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Comparative Study on Wind Analysis on High-Rise Building Structure with Different Aspect Ratios with Normal Building and Building with Shear Wall

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Abstract: *The rapid increase in the population in developing countries such as India has an acute shortage of land and space. To get rid of all these problems, people have resorted to multistory or tall buildings both for commercial as well as for residential purposes. As the height of the building increases wind flow is an important consideration for the designers if the height of building exceeds 10metres than only we can consider wind loads. It is well recognized that the incorporation of lateral load resisting systems in the form of shear walls, bracing systems etc. improve the structural performance of buildings subjected to lateral forces due to lateral loads like wind loads. The building with structural shear walls Improve the lateral load resistance. In the present project, an analytical parameter study is done for the G+16 .In this project ,6 models were created in that 3 models were created normally i.e without using shear wall and of increasing aspect ratios and then 3 models of same aspect ratios as of previous 3 models were created but here shear wall is used and this models with shear wall and models without shear wall are compare and by seeing results conclusion is made USING ETABS .The results in terms of Storey drift, Storey displacement, Storey shear ,Base shear and Time period are seen.*

Keywords: High-rise structure, ETABS, Time Period, Base shear, Storey Drift, Storey displacement

I. INTRODUCTION

1.1 High-Rise Building

A building with G+4 storeys or more, measuring at least 510 feet (15 metres), is considered a highrise building, according to the buildings bye-laws of 2003. In today's world, as the population grows, so does the demand for high-rise buildings because, first, a growing population increases population density, and second, the need for land grows quickly. As a result, there is a greater demand for high rise buildings in order to address the issue of growing land requirements. High-rise structures have certain features. The structures are high & lead to higher vertical loads and higher lateral loads (mainly due to wind stress) in comparison with lower buildings. The materials used for the structural system of high-rise buildings are reinforced concrete and steel.

1.2 Shear Wall

A shear wall is a vertical component of a structure that is designed to withstand inplane lateral forces, most often caused by wind and seismic loads, in structural engineering. The International Residential Code and International Building Code are frequently used as guidelines for shear wall design.

In the design of high-rise building, the lateral system that resists wind and earthquake load often dominates. Because of their high bearing capacity, high ductility and rigidity etc. The shear wall's shape and position have a considerable impact on the structural integrity behavior under lateral loads.

II. LITERATURE REVIEW

[1] In 2020 [Ashish Padiyaar]

Presented a project on effects of lateral forces on tall buildings of different aspect ratios. He created 2 models of building height G413 with aspect ratios of 187 und 2.33 Along X direction, there are 4 bays and along Y-direction, there are 5 baysHe concluded that, displacement increases with increase in building's height. Rectangular shaped building offers more displacements and drifts when compared to the square ones. Bending moments and the shear force is maximum in lower floors compared to the upper floors, Moment and shear are less in square shaped building compared to rectangular shaped building..

[2] In 2019 [Lekhraj K pandit)

Presents a project on effects of lateral forces on tall buildings of different aspect ratios. He considered 4 nos. G+9 building with aspect ratios varying from 11 to 154. He concludes that storey displacements increases with increase in aspect nutio: Displacement is very more in model of no 1:4 conqure to model of ratio 1:1

[3] In 2017 [Chandradhara G.P)

Presents a project on effects of lateral forces on tall buildings of different aspect ratios. He created 5 models and considered aspect ratios from 0,25 to 2 and he also considered buildings of different story heights. He concludes that, bending moments in column decreases as aspect ratios are increased. Bending moment increases as the building's height increases. When designing the high rise buildings, moments in column are considered to be very critical

[4] Tabassum G Shrihatti (2015)

looked at the findings of a conventional research using RC and steel building construction stage analysis. As the effects of the investigation begin, three-dimensional RCC and 30-story steel building modelling located here in zone IV with solids and form will be taken into consideration. The rigid frames in both buildings serve as indicators of the structures

III. METHODOLOGY

3.1 Modeling and Analyzing by ETABS Application

The process of modeling & analyzing the models is explained in the following steps:

1. Initial settings and Grids
2. Define the materials and Sections property
3. Drawing components (like beam, colums, slab)
4. Defining the diaphragm
5. Defining all load pattern
6. Define load combinations
7. Apply loads
8. Finding errors
9. Model Analysis
10. Generated Results

3.2 ETABS

The building is modelled in ETABS 2016.A standalone structural analysis tool with specialised features for structural design and analysis of building systems is called ETABS [EXTENDED 3D ANALYSIS OF BUILDING SYSTEM]. Its capacity to handle the entire gamut of duties required in the process of structural analysis and design sets ETABS apart from other software programmes. It is housed in a very user-friendly environment and has advanced algorithms and cutting-edge graphics.

3.2.1 Material Properties

- Grade of concrete (M30)
- Grade of steel (Fe500)
- Density of concrete (25KN/m3)
- Density of brick wall (19KN/m3)
- Floor finishes (1.2KN/m)
- Live load (2.5KN) (IS 875 part 2)

3.2.2 Members Properties

- Thickness of RC slab (150mm)

Column size

- C – 550mm X 600mm

Beam size

- B – 300mm X 375mm

3.2.3 Thickness of brick masonry wall

- Wall = 230mm

3.2.4 Storey height

- H = 3.3528m

3.2.5 Load Calculations

- Outer Wall load = 19 x 0.23 x 3.3528 = 14.56 KN/m
- Parapet wall load = 19 x 0.102 x 1.524 = 2.35KN/m
- Floor finish load = 1.5KN/m^2
- Live load on slab =2KN

IV. ANLYTICAL MODELING

4.1 General

As Wind is a randomly varying dynamic phenomenon, it has significant dynamic effects on buildings and structures especially on high rise flexible structures. Codes and standards utilize the 'Gust loading factor (GLF)' approach for estimating dynamic effect on high-rise structures.

4.2 Description of Models.

1. **Model 1:** The model contains 5 bays along both the directions, the distance between the two columns is 4 meters each along X-direction and in 3 metres each along Y direction. Aspect ratio of this model is = (H/B) =(52/15)=3.5m
2. **Model 2:** The Model contains 5 bays along both the directions, the distance between the two columns is 4 meters each along the X-direction and also 4 meters each along the Y-direction. Aspect ratio of this model is (H/B) = (52/20) = 2.6m
3. **Model 3:** The Model contains 5 bays along both the directions, the distance between the two columns is 4 meters each along the X-direction and 5 metres each along the Y-direction. Aspect ratio of this model is (HB) = (52/25) =2.08m
4. **Model 4:** The model contains 5 bays along both the directions, the distance between the two columns is 4 meters each along X-direction and in 3 metres each along Y-direction. Aspect ratio of this model is = (H/B) =(52/15)=3.5m (with shear wall)
5. **Model 5:** The Model contains 5 bays along both the directions, the distance between the two columns is 4 meters each along the X-direction and also 4 meters each along the Y-direction. Aspect ratio of this model is (H/B) = (52/20) = 2.6m (with shear wall)
6. **Model 6:** The Model contains 5 bays along both the directions, the distance between the two columns is 4 meters each along the X-direction and 5 metres each along the Y-direction. Aspect ratio of this model is (HB) = (52/25) =2.08m (with shear wall)

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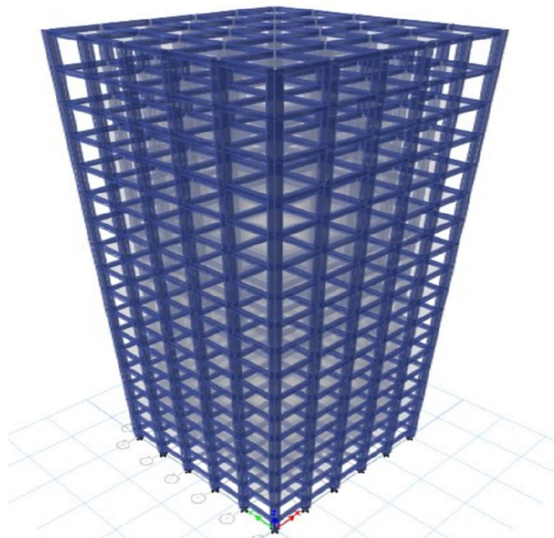
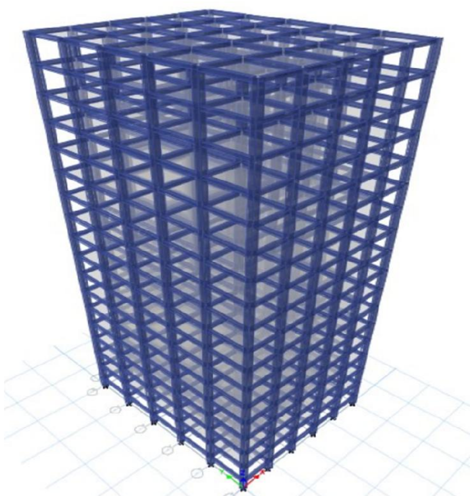
MODEL 1



MODEL 2



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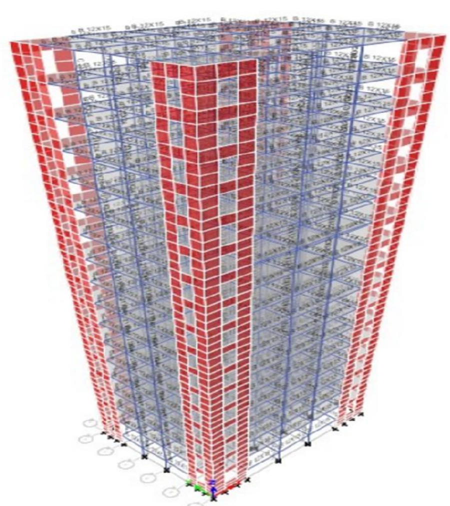
MODEL 3



MODEL 4

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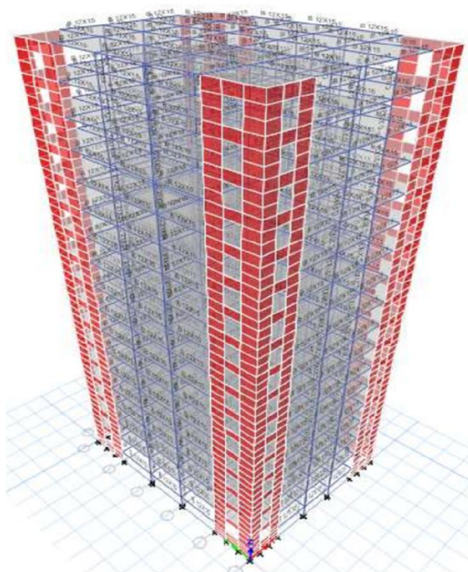
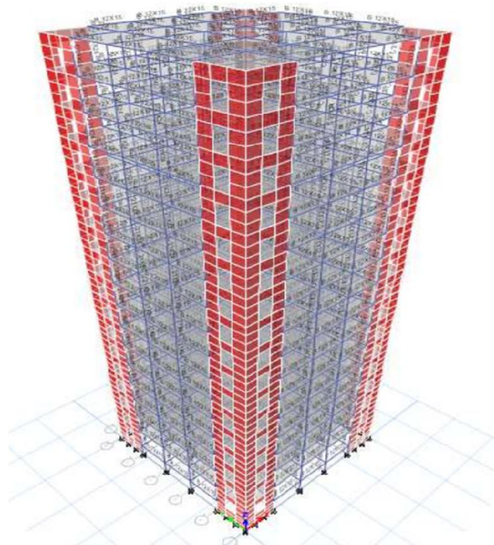


MODEL 5



MODEL6

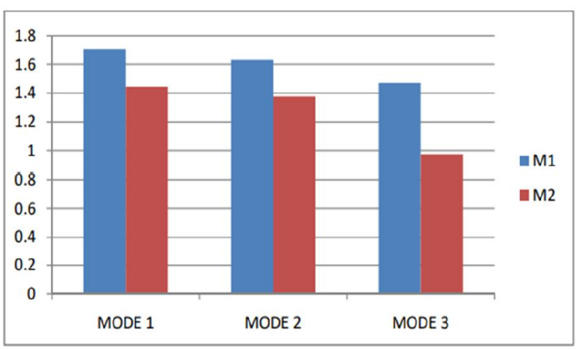
V. RESULTS

Here we are considering 3 Models and seeing results of all 3 models and each model is designed with different aspect ratios without using shear wall and By using shear wall at corners .The results which are attained by these Analysis are associated by the parameters such as Time period, base shear, storey displacement and storey shear.

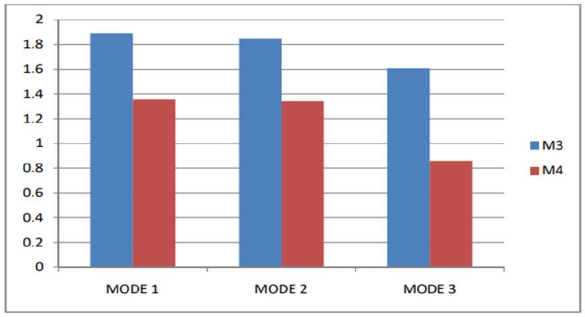
5.1. Time Period

All items, including structures and the ground, have a natural period, is the amount of time it takes to swing from point A to point B and back. When seismic wave travel beneath ground, they move at their natural period. It will pose a problem if the period of both ground an building resting on ground is same. When these two vibrate at the same rate, they resonate which leads to disaster. Height is also one of major factors affecting the period. Following the analysis, the time period will display the values in seconds that occurred throughout the time it took for the ground of seismic waves to swing backwards and forwards.

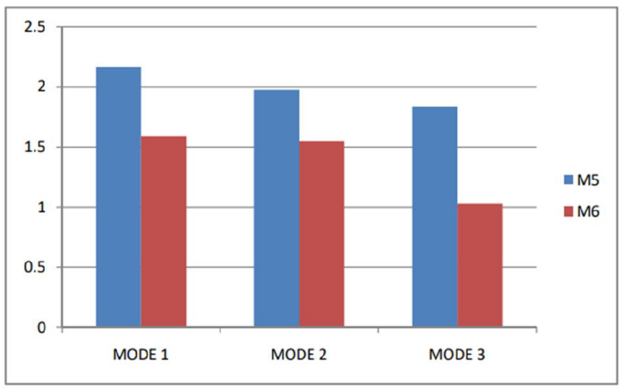
5.1.1. Seeing Results of Model 1 with Each Bays as 4mx3m



5.1.2. Seeing Results of Model 2 with Each Bays as 4mx4m



5.1.3. Seeing Results of Model 3 with Each Bays as 4mx5m



5.2. Base Shear

The highest lateral fincethat will occur at the foundation of a structure as result of sec activities known as base shear. When a structure is exposed to seismic or wind load, the largest lateral forces at the building's base are known as base shear.

5.2.1 Seeing Results of Model 1 with Each Bays as 4mx3m

Fig 5.2.1.1 Base shear in x direction

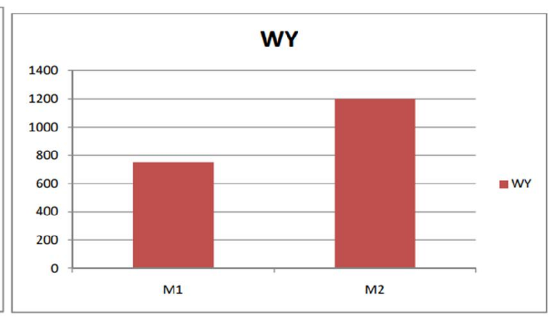


Fig 5.2.1.2. Base shear in y direction

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5.2.2 Seeing Results of Model 2 with Each Bays as 4mx4m

Fig 5.2.2.1 Base shear in x direction

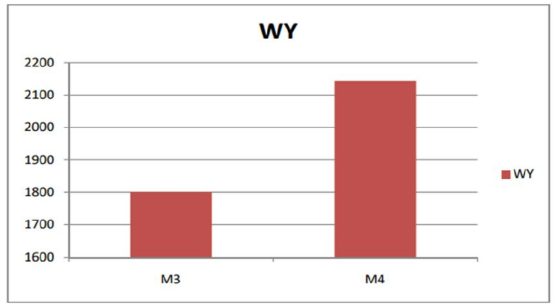

Fig 5.2.2.2 Base shear in y direction

5.2.3 Seeing Results of Model 3 with Each Bays as 4mx5m

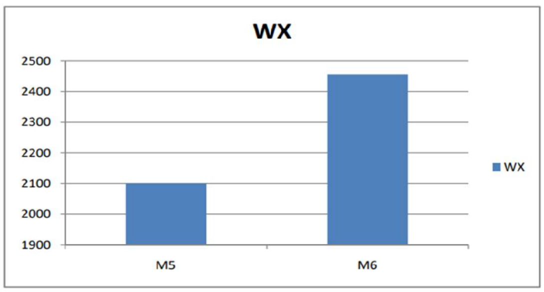

Fig 5.2.3.1 Base shear in x direction

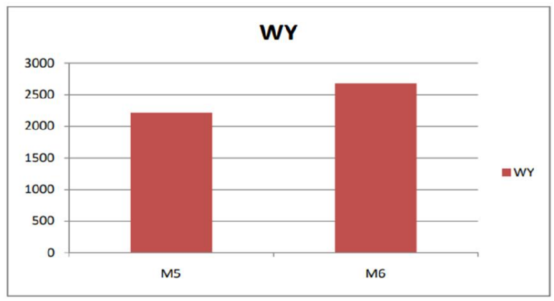

Fig 5.2.3.2 Base shear in x direction

5.3 Storey Displacement

Following the study, the displacement values were displayed in tables (6.2) and illustrated in charts. This method is applicable to the model's transverse and longitudinal directions. The displacement is greatest at the highest point of the level structure and lowest at the base level. according to this. When a result, as lateral displacement increases, so does the storey height.

5.3.1 Seeing Results of Model 1 with Each Bays as 4mx3m

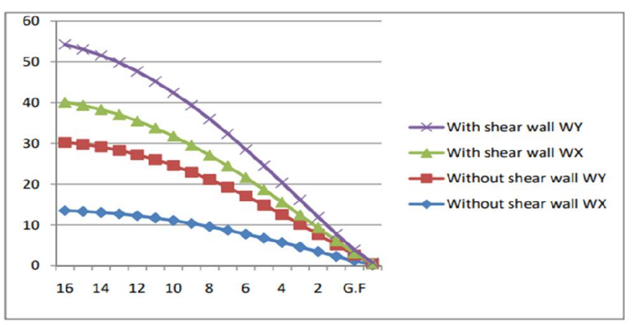

Fig 5.3.1

5.3.2 Seeing Results of Model 2 with Each Bays as 4mx4m

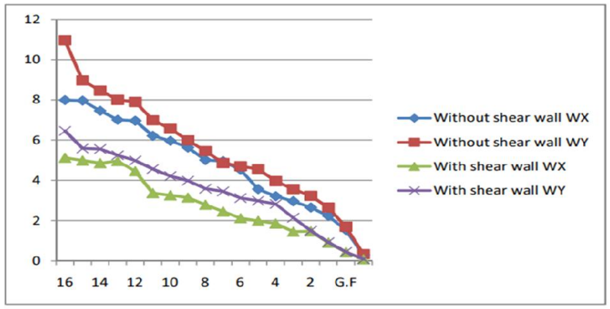

Fig 5.3.2

5.3.3 Seeing Results of Model 3 with Each Bays as 4mx5m

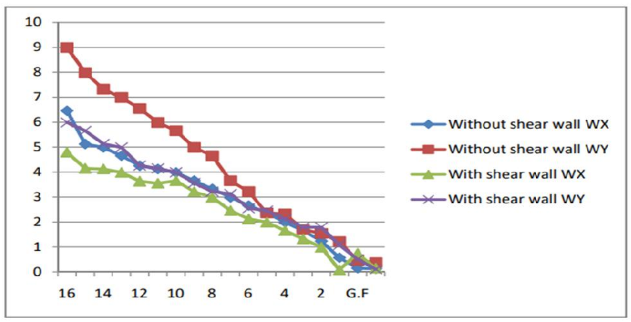

Fig 5.3.3

5.4 Storey Drift

Drift is mostly defined as comparative of lateral displacement of two floors. Drift is absolutely essential for control limit damage to interiors and exteriors part systems. According to INDIAN STANDARD 1893 (part 1) of 2002 consider that the allowable story drift is measured as 0.0004 times of one story height of structure. According to the tale drift notion, the drift is the least at the bottom and top of the story structure, and the most at the centre.

5.4.1 Seeing Results of Model 1 with Each Bays as 4mx3m

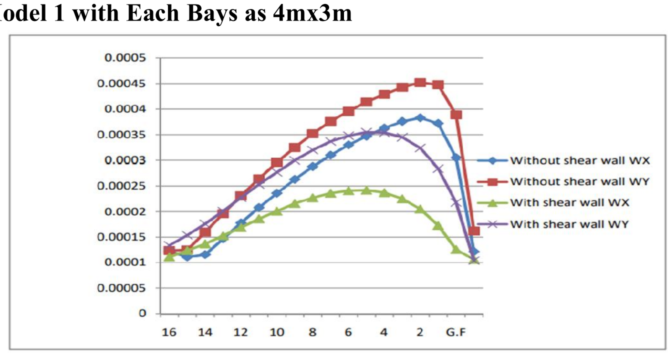

Fig 5.4.1 Storey Drift

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5.4.2 Seeing Results of Model 2 with Each Bays as 4mx4m

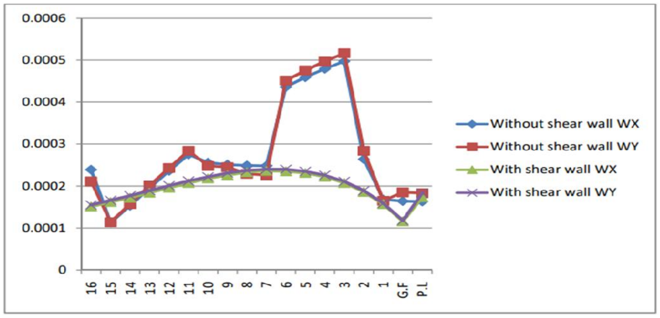

Fig 5.4.2 Storey Drift

5.4.3 Seeing Results of Model 3 with Each Bays as 4mx5m

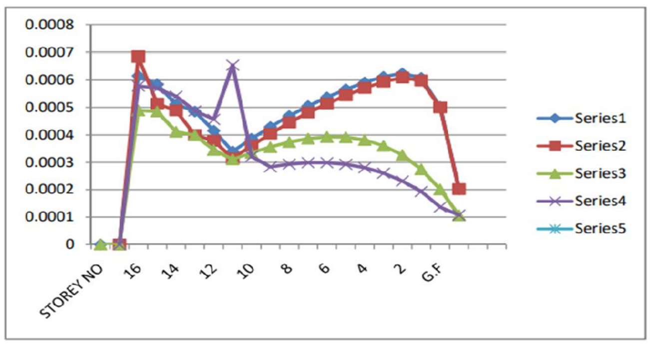

Fig 5.4.3 Storey Drift

5.5 Storey Shear

The effect of lateral loading on a multi-story building owing to seismic or wind loads is known as Storey Shear. The graphs of Storey Shear and Storey Drift tell an useful storey. The storey shear graph shows height-wise distribution storey shears and lateral forces. A normalized storey shear graph has its shear values divided by the shear that occurs at ground level so that the normalized shear at that level is 1.0. It is therefore important to specify the ground level accurately in the form so that the graph is normalized to the correct shear.

5.5.1 Seeing Results of Model 1 with Each Bays as 4mx3m

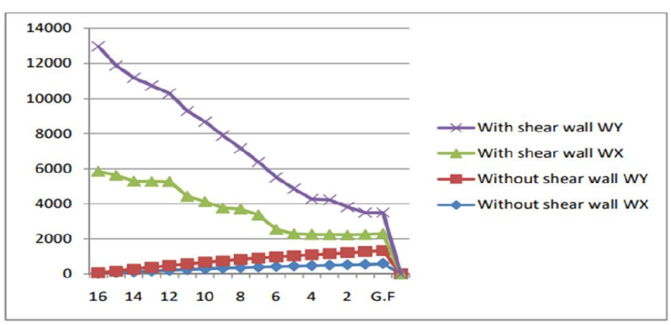

Fig 5.5.1 STOREY SHEAR

5.5.2 Seeing Results of Model 2 with Each Bays as 4mx4m

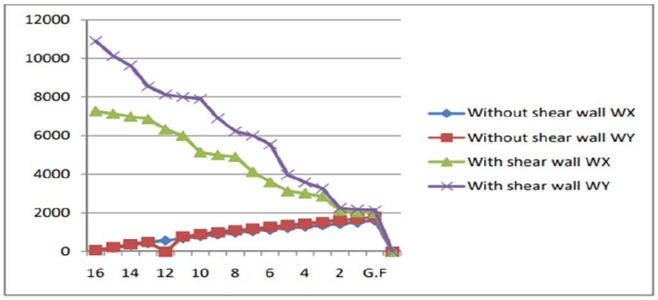

Fig 5.5.1 STOREY SHEAR

5.5.3 Seeing Results of Model 3 with Each Bays as 4mx5m

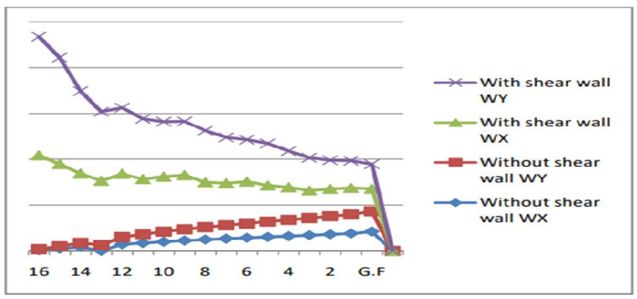

Fig 5.5.3 STOREY SHEAR

VI. CONCLUSIONS AND FUTURE SCOPE

6.1 Conclusion

The study's main goal was to figure out how a building's construction would react in a wind loads case in the absence of shear wall and by the presence of shear wall in the building . By reference to IS 875-1987(part 111) and 15 875-1987(part IV), all load scenarios applied to the building structure can be determined (Part V). A variety of factors were detected in this study, including changes in beam behaviour, storry drift, storey shear, Base shear, Time period and structural displacement. The higher the building's storey, the greater the lateral wind force will be there. This causes torsion and displacement in the building's diaphragm. The eccentricity between the centre of gravity of the load and the centre of gravity of the mass is created by diaphragm displacement. High wind pressure causes higher diaphragm movement in high-rise structures. It causes structural members to be subjected to increased stresses.

After performing the analysis of the building using Etabs software some of the Conclusions that are obtained are described below are:

1. According to tale drift, the story drift is least at bottom, and top at the height of the structure and mostly at the centre.
2. The storey drift of buildings without shear walls is greater than that of buildings with shear walls, and as the aspect ratio rises, both buildings with and without shear walls experience an increase in drift.
3. Storey drift is maximum in model 3 of building where there is no shear wall that is 0.000684 and least in model 1 of building having shear wall that is 0.000104 therefore we can say that storey drift will be max where there is not shear wall.
4. Storey displacements increases as height of building increases in both the cases that is building with shear wall and as well as in building with no shear wall.
5. Here for both models it is common that storey displacement will increase gradually from base and will be max at top.
6. Displacement gets decreasing as the aspect ratio increases and so on.
7. Here in our Models we can see that the max displacement value is seen in Model 1. i.e 16.732(Without shear

wall building) and min in Model 3. i.e 0.104(With shear wall building).

8. As height increases shear force also gets increases i.eIn building with shear wall structure but it is vice-versa in building having without shear wall structure (i.e. it gets decreases as building height increases)
9. Shear wall buildings has more base shear value than the building with shear wall structures.
10. Finally, shear walls show that they have higher stiffness in comparison to structures without them since they exhibit less time under stress, which is helpful for building structures.

6.2 Future Scope of the Work

1. Shear walls have a vast application in the construction industry and have generated interest ever since their introduction to the market.
2. Shear walls are typically built as a way to balance the lateral loads that are operating on the structure, which are mostly caused by wind and earthquake loads.
3. Ground water displacement is the primary cause of the increasing intensity of earthquakes, thus it is always advisable to protect ourselves from future disasters in order to deal with the various repercussions of earthquakes.
4. Shear walls offer earthquake resilience and can withstand horizontal lateral force.
5. Shear walls aid in reducing deflection, and RCC shear walls are simple to build with the right reinforcement detailing.
6. Shear walls reduce both structural and non-structural damage from earthquakes.
7. As the height of buildings is increasing, it is more before considering that a structure can resist vertical or lateral load such as earthquake and wind load (Verma et al., 2022) rather than cost-effectiveness (Firdose et al., 2022 and Seo et al., 2010).
8. By changing the aspect ratios we can come to conclusion that how the building characteristics like displacement, shear etc will react.

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