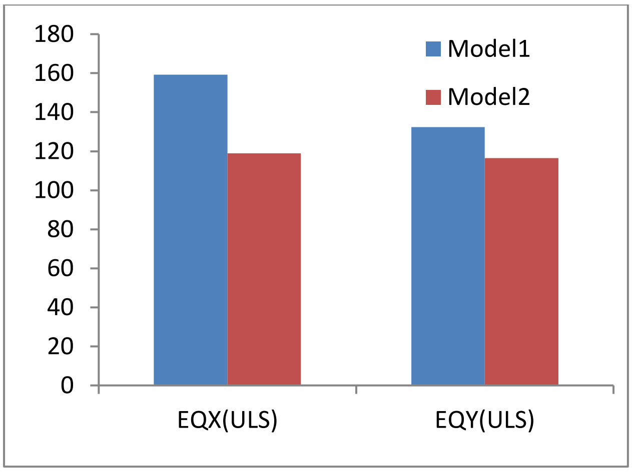


Figure 10 Top story displacement for all model

**Drift**

Interstory drift is another important significant parameter for examining the structural behaviors effectively. The inter-story drift (ISD) is the more reliable parameter to observe the structural and nonstructural damage as compared to the displacements. Figure 11, figure 12 and figure 13 shows the maximum story drift in each models. The values of drift of different stories for all models when a response spectrum is along longitudinal direction are show in the Figure 11. The data shows the maximum drift are observed in story 3 and 4 in each models. The analysis shows that the maximum drift are 0.0036 in model 1 and 0.0039 in models 2 along the x directions. The data shows the maximum drift along the x directions in models 2 is almost near to the codel provisional value. According to the Indian and Nepal standard the maximum drift ratio should be under 0.004. Hence it shows that vertical irregular buildings are critical at this condition. 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. As comparative analysis model 1 shows suitable drift value.

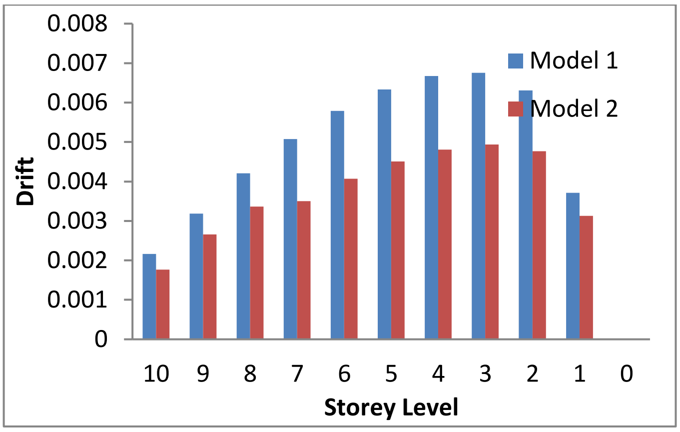


Figure 11 Maximum story drift for all model along longitudinal direction

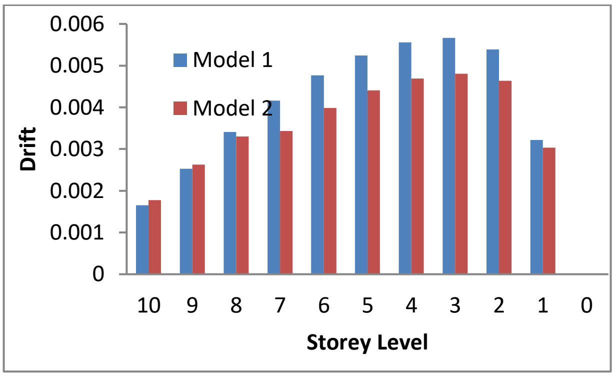


Figure 12 Maximum story drift for all model along transverse direction

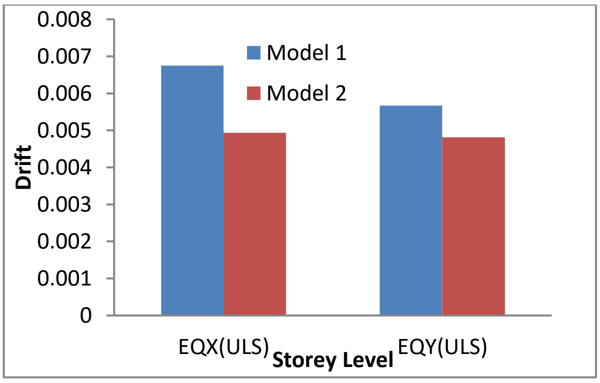


Figure 13 Top story drift for all model

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. The base shear is affected by the plan asymmetry of the building or due to lateral-torsional coupling phenomena. It also depends upon the seismic weight of the structures. In the study, the two cases are analyzed where the in model 1 and model 2. The distribution of story shear is parabolic for the equivalent static case. In both cases, the story shear is observed in both directions as shown in Fig 14. It is observed that adding the shear wall in the models, increases the story shear values of the models (Bohara, 2021; Bohara & Saha, 2022) . The values of storey shear of different stories for all models when a response spectrum is along longitudinal direction are show in the Figure 14. From Figure 14 it is observed that storey shear is more on model with shear wall than model without shear wall.

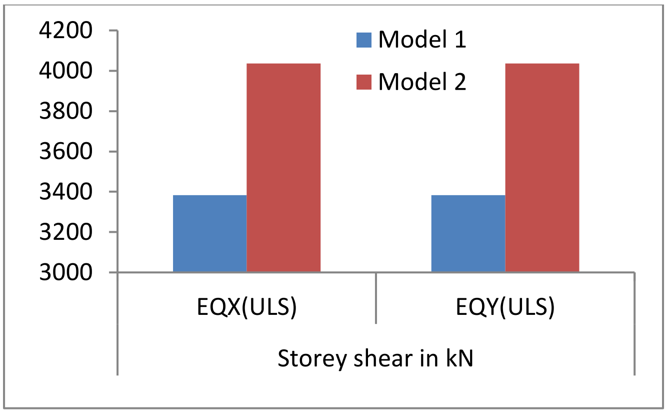


Figure 14 Maximum storey shears for models

Overturning moment

From the Figure 15, it is observed that the model 2 have more overturning moment than model1 in both longitudinal and transverse direction.

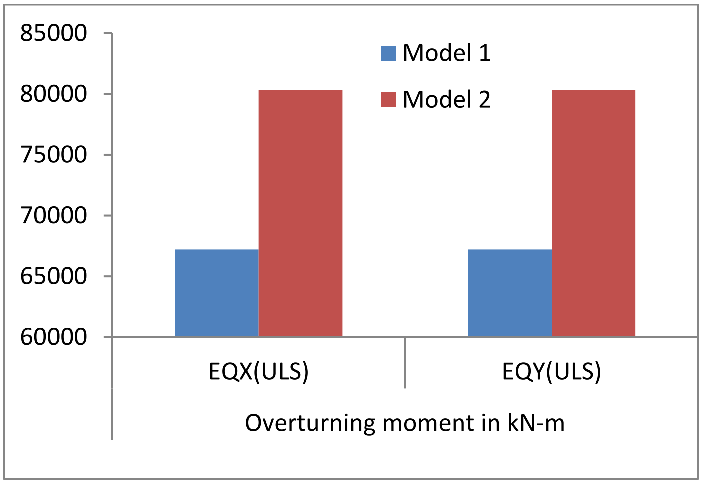


Figure 15 Overturning moment for models.

Stiffness

The values of storey stiffness of different stories for all models when a response spectrum is along longitudinal direction are show in the Figure 16. The Figure 16 shows that stiffness of model 1 is greater than model 2.

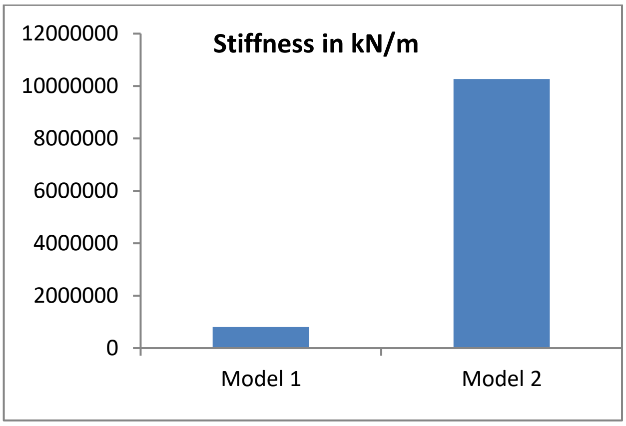


Figure 16. Stiffness of models.

Base shear

Comparison of base shear for each model is shown in figure 17. From above Figure 17 it is observed that the base shear for model 2 is more than model 1.

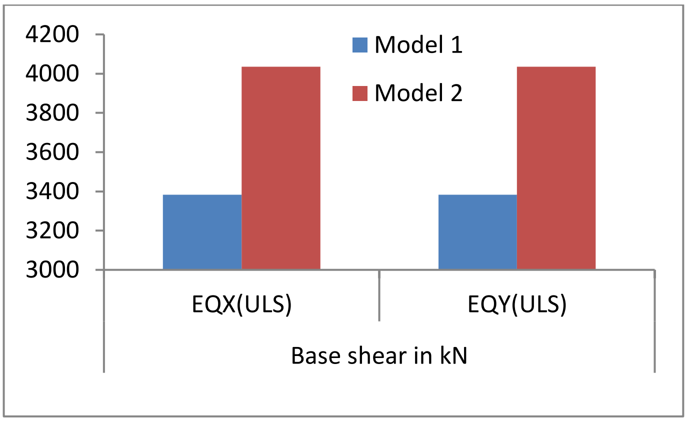


Figure 17 Base shear of models.

Time period

Normally to calculate the time period of the buildings, the code provided the empirical formula. However the formula is only for regular structures, the code-provided formula does not give accurate time period for structures when the buildings are irregular. Table 1 and 2 shows the variation of the fundamental time period of the structures on both the x and y-axis. Table 1 it is clear that where the shear wall are used to resist the lateral load, the fundamental time period at that axis is decreased however the base shear at that axis increases. The values of time period for all modes meeting the codal requirements for all four models are shown in Table 1. Comparison of time period for first three mode for each models are shown in Table 2. The data shows the as increases in mode in models the values also increased. The mode 1 and 2 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. Table 2 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.

Table 1. Values of time period for different modes for each model considered.

| Mode | Time periods (sec) | |
|---|---|---|
| | Model 1 | Model 2 |
| 1 | 0.972 | 1.013 |
| 2 | 0.963 | 0.968 |
| 3 | 0.744 | 0.812 |
| 4 | 0.365 | 0.372 |
| 5 | 0.338 | 0.352 |
| 6 | 0.312 | 0.319 |
| 7 | 0.216 | 0.205 |
| 8 | 0.202 | 0.192 |
| 9 | 0.19 | 0.178 |
| 10 | 0.15 | 0.145 |
| 11 | 0.141 | 0.138 |
| 12 | 0.134 | 0.128 |

Table 2 Comparison of time periods of each model.

| Mode | Time periods | |
|---|---|---|
| | Model 1 | Model 2 |
| 1 | 0.972 | 1.013 |
| 2 | 0.963 | 0.968 |
| 3 | 0.744 | 0.812 |

Axial forces in columns

As increases in story load also increased and bottom columns have high axial forces which results the percentages of reinforcements. The axial forces in critical columns are shown in the table 3. Data shows that axial force is more in model 1 as compared to model 2. These calculations are crucial for ensuring that the column's design is structurally sound and capable of withstanding the anticipated loads and forces without excessive deformation or failure.

Table 3 Axial forces in columns.

| Models | Axial force in kN(envelope) |
|---|---|
| | Max |
| Model 1 | -1558.53 |
| Model 2 | -1524.51 |

Torsion in columns

Torsional diaphragm rotation is considered significant parameter to evaluate torsion moment plus probability of local failure for outer element threatening the robustness of a structure that is highly dependent on the performance of the diaphragms. The floor system that experiences twisting due to differential movement of slab edges undergoes in-plane bending. The relative stiffness of the horizontal to vertical structural systems affects the torsional resistance of the frames and the in-plane rotation of the slabs. The torsion in the critical columns are shown in Table 4.

Table 4 Torsion in critical beams

| Models | Torsion in kN-m |
|---|---|
| | Max torsion(envelope) |
| Model 1 | 26.02 |
| Model 2 | 50.31 |

Bending moments in beams

This analysis helps in determining the maximum bending moment and the corresponding stress levels, which are essential for ensuring the structural integrity and safety of the beam in a given application. The bending moment in critical columns is shown in Table 5. Bending moments is the responsible for main reinforcements requirements of the beams. So that as increases in bandings moments the reinforcements demand also increases. Models 1 shows that maximum bending moments almost 311.57 kNm where as the models 2 have just 219.8 kNm.

Table 5 Bending moments in critical beams

| Models | Bending moment in kN-m |
|---|---|
| | Max bending moment(envelope) |
| Model 1 | 311.57 |
| Model 2 | 219.84 |

**CONCLUSION**

Two models of 10-storey building with shear wall and without shear wall using ETABS software. From analysis results, the parameters like storey displacements, storey drift, storey stiffness, time period, base shear and overturning moment are determined for comparative study. From the analysis carried out following conclusion are drawn:

i. The displacement of 10-storey building with shear wall has less displacement while comparing to the building without shear wall.
ii. The displacement of 10-storey building with shear wall decreases by 78% when building is without shear wall.
iii. The storey drift of the building with shear wall is less than building without shear wall. The drift has decreased 19.35% in case building with shear wall .
iv. It is observed that the storey shear of building with shear wall get increased by 9.21% than that of building without shear wall.
v. The fundamental time period of the building with shear wall is less than without shear wall.
vi. The base shear of model increase in shear wall in comparison to without shear wall.
vii. The overturning moment in building with shear wall is more than building without shear wall and it is 23% more.

viii. The stiffness of the structure gets increase when building is with shear wall.

From above conclusions it is concluded that the seismic performance of building with shear wall is better than building without shear wall because of its higher stiffness and less displacement. Also presence of shear wall in building reduces fundamental time period, axial forces, torsion in columns, storey shear, and floor displacement considerably which make it more suitable in earthquake prone areas.

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