Analysis of A Tall Structure Considering Shear Wall With Different Sections of Openings Using Etabs

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Abstract- *High-rise building construction is becoming more and more common in the modern period due to aesthetic reasons and land scarcity. Lateral forces have a greater impact on tall structures.Shear walls are typically designed to minimise the cause of damage, such as seismic and wind loads. Structures are getting thinner and more prone to swaying these days, making them more dangerous during earthquakes. In the past, engineers and researchers have designed structures to withstand earthquakes.The implementation of lateral load-resisting devices in building configuration has significantly enhanced the structure's seismic performance, according to numerous empirical investigations. The primary purpose of shear walls, which are flexural members, is to prevent high-rise structures from completely collapsing under earthquake pressures.*

In this study, the G+10-story building is analysed utilising the response spectrum method with ETABS 2016. By altering the opening's location and size, five distinct models are examined. The analysis findings of each model are compared, and the most appropriate opening position is determined. The structure is examined for type 2 soil conditions and seismic Zone V. Story shear, maximum displacement, and story drift are the results that are compared.

Keywords- Shear wall openings, shape of openings , seismic loads ,ultimate strength , economy.

I. INTRODUCTION

Since earthquakes can happen anywhere in the world and are more harmful for tall buildings during large ones, extra care should be taken in their study and construction. This is because towering buildings frequently house thousands of people. The construction should be built to withstand earthquakes and maintain the building's functionality without suffering significant structural damage. It is necessary to design buildings to withstand lateral force, which can be accomplished by making them more rigid. Adding a shear wall enhanced the stiffness. Compared to buildings having a structure wall in addition to the frame, framed buildings are less rigid and are less likely to sustain damage or excessive deformation.

In addition to slabs, beams, and columns, shear walls—vertical plate-like RC walls—are frequently seen in reinforced concrete (RC) buildings. These walls are often continuous throughout the building's height, beginning at the foundation level. In high-rise buildings, their thickness can range from 150 mm to 400 mm. Shear walls are typically incorporated into buildings' breadth and length. Shear walls, which bear seismic loads downhill to the base, resemble broad beams orientated vertically.

Vertical components of the horizontal force-resisting system are called shear walls. The purpose of shear walls is to mitigate the impact of lateral loads on a structure. Straight external walls that usually form a box and give the structure all of its lateral support are known as shear walls in residential construction. A stiff vertical diaphragm used in building construction that may transfer lateral stresses parallel to the planes of exterior walls, floors and roofs to the ground foundation.The weight of the building and its occupants, along with lateral stresses brought on by wind, earthquakes, and uneven settlement loads, produces strong torsion. When a rigid wall is attached or placed inside a frame, it reinforces the frame, keeping it in place and preventing rotation at the joints. Particularly crucial are shear walls in tall structures that are vulnerable to seismic and lateral wind stresses.

Over the past few decades, shear walls have grown in importance in residential mid- and high-rise structures. These walls reduce lateral displacements under earthquake loads and are incorporated into building plans as part of an earthquake-resistant building design. The result is shear-wall frame structures. Buildings with shear walls often have regular elevations and plans.

SHEAR WALL

A vertical structural component called a shear wall is made to withstand lateral pressures operating on a building, usually those caused by wind and seismic activity. High inplane stiffness and strength are its primary means of efficiently transferring horizontal loads from walls, floors, and roofs to the base. Shear walls are usually made of masonry or reinforced concrete and are positioned in the building layout to maximise their load-resisting capacity without sacrificing architectural functionality. These locations are frequently around stairwells, lifts or perimeters. By minimising lateral displacements, decreasing inter-story drift, and boosting overall stability, their inclusion greatly improves the seismic performance of structures. Shear walls are an essential part of earthquake-resistant and high-rise architecture, improving occupant safety and structural integrity while guaranteeing adherence to contemporary performance and design standards.

II. OBJECTIVES OF THE RESEARCH

- Analysis of G+10 storied framed structure using ETABS software.
- To study the response of building with openings arranged in different patterns and varying the size of opening for seismic zone V.
- To study the storey displacement, storey drift, time period and storey acceleration of the building with or without opening in shear wall.
- Comparing the analysis results like story drift, displacement and base shear results of all models and check the best method of opening.

III. REVIEW OF LITERATURE SURVEY

Manish Bhoir and Dr. Vikram Patil (2024) used ETABS to do a 3-D analysis of the frame shear wall structure for three distinct building heights in Mumbai, which is classified as terrain category 3 according to I.S. 875 (Part3)-2015. A dynamic wind force, also known as a gust force, was used to analyse the types and locations of shear wall apertures.

As the shear wall's aperture widens, it was found that deflection, bending moment, and shear force all rise. The strength and stiffness of a shear wall are reduced by the presence of openings, depending on the size and geometry of the openings. Shear force, bending moment, and deflection are more frequently encountered in G+70 in the across direction as a result of the observation that growing forces in the across direction become more essential than in the along direction as building height increases. In both the across and along directions, the deflection for G+70 is greater than what is allowed for wind. It was therefore determined that, as building height increases, shear wall openings should be avoided or kept to a minimum in size and quantity.

IV. METHODOLOGY

Steps involved in Modelling and Analysis

Step 1: Research paper from different authors was summarized in this section who have focused towards analyzing multi storey high rise structures considering seismic loads with different zones and soil condition

Step 2: In order to initiate the modelling of the case study, firstly there's need to initialize the model on the basis of defining display units on metric SI in region India as ETABS supports the building codes of different nations. The steel code was considered as per IS 800:2007 and concrete design code as per IS 456:2000.

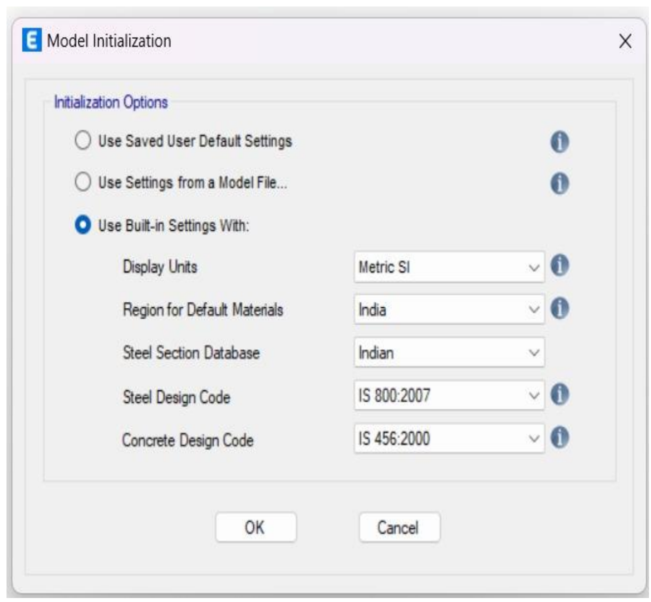

Fig 1 Model Initialization

Step 3: ETABS provides the option of modelling the structure with an easy option of Quick Template where the grids can be defined in X, Y and Z direction. Here in this case, 7 bays in X and Y direction with a constant spacing of 3.5m in both X and Y direction making the model symmetrical in nature. G+10storey structure is considered with typical storey height of 3m and Bottom storey height of 3m.

Step 4: Next step is to define the material properties of concrete and steel. Here in this case study, green concrete and rebar HYSD 550 is considered and its predefined properties are available in the ETABS application.

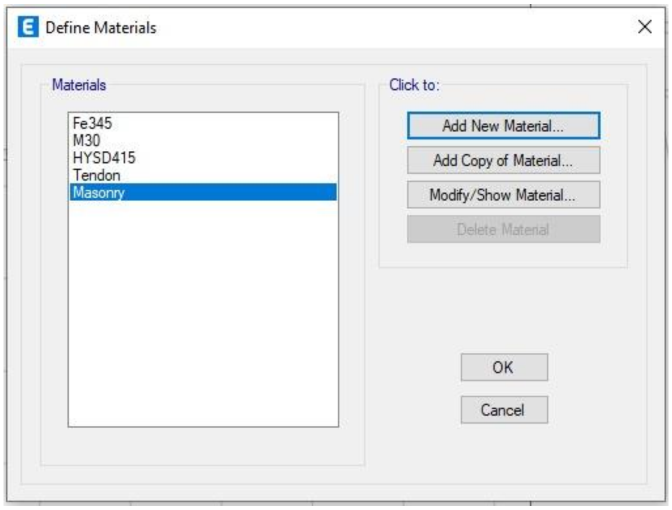

Fig Defining Materials

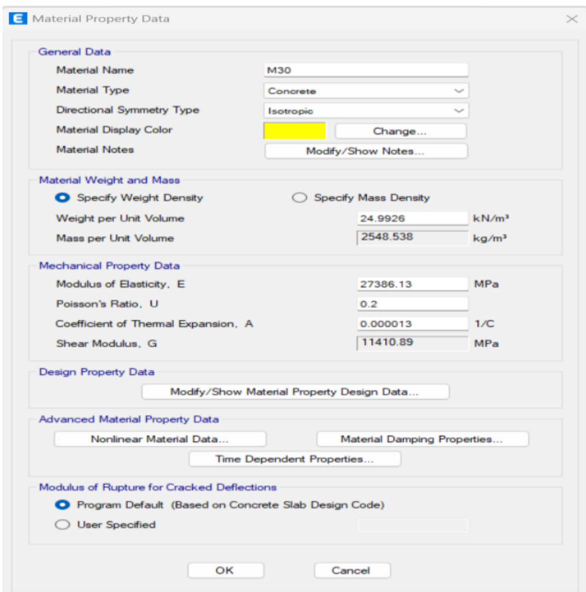

Fig 3Defining Properties of Concrete M30.

Step 5: Defining section properties for Beam, Column. Beam size of 400x350mm, Column size of 400x400mm and Slab size of 200 mm is considered in the study.

Step 6: Assigning Fixed Support at bottom of the structure in X, Y and Z direction in both the considered cases.

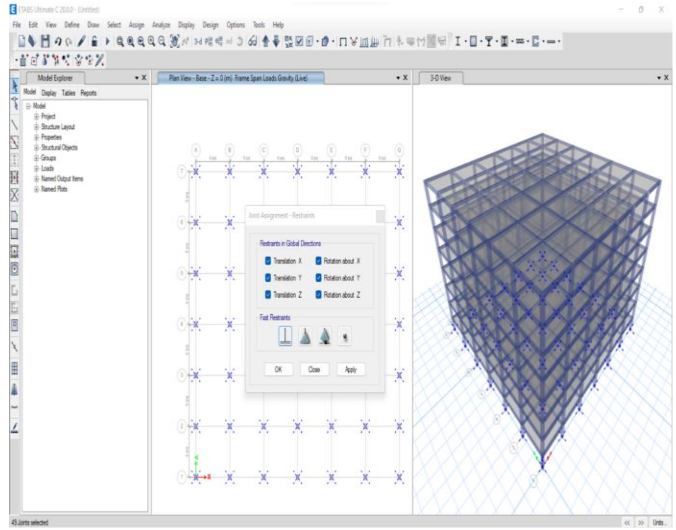

Fig 4 Assigning Fixed Support

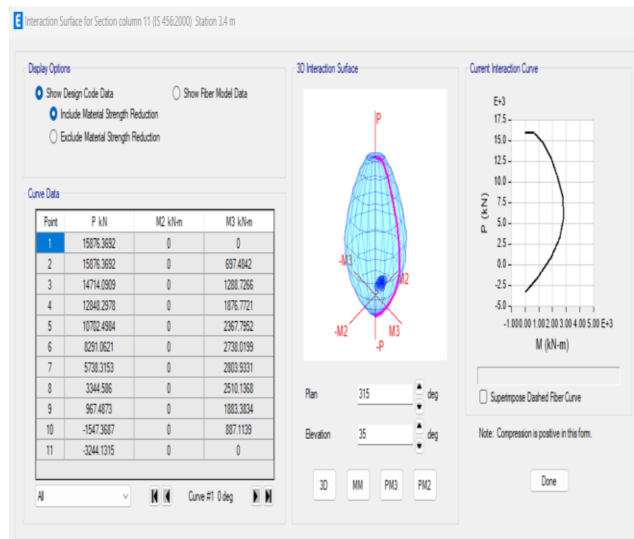

Fig 5 Interaction of Column

Step 7: Defining Load cases for dead load, live load, temperature load and seismic analysis for X and Y Direction.

Step 8 Defining Seismic Loading as per IS 1893: 2016 Part I.

Step 9: Conducting the model check for both the cases in ETABS and analyzing the structure for dead load, stress analysis and displacement.

V. RESULTS AND DISCUSSION

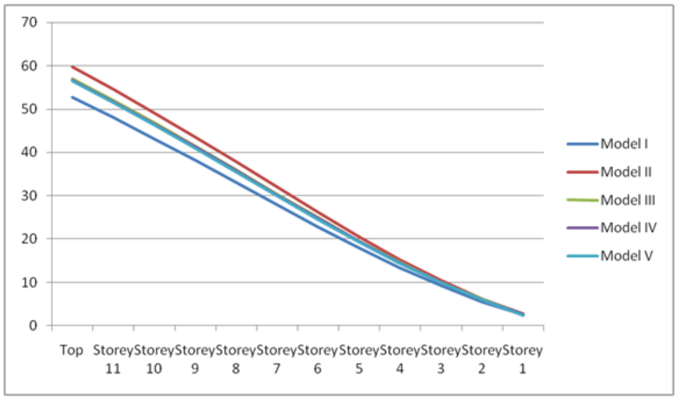

Fig Storey Displacement in mm

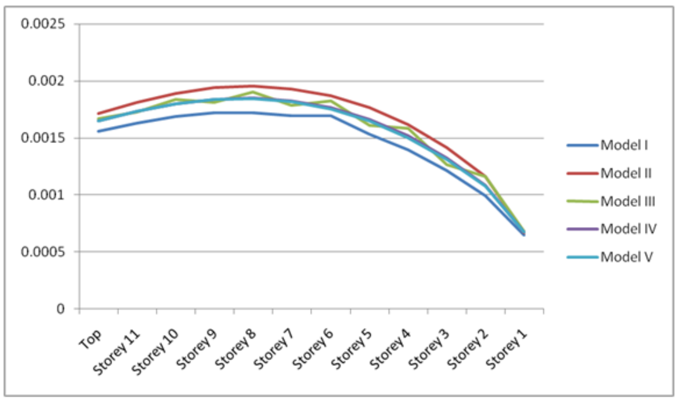

Fig Storey Drift

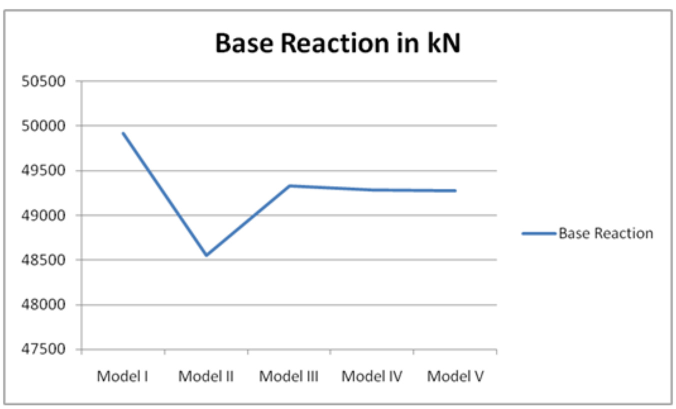

Fig Base Shear in Kn

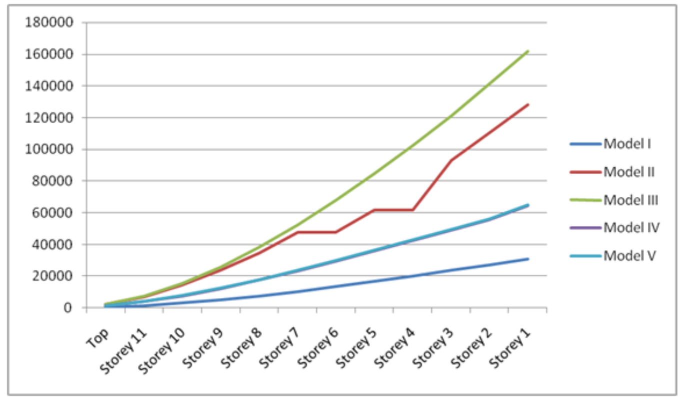

Fig Bending Moment in kN

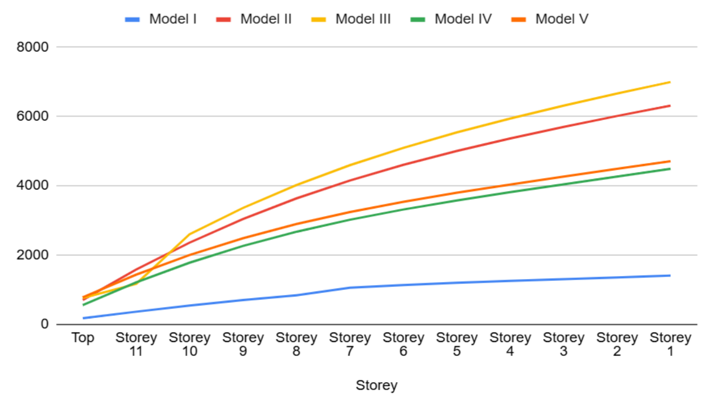

Fig Storey Shear in kN

VI. CONCLUSION

Storey Displacement

Model II exhibits the highest displacement values at every storey level, indicating a more flexible structural response. In contrast, Model V demonstrates the lowest displacement, reflecting a stiffer system with superior lateral resistance. At the top storey, displacements range from 52.669 mm in Model I to a maximum of 59.711 mm in Model II, while Model V records a lower displacement of 56.41 mm. At the base, displacement varies narrowly, with Model V showing the least value of 2.407 mm. These findings suggest that structural enhancements in Models IV and V—likely through the inclusion of shear walls or bracing elements—have effectively mitigated lateral deformation and improved overall structural performance.

Storey Drift

The analysis of storey drift, a key measure of inter-storey deformation under lateral loads, highlights variations in seismic performance across five structural models. Drift values generally rise from the base to mid-level storeys, peaking between Storeys 7 and 10, before decreasing towards the top—a trend consistent with typical dynamic structural response. Model II shows the highest drift values across most storeys, indicating greater flexibility and potentially lower seismic resilience. Drift values at the top storey are relatively uniform across models, ranging from 0.001559 to 0.001718, while Storey 1 exhibits the lowest values due to fixed base constraints. Overall, the comparative results affirm that Model V offers improved seismic performance by effectively limiting inter-storey deformations, thereby supporting safer and code-compliant building design.

Base Shear

Model I records the highest base reaction at approximately 49,800 kN, indicating a stiffer or more massive structural configuration. A significant drop is noted in Model II, where the base reaction falls below 48,600 kN, suggesting possible changes in mass, stiffness, or boundary conditions. Models III, IV, and V show a marginal increase and stabilization of base reaction values around 49,300 kN, with a slight downward trend from Model III to V. This indicates that structural modifications introduced in these models—such as retrofitting with shear walls or bracing—result in more efficient load distribution without notably increasing the base reaction.

Bending Moment

Model I consistently records the lowest bending moments, with a peak of 31,012.58 kN at the base, reflecting its status as the unmodified or baseline structure. In contrast, Model III exhibits the highest bending moments, reaching up to 161,750.02 kN at Storey 1, suggesting a substantially stiffer configuration or greater loading demands. Model II also shows elevated bending moment values, peaking at 128,318.4 kN, indicative of considerable structural demands. Models IV and V, with peak values around 64,570.31 kN and 64,770.39 kN respectively, demonstrate more moderate responses, implying the presence of efficient retrofitting measures such as shear walls or bracing systems that enhance performance while minimizing excessive internal forces. The distribution of bending moments across storeys reinforces the critical role of structural modifications in managing load transfer and highlights the need for carefully balanced design strategies, particularly in lower storeys where stress concentrations are highest.

Shear Force

The analysis of shear force distribution across all models reveals a consistent upward trend from the top storey to the base, reflecting the expected accumulation of lateral loads in multi-storey structures. Model III exhibits the highest shear forces, with a peak value of 6998.45 kN-m at Storey 1, indicating a configuration designed for high lateral load resistance, potentially due to increased stiffness or loading conditions. Model II follows with a base shear of 6317.61 kN-m, reflecting similar structural enhancements. In contrast, Model I—the baseline or existing structure—shows the lowest shear capacity, peaking at only 1412.31 kN-m, thus underscoring its limited resistance to seismic or wind forces. Models IV and V present intermediate shear force values, reaching 4491.92 kN-m and 4713.37 kN-m respectively.

6.2 FUTURE SCOPE

In the present study analysis of 11-storey building has been performed using ETABS. The same exercise can be carried out for more tall buildings.

- The effect of the location of the shear walls can also be studied by shifting these walls symmetrically towards the center.
- Thickness of shear walls throughout the height of building is constant. Analysis can be performed considering different thickness in building height.

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