International Journal of Innovative Research in Engineering & Management (IJIREM)
ISSN: 2350-0557, Volume-9, Issue-5, October 2022
https://doi.org/10.55524/ijirem.2022.9.5.25
Article ID IJIRD-1211, Pages 181-187
www.ijirem.org

Study on Seismic Analysis of Multi Storey RCC Frame With and Without Shear Wall Using NBC 105:2020

Suman Bhattarai[1], and Richika Rathore[2]

[1]M. Tech Scholar, Department of Civil Engineering, RIMT University, Mandi Gobindgarh, Punjab, India
[2]Assistant Professor, Department of Civil Engineering, RIMT University, Mandi Gobindgarh, Punjab, India

Correspondence should be addressed to Suman Bhattarai; suman.bhattarai789@gmail.com

ABSTRACT- The aftermath of an earthquake manifests great devastation due to unpredicted seismic motion striking extensive damage to innumerable buildings of varying degree, i.e. either
full or partial. This damage to structures in turn causes irreparable loss of life with a large number of casualties. Strengthening of structures proves to be a better option catering to the economic considerations and immediate shelter problems rather than replacement of buildings. Moreover it has been often seen that retrofitting of buildings is generally more economical as compared to demolition and reconstruction. Therefore, seismic retrofitting or strengthening of building structures is one of the most important aspects for mitigation seismic hazards especially in earthquake prone areas. Seismic strengthening or retrofitting is generally carried out in two ways either global retrofit methods or local retrofit methods. In this study, the seismic performance of reinforced concrete (RC) buildings with shear walls is studied. The effect of shear walls on lateral capacity of the building has been examined. For this purpose RC building with and without shear walls has been analyzed. The performance of the building is evaluated using parameters such as time period, lateral displacement, base shear and storey drift. It is observed from the present study that the shear wall system improves not only the lateral stiffness and strength capacity but also the displacement capacity of the structure. The seismic performance of the frame also depends upon location of shear walls and its symmetry. Hence, addition of shear walls in existing buildings is an effective tool for seismic strengthening like the other methods of retrofitting.
In this project attempt is made to understand the Seismic performance of building with shear wall and without shear wall. The main objective of this project is to find out which will have better seismic performance either building with shear wall or building without shear wall. In present study RCC building models having G+9 stories with shear wall and without shear walls considered for analysis. The analysis of model is done using equivalent static 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.

KEYWORDS- Displacement; Stiffness; Base Shear; Storey Drift.

I. INTRODUCTION

The earthquake-damaging shear and lateral forces are what the shear wall is designed to endure. Studying shear walls is an integral part of an engineering education since their functions are mandated by building standards to improve the stability and safety of buildings. When constructing a structure, engineers must account for shear walls and other safety features to ensure the project is both structurally sound and aesthetically pleasing. These are some of the possible functions that the shear wall might serve in a building design:

- Perform the function of a divider.
- Provide load-bearing walls, hence reducing the need for a - great number of columns.
- Since they are incredibly rigid in their own planes, walls take on a disproportionate amount of the lateral stresses caused by wind and seismic forces.

A strong, rigid shear wall is essential for effective shear loading. The more rigid something is, the more brittle it becomes and the more likely it is to shatter. Therefore, rigidity alone is not sufficient. It's not enough to rely just on strength, as something may be very strong while still being quite selfless. A solid, rigid wall, on the other hand, can withstand and even redirect lateral forces while providing stability. A shear wall may be found covering the elevator cab, stairwell, or central core unit. Shear walls in buildings could be built more cheaply if structural components such as beams and columns were designed with lateral force in mind .In multi-story structures, shear walls are essential because they prevent the outside walls from collapsing and protect the interior floors from sinking due to lateral movement during an earthquake. Many frame buildings can't be built to code without a shear wall to distribute lateral loads. The primary function of shear walls in these buildings is to increase the lateral stiffness of the structure. Shear walls made of reinforced concrete are often used to reduce the destructive power of earthquakes.
Numerous buildings, particularly those made of reinforced concrete, have suffered damage or collapsed as a result of earthquakes in the past. There is a lot of research on the functionality of buildings that have been damaged by earthquakes. Several key flaws are identified, including strong beam-weak column behavior; the use of low-quality concrete; an inadequate connection between the end supports; an inadequate length of slices given; the behavior

of short columns; and a lack of or unsuitable design consideration. There have been many code updates as a result of these fundamental flaws. Ductility, lateral stiffness, and strength requirements are far lower than those specified by current building regulations. These constructions are particularly vulnerable to considerable lateral displacement since their ductility values, stiffness, and strength are all relatively low. Meanwhile, in the current day, global strengthening procedures are often regarded as strength-granting tactics. In these methods, it is essential to think about how the structure's global behavior changes in response to external loads. By using this technique, the building's lateral load capacity and overall strength are both improved. Using this technology necessitates the placement of shear walls on all four sides of the building. Cost-effectiveness and convenience in building make this external strengthening technology preferable.

II. OBJECTIVES OF THE STUDY

Analysis of multi-story R.C. structure with and without shear walls utilizing the most recent Nepali building codes is the primary goal of this work (NBC:105: 2020). The study's aims are as follows:

The G+9 building information software may be evaluated in ETABS with or without shear walls.

To make a fair evaluation, we will also run the simulations using the linear equivalent method.

The output of the software will be looked at to draw conclusions about how well shear walls and buildings without them (reinforcements, drifts, displacements, storey shears, and storey stiffness) protect against earthquakes.

To improve the findings so that we can extrapolate and have a meaningful conversation about them.

III. LITERATURE REVIEW

Usually, they are installed in high-rise structures to mitigate the effects of earthquakes on the whole structure. Their primary function is to flex the body. A 25-story structure in Zone V is analysed in this research, with the shear wall's location altered to determine key performance indicators such shear, displacement, and drift with the use of the standard ETAB software. Using linear static and linear dynamic analysis, a three-dimensional model was built to examine the effect of the central concrete core wall.

Prakash A N. [1] determines Shear walls, one of the most essential elements of an earthquake-resistant structure, are the focus of this research. Shear walls, which are designed to resist twisting forces, must be placed symmetrically in the building's floor plan. In this analysis, we investigate a five-story RC building in seismic zone V that has four shear walls. There are five different shear wall arrangements to consider: skeleton alone, arranged symmetrically along the buildings outside bays, centrally, and adjacently. The lateral displacement was reduced by as much as 83% due to the presence of shear walls at the frame's centre and at the centre of the exterior bays. There has been a reduction of 86% in shear forces and 49% in axial forces in the column. The optimal location of the shear wall is suggested based on the calculated results.

Mahdi Hosseini et al [2] they optimal plan for a multi-story The examination of the solidity of RC shear is conducted in a private building that is famous for its many rooms.

Mahdi Hosseini, Mohamed Farookh et al. [3] they study 6-story RCC building fell in the HYDERABAD earthquake, covering most of Zone II. Shake load is calculated using the seismic coefficent in accordance with the IS 1893 (PART-I):2002 standard. The ETABS software is used for earthquake testing. They found that the y and x top frame deflections were decreased with type 2 shear wall provisions.

Seismic study of an RRC construction of a ten-story building with and without a shear wall is performed in a work by **Syed Ehtesha [4]** study the work is concerned with the structural integrity of the shear wall position solution for a multi-story building. There are four possible designs, designated as Zone 2, Zone 3, Zone 4, and Zone 5. It is necessary to determine parameters for these four models and seismic zones, such as storey drift and displacement. The overall cost of demolishing the shear wall column on the bottom level, including the cost of the double cases, is also determined. To conduct this comprehensive study, we use ETAB software. Any structure with less than 10 stories would not benefit from a shear wall. It's more cost-effective and useful for structures with more than 10 floors. As a precaution against earthquakes after relocation, shear walls should be built in strategic locations.

Shear walls, as mentioned by **G. Jaeger [5]**, are built to bear horizontal forces that are perpendicular to the wall's plane. With its strong in-plane stiffness and strength, shear walls can bear gravity loads while simultaneously withstanding substantial horizontal stresses. Building has been analyzed, taking into account the potential for shear wall movement. In order to meet the standards set by UBC, the programmed ETABS was used to analyze four separate shear wall spot cases for a 25-story building as a spatial structural system. Twisting moments in sections are observed to increase whenever the discrepancy between the geometrical centroid of the building and the position of the shear wall increases. Elements of a shear wall that run parallel to its displacement direction are more negatively affected by stresses than those that run perpendicular to it. Without any eccentricity, the structure's lateral motions will be uniform. To the contrary, if the shear wall is located eccentrically, then the drift will be more pronounced on one side than the others. As far as we're concerned, the optimal location for the shear wall is where the centroid and the structure's centre of mass meet.

A. Ghobarah et al. [6] This study details a software programmed for the analysis of tall buildings that incorporates connected frames and shear walls. Static and free vibration tests are performed on buildings with uniform and non-uniform parts on rigid or flexible foundations. The governing equations are developed using a continuous approach, with the structures modeled as shear-flexure cantilevers. Simple as it may seem, the method has been shown to be very efficient.

An earthquake was simulated on a 6-story building in zone II using STAAD Pro, and the earthquake load was calculated using the seismic coefficient technique (IS 1893 Part II). The four cases that were looked at were: a building with no shear wall, a building with an L-shaped shear wall, a building with a shear wall around the perimeter, and a building with a cross-shaped shear wall. There is less lateral displacement of the column in a building with a shear wall around the outside compared to one without one. **M. Ashraf [7**] This research concluded that the perimeter shear wall is the most effective kind of shear wall.

P. P. Chandurkar et al.[8] Multi-story R.C.C buildings with and without shear walls were both studied. They applied the earthquake load to the structure for several shear wall orientations (G+12, G+25, and G+38) in zones II, III, IV, and V. They calculated the amount of back-and-forth movement and narrative drift inside each individual example. In this study, it was shown that shear walls improve the cost-effectiveness of multi-story R.C.C buildings. Compared to a similar R.C.C construction without shear walls, tall structures with them greatly reduce the amount of displacement experienced at different floors. This has major repercussions for the design and implementation of shear walls in buildings.

IV. METHODOLOGY

For the purpose of the study, an ETABS model of a 10-story building is built both with and without a shear wall. The floor plans for the building models are 15 metres by 15 metres. Every model uses a storey height of three metres. The X and Y orientations each have a total of three bays available. The depth of the foundation is 1.6 metres. In these models, it is anticipated that each level will have beams and columns of the same size across the whole structure.

The following types of models have been created for this research project:

Model 1: A structure without shear walls.

Model 2: A structure with shear walls.

A. Loads

Dead loads

Brick masonry	: UnitWeight20KN/m3
Finishes (Floor Finishes)	:1.5KN/m2
Reinforced Concrete	: UnitWeight25KN/m3
Live load roof.	:3.0KN/m2 on all floors except
Lateral loads	:Earth quake Loads as per "NBC: 105:2020"

B. Lateral Load

The analogous static approach is employed, as stated by NBC: 105: 2020, to compute the lateral forces at each storey level, and the ETABS 2016 software is used to establish the time period of the modes. During the process of determining the lateral pressures exerted on the structures, the following considerations were taken into account.

- Zone factor(Z) = 0.40
- Importance Factor (I) = 1.25
- Response Reduction Factor (R) = 5(SMRF)
- Soil Type = "A"

Load Combination considered in the analysis are mentioned below

1.2DL+1.5LL

DL+0.3LL+EQX(SL)DL+0.3LL-EQX(SLS)DL+0.3LL+EQY(SL)DL+0.3LL-EQY(SLS)DL+0.3LL+EQX(ULS)DL+0.3LLEQX(ULS) DL+0.3LL+EQY(ULS)DL+0.3LL-EQY(ULS)

C. Material Properties

Concrete grade : M25 for beam & Column

Steel grade : Fe500

Modulus of Elasticity of concrete (Ec) : 5000√fckN/mm2

Modulus of Elasticity of Steel (Es) : 2x105N/mm2

D. Element Dimensions

All construction models take into account a slab with a thickness of 125 millimetres. The thickness of the outside walls is assumed to be 230 mm, the thickness of the inner walls is assumed to be 115 mm, and the dimensions of each beam are assumed to be 350 mm by 650 mm.

List of figures:

E. Model Generated in ETABS

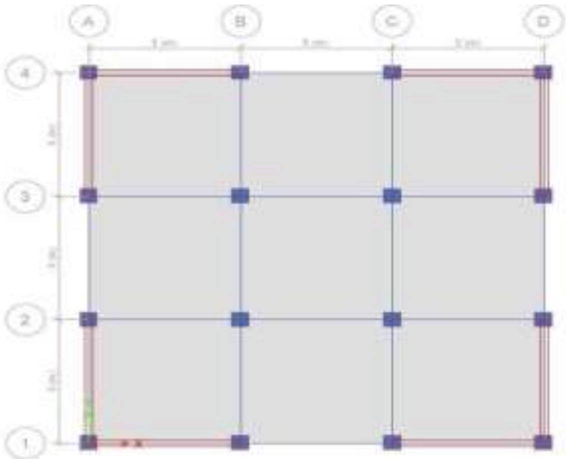

Figure 1: Plan of building with shear wall

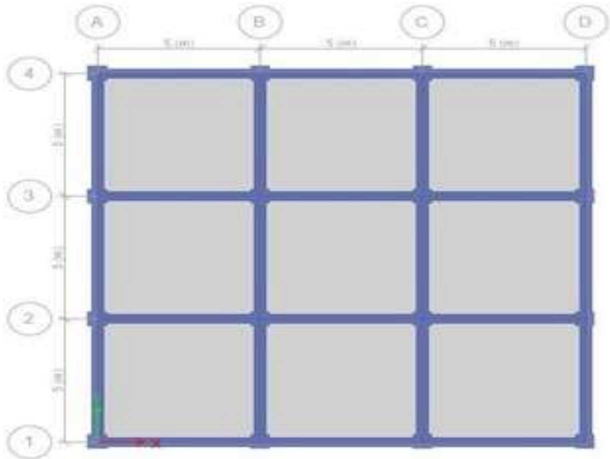

Figure 2: Plan of building without shear wall

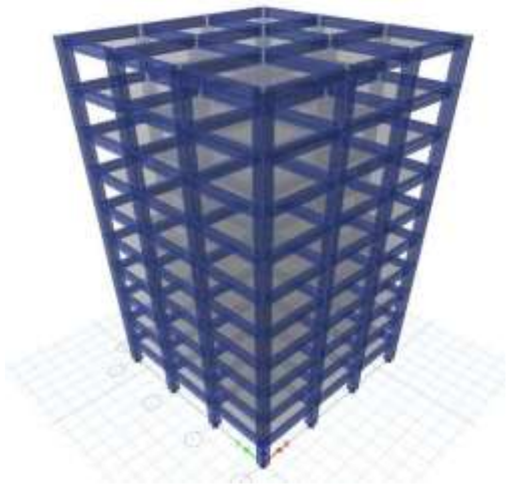

Figure 3: 3D view without shear wall

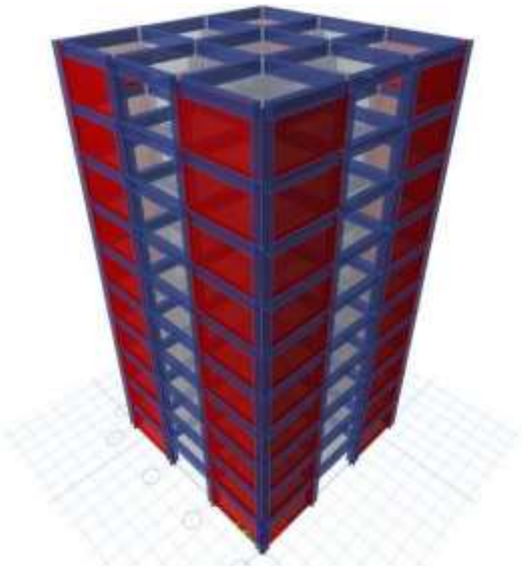

Figure 4: 3D view with shear wall

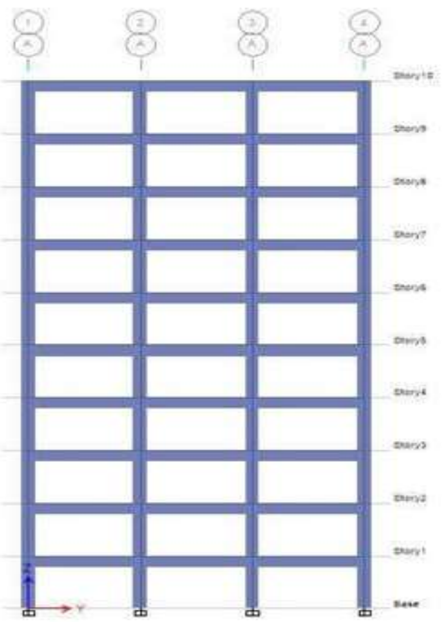

Figure 5: Elevation view of building without shear wall

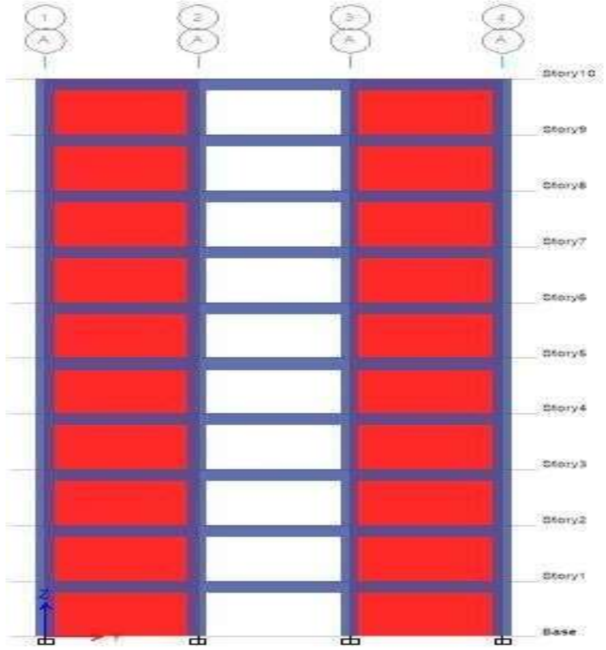

Figure 6: Elevation view of building with shear wall

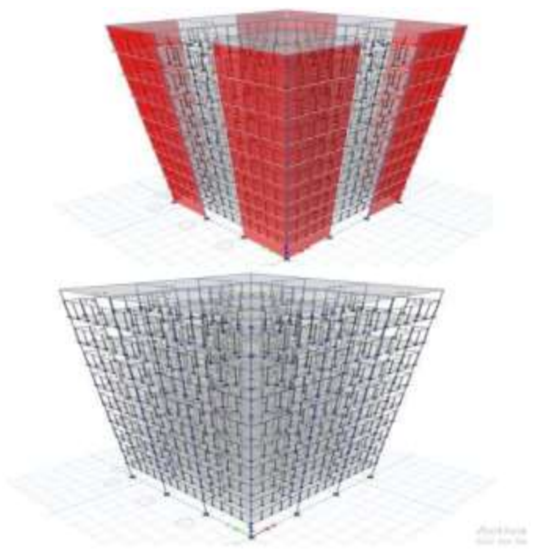

Figure 7: Wall load

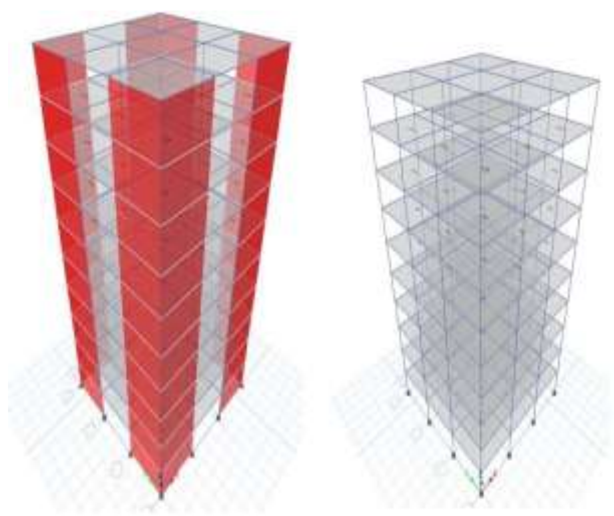

Figure 8: live load

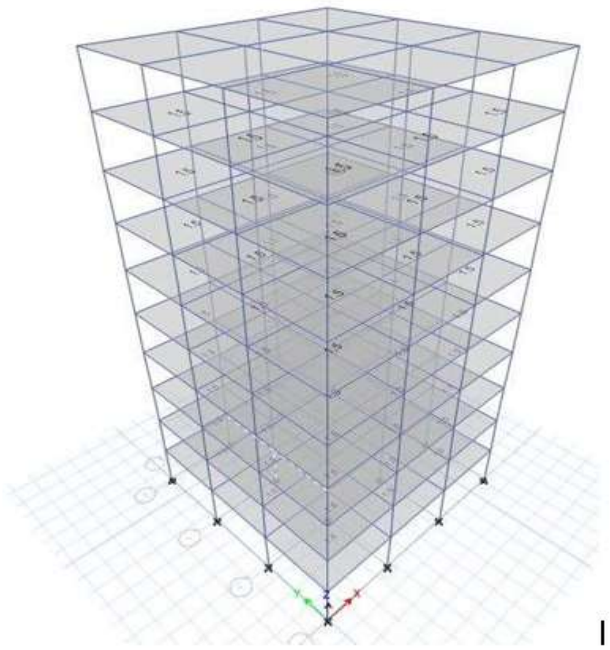

Figure 9: Floor Finish load

V. EXPERIMENTAL RESULTS

A. Displacements

Table no.1 shows that Model 1 has the higher displacement than model 2. This shows that building without shear walls has higher displacement value than building with shear walls

Table 1: Displacements of models

Models	Displacement in mm	
	EQX(ULS)	EQY(ULS)
Model 1	49.640	49.640
Model 2	11.664	11.664

Figure 10 which is the graph of displacement for both models which shows that Model 1 has the higher displacement than model 2. This shows that building without shear walls has higher displacement value than building with shear walls

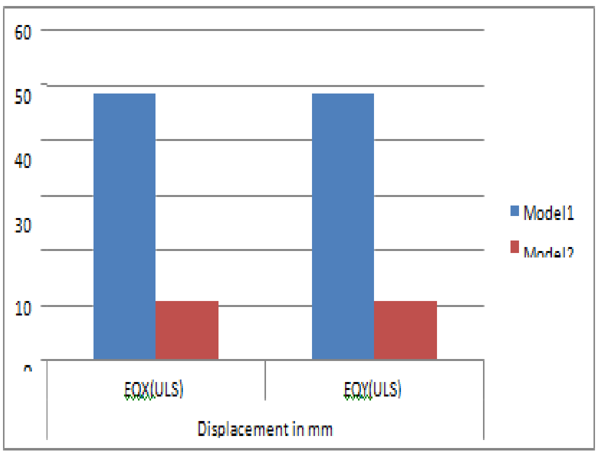

Figure 10: Storey Displacements

B. Drift

Table no.2 shows that Model 1 has the higher drift than Model 2. This shows that building without shear walls has higher drift value than building with shear walls

Table 2: Drift of Models

	Drift	
Storey Level	**Model 1**	**Model 2**
10	0.000465	0.000375
9	0.000825	0.000398
8	0.001208	0.000416
7	0.001549	0.000428
6	0.001839	0.000429
5	0.002073	0.000415
4	0.002247	0.000382
3	0.002343	0.000328
2	0.002264	0.000249
1	0.001409	0.000135
0	0	0

Figure 11 which is the graph of drift for both models which shows that building without shear walls has higher drift value than building with shear walls.

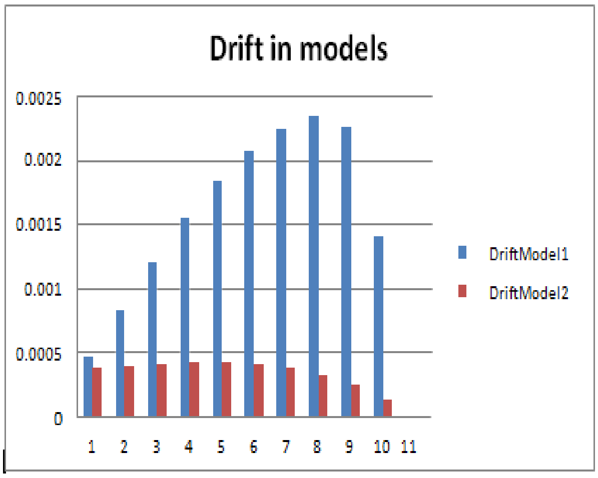

Figure 11: Storey Drifts

C. Storey Shear

Table no.3 shows that Model 2 has the higher storey shear than model 1. This shows that building with shear walls has higher storey shear value than building without shear walls

Table 3: Storey shear of models.

Models	Storey shear in Kn	
	Rx	Ry
Model 1	-3392.520	-3392.520
Model 2	-4135.4494	-4135.4494

Figure 12 is showing the graph of storey shear for both models which shows that building with shear walls has higher storey shear value than building without shear walls.

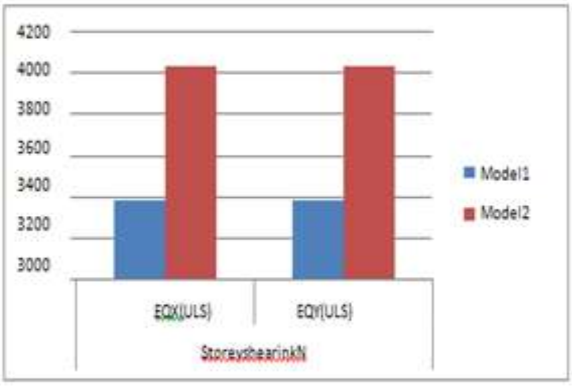

Figure 12: Storey Shear

D. Overturning Moments

Table no.4 shows that Model 2 has the higher overturning moment than model 1. This shows that building with shear walls has higher overturning moments value than building without shear walls.

Table 4: Overturning moment of models

Models	Overturning moment in kN-m	
	EQX(ULS)	EQY(ULS)
Model 1	-67211.5428	-67210.5428
Model 2	-80336.8618	-80335.8618

Figure13 which is the graph of overturning moment for both models which shows that building with shear walls has higher overturning moments value than building without shear walls

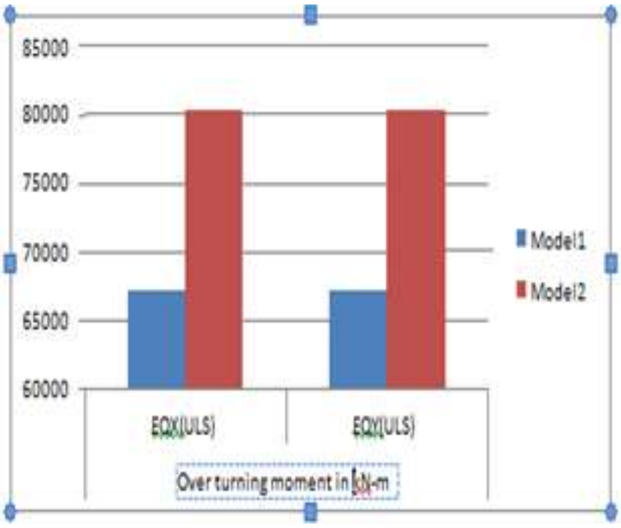

Figure 13: Overturning moment

E. Base Shear

Table no.5 shows that Model 1 has the higher base shear than model 2. This shows that building with shear walls has higher base shear value than building without shear walls.

Table 5: Base shear of models

Models	Base shear in Kn	
	EQX(ULS)	EQY(ULS)
Model 1	3382.5173	3382.5173
Model 2	-4035.4494	-4035.4494

Figure 14 is showing the graph of base shear for both models which shows that that building with shear walls has higher base shear value than building without shear walls.

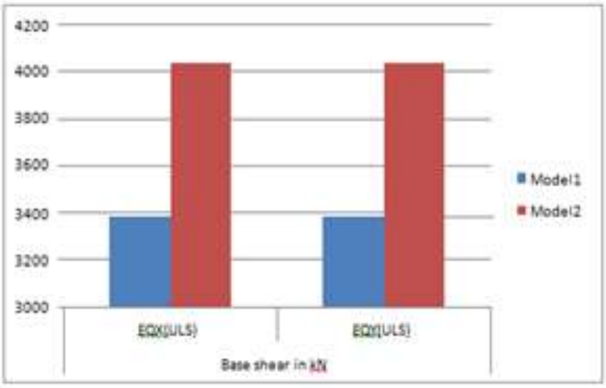

Figure 14: Base Shear

VI. CONCLUSIONS

ETABS analyses two 10-story models: one with a shear wall and one without. The study findings include storey displacements, drift, stiffness, time period, base shear, and overturning moment for comparison. The study revealed the following:

- The displacement of a 10-story structure that has shear walls has a lower value when compared to the displacement of a building that does not have shear walls.
- When a building is missing its shear wall, the displacement of a 10-story structure that has a shear wall is reduced by 78%.
- A building that has a shear wall has a storey drift that is lower than that of a structure that does not have a shear wall. The drift has lowered by 19.35 percent in cases when the structure has a shear wall.
- It was discovered that buildings with shear walls have a storey shear that is 9.21% higher than buildings that do not have shear walls.
- The building with a shear wall has a shorter fundamental time period than the one without a shear wall.
- The base shear of the model is greater when it includes a shear wall as opposed to when it does not include a shear wall.
- The overturning moment of a structure with a shear wall is greater than that of a building without a shear wall by 23%.
- When a building is constructed using shear walls, the structure's stiffness is increased.

Due to the former's greater rigidity and the latter's lower displacement, a structure with a shear wall has superior seismic performance than one without. Shear walls minimize a structure's basic time period, axial stresses, column torsion, storey shear, and floor displacement, making it more suitable for earthquake-prone zones.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES

[1] Prakash A N"Analysis of a multistoried building with and without shear wall" ,international journal for research in engineering applications and management (IJREAM), vol-04,Issue-03,2018

[2] Mahdi Hosseini ,Ahmednajm Abdullah A1-Askari,"Dyanmic analysis of multi storey building with openings in shear wall", international journal of emerging trends inengineeringanddevelopment.Issue8,Vol5, Aug-Sep2018.

[3] Mahdi Hosseini, Mohamed Farookh, Dr.HadiHosseni (2017) "Seismic analysis of high-rised building with L shape shear walls at the center Core and Corners with opening"

[4] Syed Ehtesha, Ali MohdMinhaj, Uddin Aquil(2014) "Investigation of solidarity of RC Shear Divider at various area of multi-celebrated private structure".

[5] G. Jaeger, A.A. Mufti,J.C.Mamet,"The Structural Analysis of Tall Buildings having Irregularly Positioned Shear Walls."Build.Sci.Vol.8.1973, pg.11-22.

[6] A. Ghobarah, M. Youssef, "Modeling of Reinforced Concrete Structural Walls."Civil Engineering Department, McMaster University, Hamilton, Ont., Canada. 10 March1998.

[7] M. Ashraf, Z.A. Siddiqi and M.A. Javed, "Configuration of A Multistory Building Subjected to Lateral Forces" Asian Journal of Civil Engineering (Building And Housing) Vol.9, No.5 (2008) Pg.525-537.

[8] P. P. Chandurkar, Dr. P. S. Pajgade, "Seismic Analysis of RCC Building with and without Shear Wall" International Journal of Modern Engineering Research Vol. 3, Issue.3, May-June2013, pg.1805-1810.