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Analysis of A Tall Structure Considering Opening Wall Conditions Using ETABS

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ABSTRACT

Shear walls are structural systems which provide stability to structures from lateral loads like wind, seismic loads. An attempt is made to apply the finite element modelling in analyzing and exploring the behavior of shear wall with opening under seismic load actions. Shear walls are generally located at the sides of buildings or arranged in the form of core that houses stairs and lifts. The properties of these seismic shear walls dominate the response of the buildings, and therefore, it is important to evaluate the seismic response of the shear walls appropriately. Due to functional requirements such as doors, windows, and other openings, a shear wall in a building contains many openings

In this research, the main focus is to determine effectiveness of shear wall with vertical opening and staggered opening in regular and irregular buildings under earthquake loads with the help of finite element software, ETABS. using the Response Spectrum method. The comparative results showed that the time period, displacement, base shear and stress distribution around the openings depend on the arrangement of openings. Finally, the staggered arrangement of openings in shear walls is suggested to be applied in practice, since it satisfies both the architectural and the seismic requirements.

Keywords : ETABS, Seismic behavior, Storey drift, Shear Wall, Staggered Openings, Seismic Loads, Finite Element Analysis and Response Spectrum Method.

I. INTRODUCTION

Shear walls are vertical structural elements for resisting the lateral loads that may be induced by the effect of wind and earthquakes. Shear wall is a structure considered to be one, whose resistance to horizontal loading is provided entirely by them. Introduction of shear walls in a building is a structurally efficient solution to stiffen the building because they provide the necessary lateral strength and stiffness to resist horizontal forces. Shear walls generally start at the foundation level and are continuous throughout the building height. They are generally provided along both length and width of the building and are located at the sides of the buildings or arranged in the form of core. Shear walls may have one or more openings for functional reasons.

The size and location of shear walls is extremely critical. They must be symmetrically located in plan to reduce the effect of twisting in buildings. Properly designed and detailed buildings with shear walls have shown good performance in past earthquakes. Also the strong earthquakes recorded worldwide in the past have shown that the damages and certain failure mechanisms of shear walls depend on a series of factors such as, the shape in plan, dimensions of the walls and openings, reinforcement and the openings layout, site condition, type of earthquake and strain rates. Even if failure modes have been extensively researched, there are still certain failure modes which have to be investigated further. One such is the case of shear walls with staggered openings.

Irregularity of Building

Many buildings in the present scenario have irregular configurations both in plan and elevation. This in future may subject to devastating earthquakes. In case, it is necessary to identify the performance of the structures to withstand against disaster for both new and existing one. Structures experience lateral deflections under earthquake loads. Magnitude of these lateral deflections is related to many variables such as structural system, mass of the structure and mechanical properties of the structural materials. Reinforced concrete multi-storied buildings are very complex to model as structural systems for analysis. The current version of the IS: 1893 (part I) -2002 requires that practically all multistoried buildings be analyzed as three-dimensional systems. This is due to the irregularities in plan or elevation or in both. The paper discusses the performance evaluation of RC (Reinforced Concrete) Buildings with irregularity. Structural irregularities are important factors which decrease the seismic performance of the structures.

Types of Irregularity

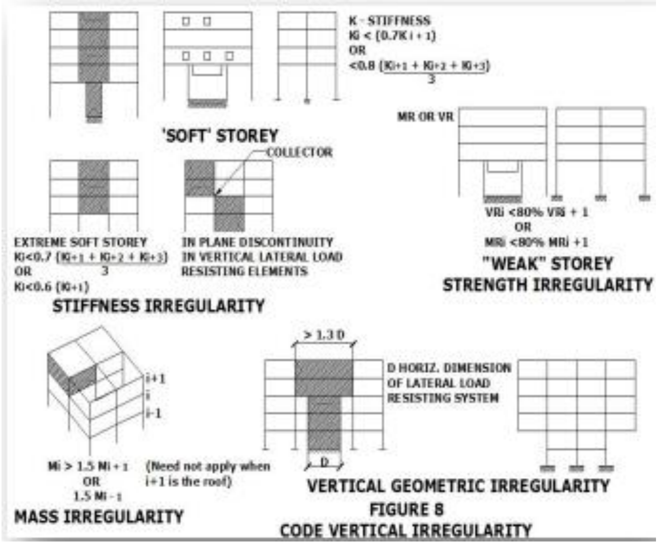


Fig 1 : Vertical Irregularities

II. Objectives of the Research

- To determine the effect of vertical and staggered openings in RC shear wall in a regular building under seismic loads
- To study the behavior of vertical and staggered openings in RC shear wall in a irregular building under seismic loading
- Comparison of effect of openings in regular and irregular building

III. Review of Literature Survey

Akash Malika et.al (2023) objective of the research paper was to determine the seismic behaviour of staggered shear wall models and staggered X bracing models when subjected to historical earthquake data with the assistance of nonlinear time history analysis carried out by ETABS software.

Results stated that base shear of the structure with staggered X bracing is 37% lower than the base shear of the structure with staggered shear walls. When compared to staggered X bracing structures, staggered shear walls have a fundamental time period that is 62% shorter. However, because the values are lower, the structure with staggered shear walls is stiffer. Therefore, the structure with the staggered X bracing can perform better than the structure with the staggered shear wall because of the higher value of time period. When compared to the staggered X bracing structure, staggered shear walls have a frequency that is 62% higher. When compared to the structure with staggered X bracing, the overall dynamic performance of the structure that has staggered shear walls is superior.

Vinodkumar S A et.al (2023) objective of the research paper was to identify the optimum location of shear wall in irregular buildings with different irregular ratios by comparing structures with shear walls at various locations like, at the edges, at the corners and at both the corner and the edges. Further the dynamic analysis was carried out by considering optimum location of shear wall and replacing it with staggered shear wall. The effectiveness of staggered shear wall was analyzed by comparing the results with the shear wall structure having regular openings considering same percentage of openings in both the models using ETABS v18 software.

Model with shear wall at edges of the structure shows 70% less displacement in regular structure and up to 50% less displacements in irregular structure models. Staggered shear wall structure shows 1.5% variation in storey displacement and 2.8% variation in storey drift ratio in comparison with the structure having no openings in the shear wall. Shear wall structure having regular openings in shear wall shows 49 % variation in storey displacements and 40 % variation in storey drift ratio in comparison with the structure having no openings in the shear wall. Hence results confirmed that staggered shear walls are more effective than the shear walls with regular openings. Staggered shear wall performs very well under seismic activity without affecting the stiffness of the building largely.

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 their's need to initialize the model on the basis of defining display units on metric SI on 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.

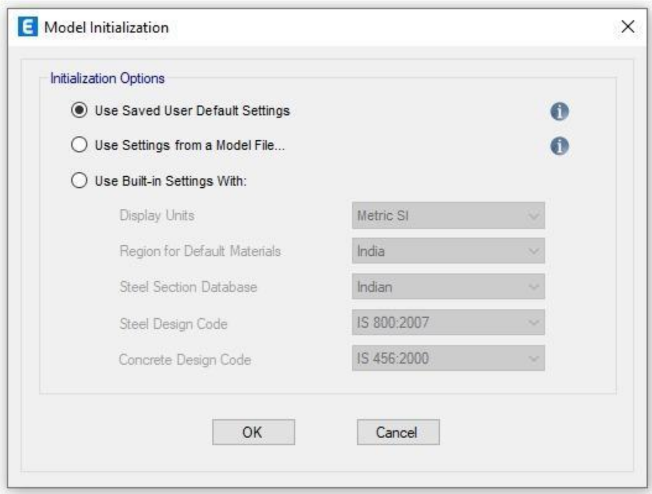


Fig 2 Model Initialization

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 direction and 5 bays in Y direction with a constant spacing of 3.5m in both X and Y direction making the model symmetrical in nature. G+12 storey structure is considered with typical storey height of 3.2 m and Bottom storey height of 2.5 m.

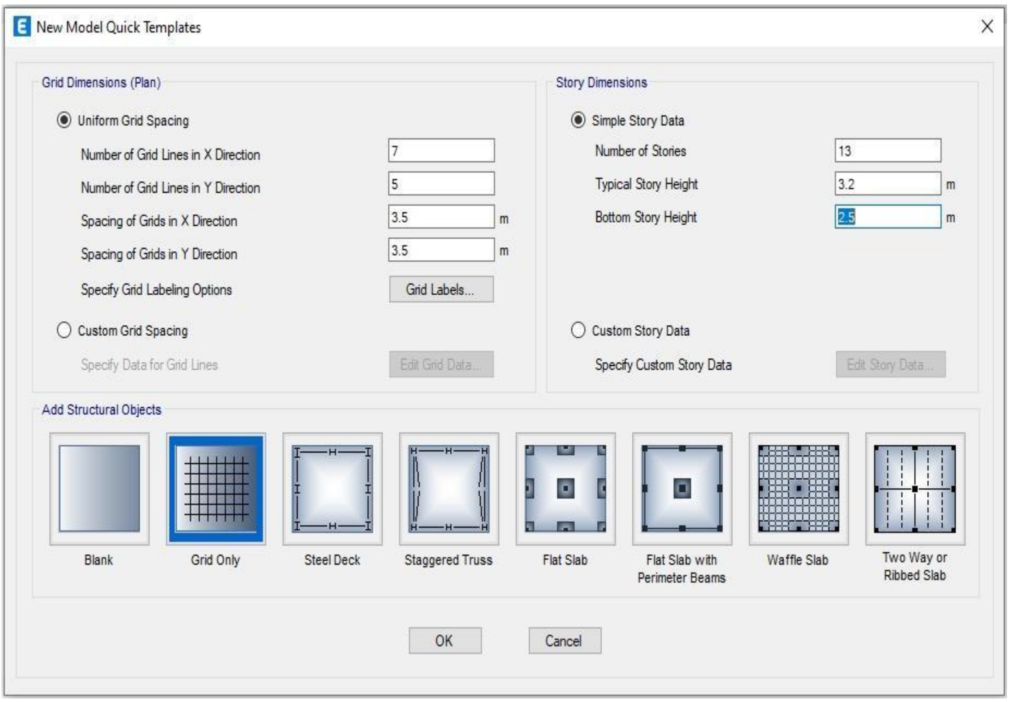


Fig 3 New Model Quick Template

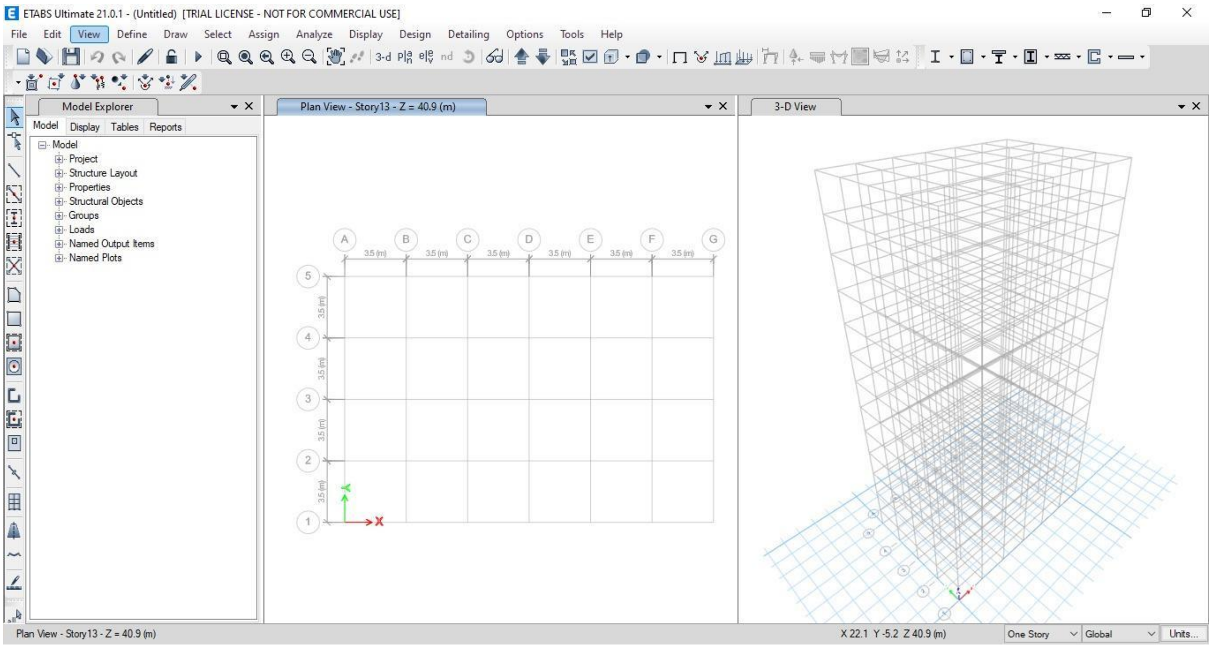


Fig 4 Grid Plan of the Structure

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.

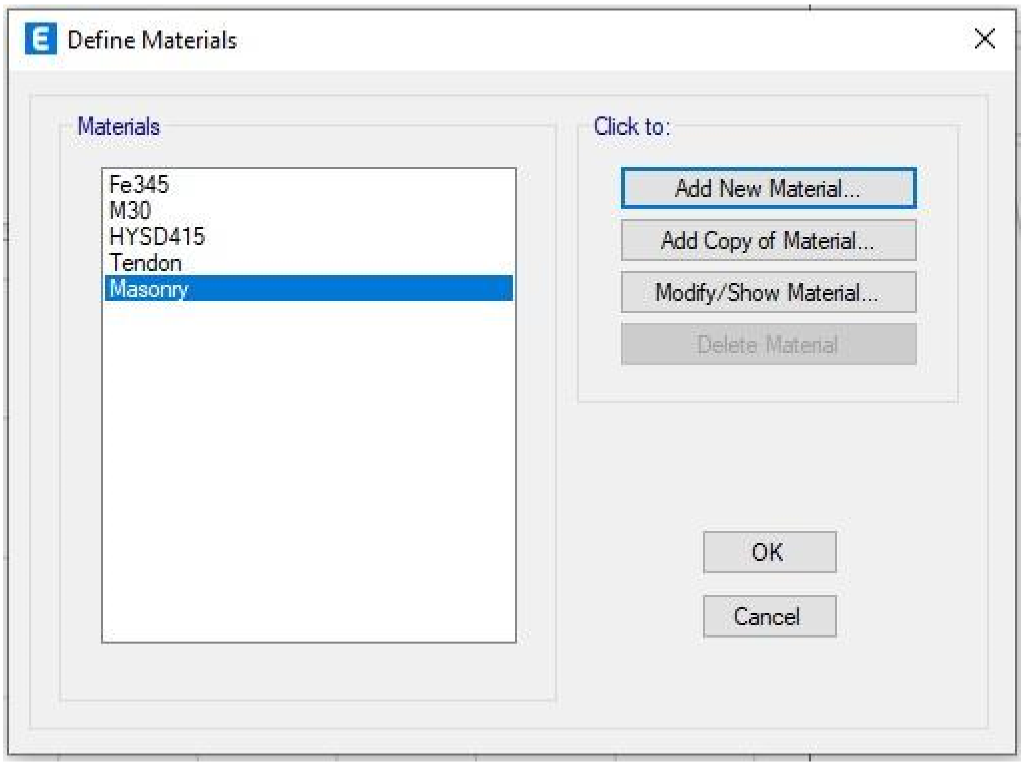


Fig 5 Defining Materials

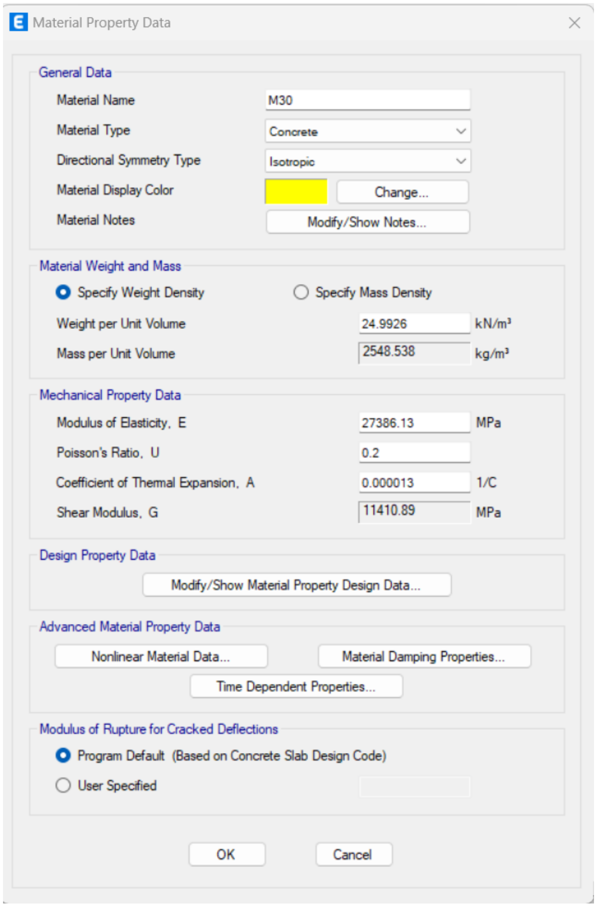


Fig 6 Defining Properties of Concrete M30.

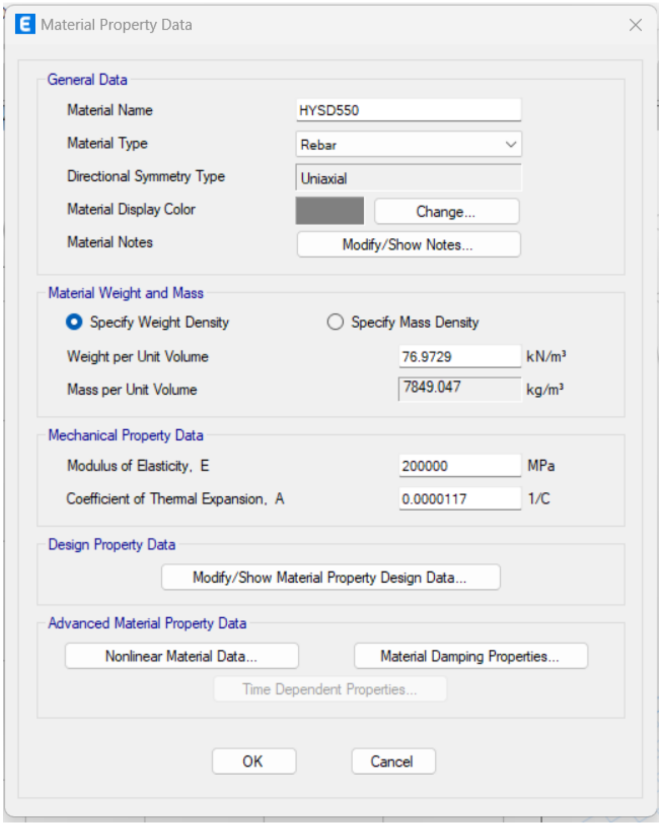


Fig 7 Defining Properties of Rebar HYSD 550

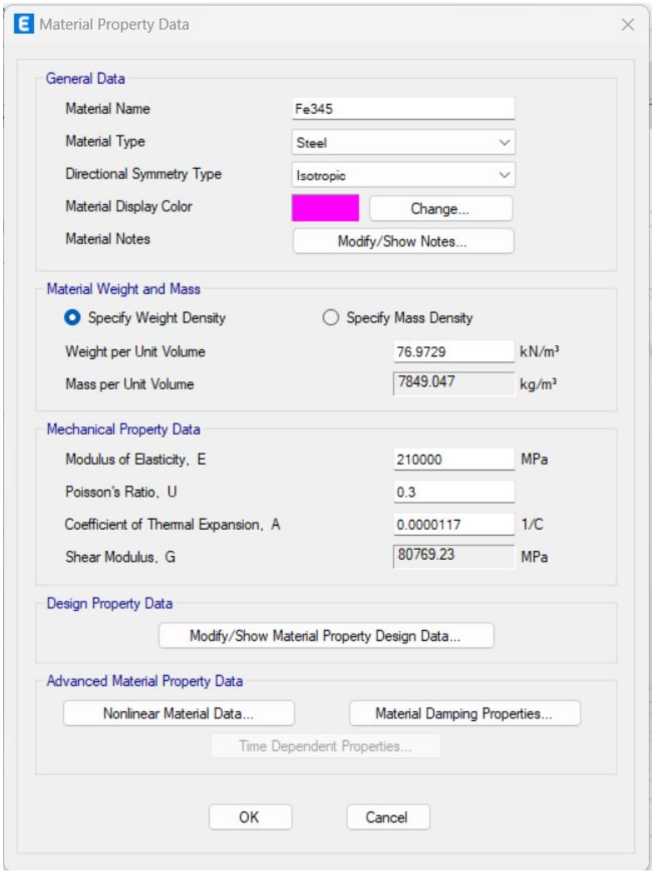


Fig 8 Properties of Steel

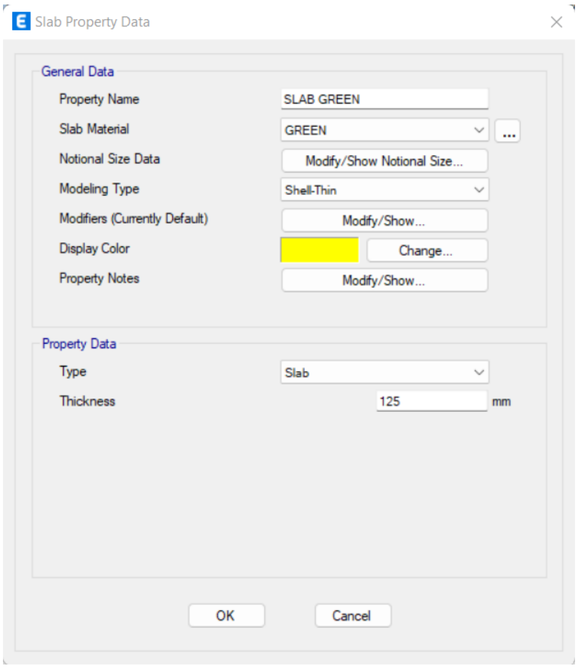


Fig 9 Properties of Slab

Step 5: Defining section properties for Beam, Column. Beam size of 350x300mm, Column size of 400x400mm and Slab size of 125 mm is considered in the study.

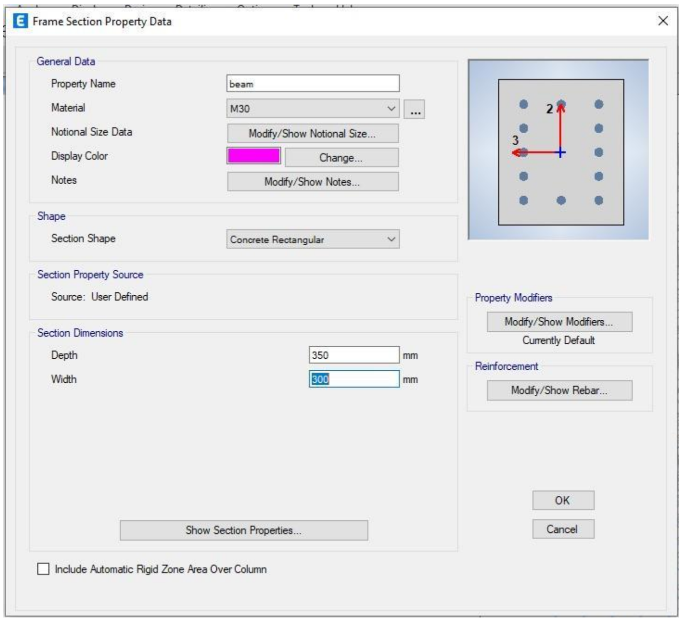


Fig 10 Defining the section properties of Beam

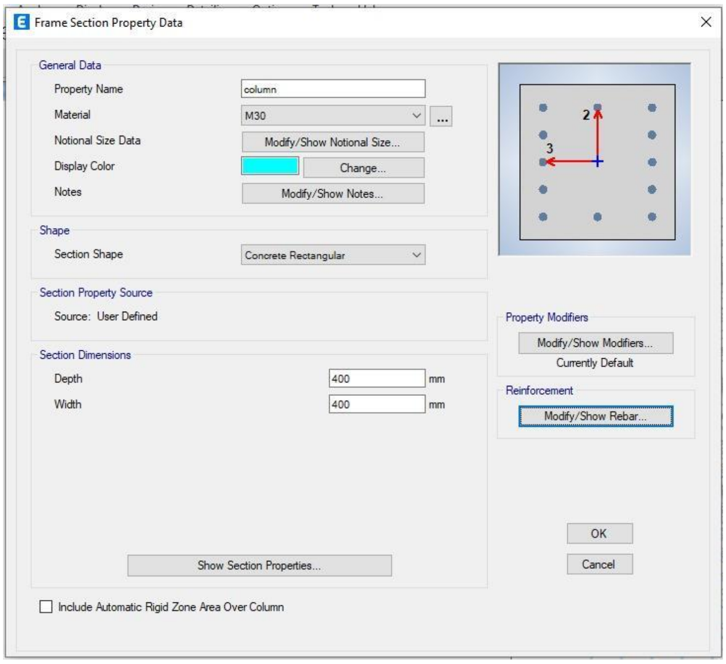


Fig 11 Defining Properties of Column

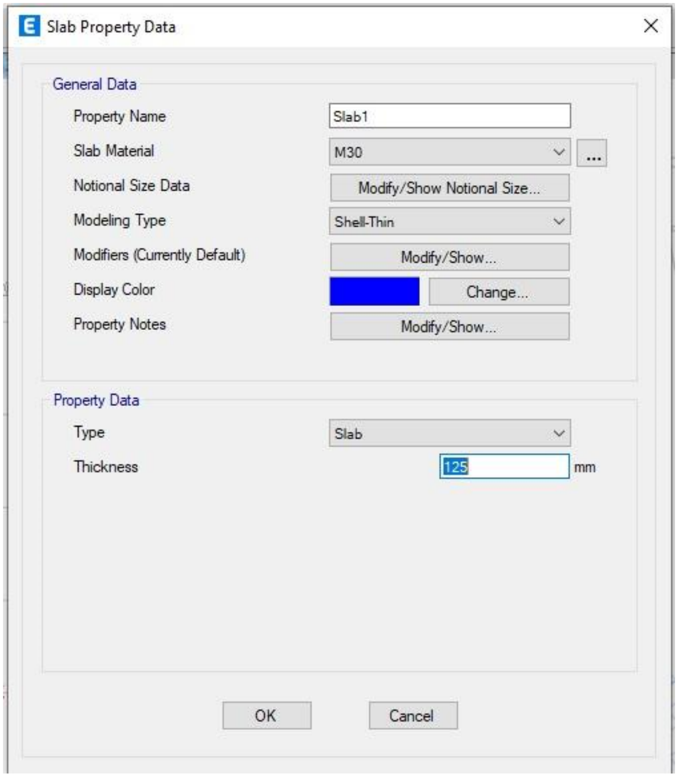


Fig 12 Defining the Properties of slab

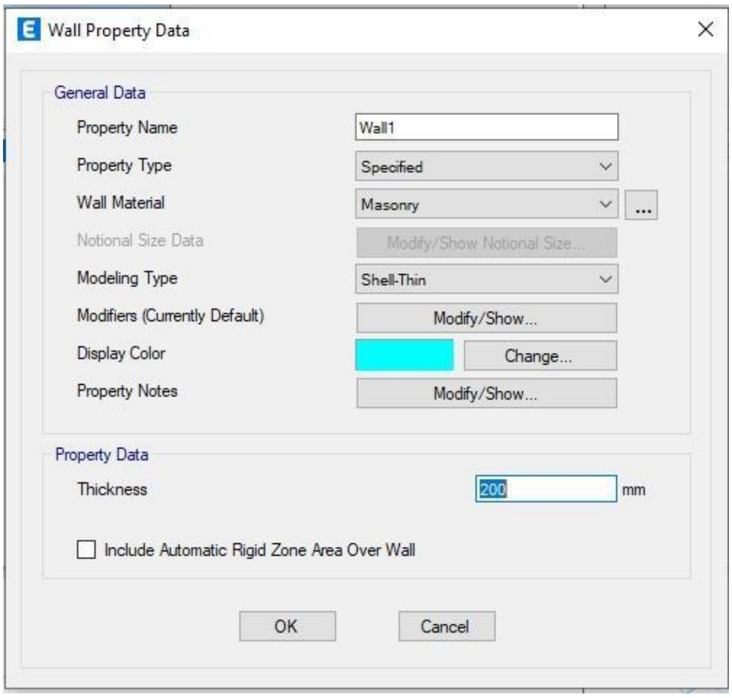


Fig 13 Properties of Masonry Wall

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

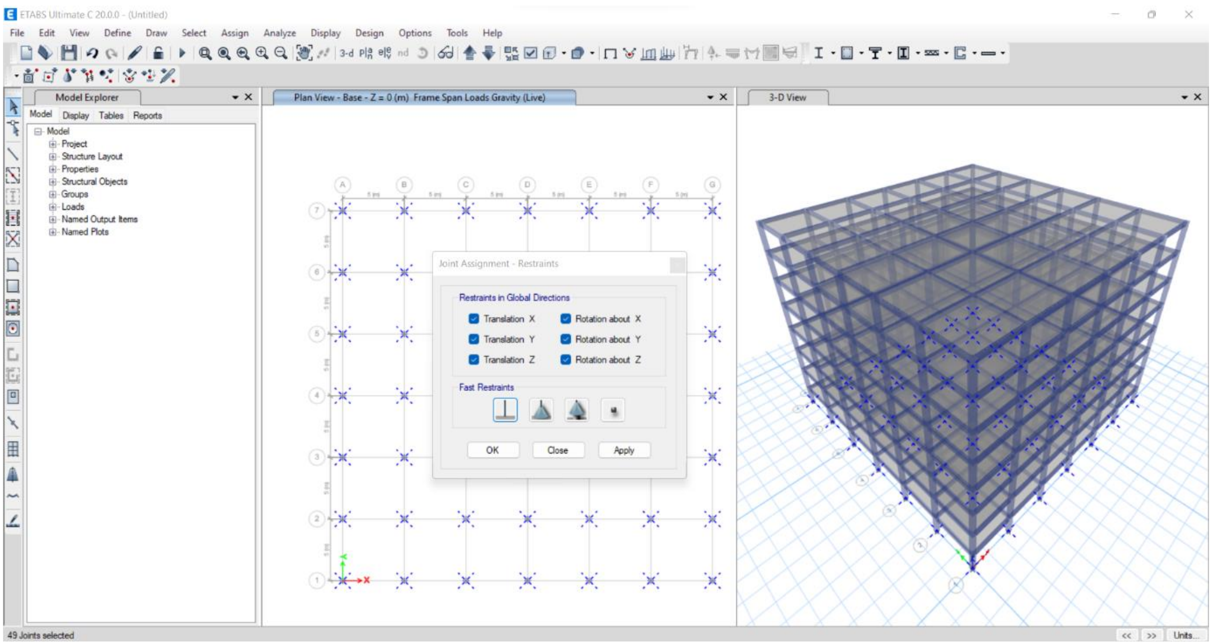


Fig 14 Assigning Fixed Support

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

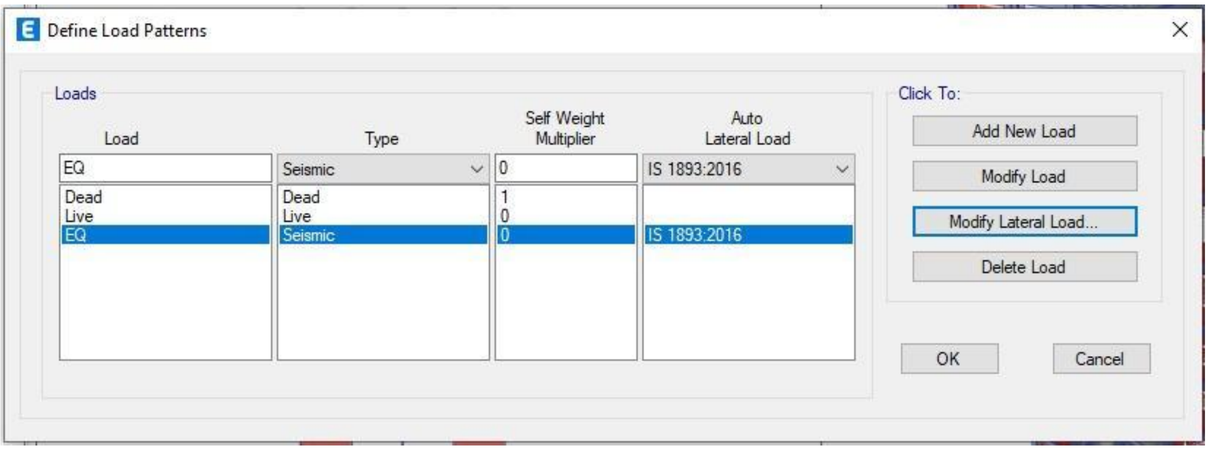


Fig 15 Defining Load Cases

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

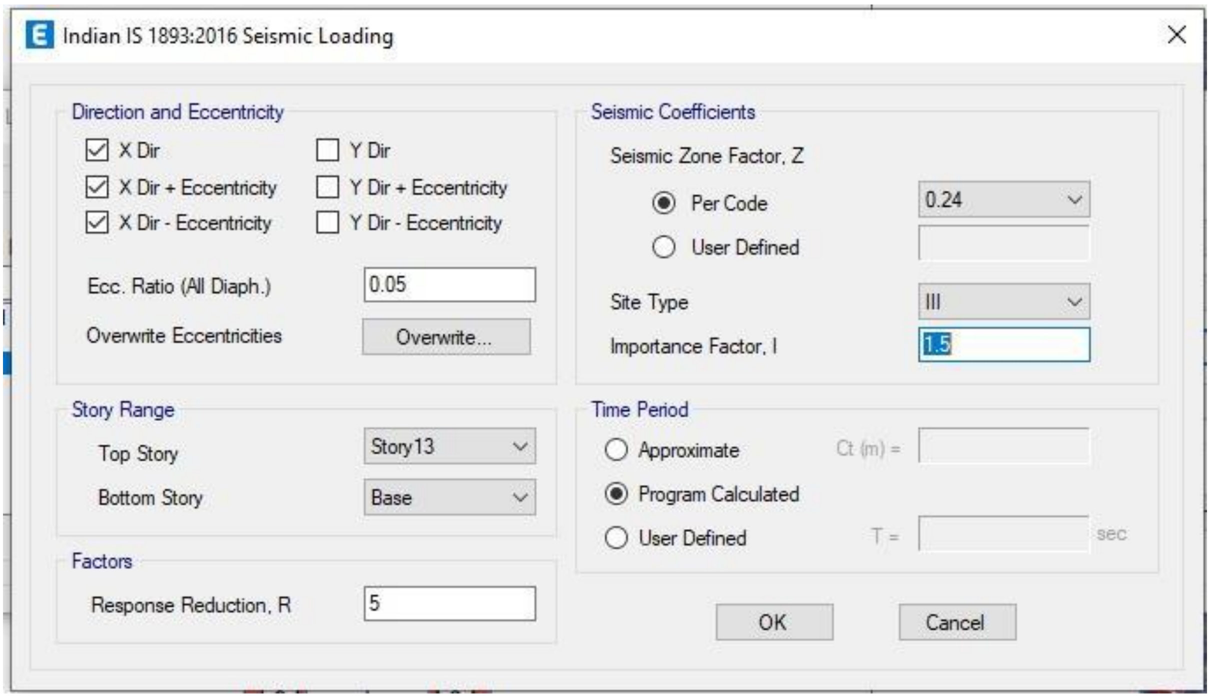


Fig 16 Seismic Loading

Step 9: Conducting the model check for both the cases in ETABS

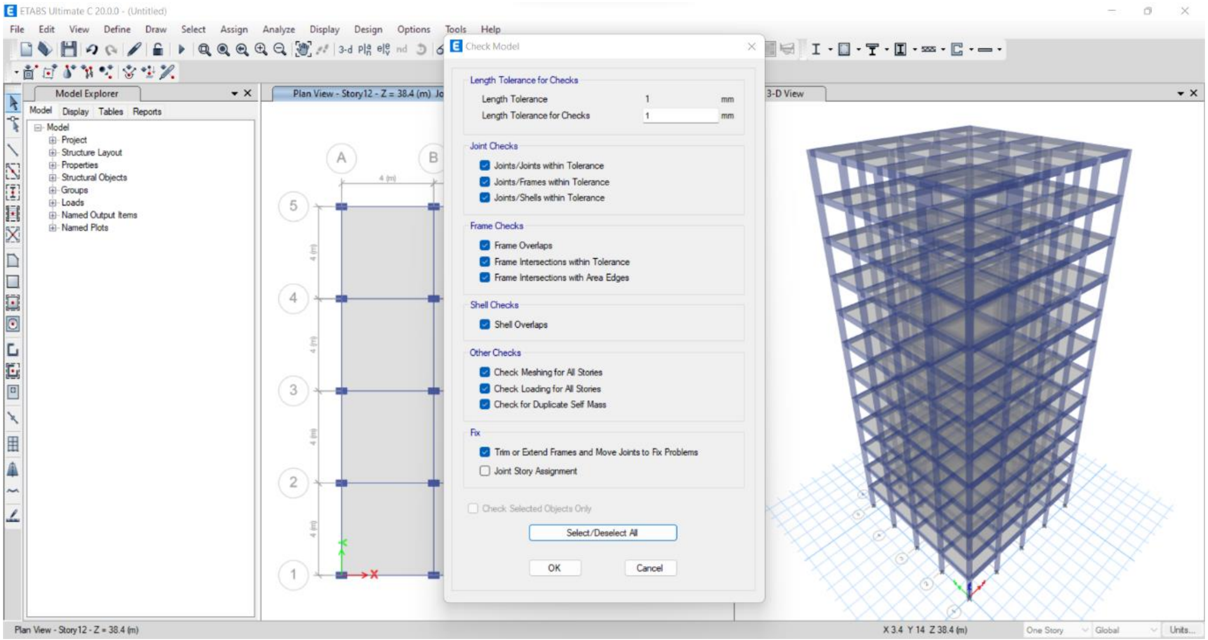


Fig 17 Model Check

Step 10: Analyzing the structure for dead load, stress analysis and displacement.

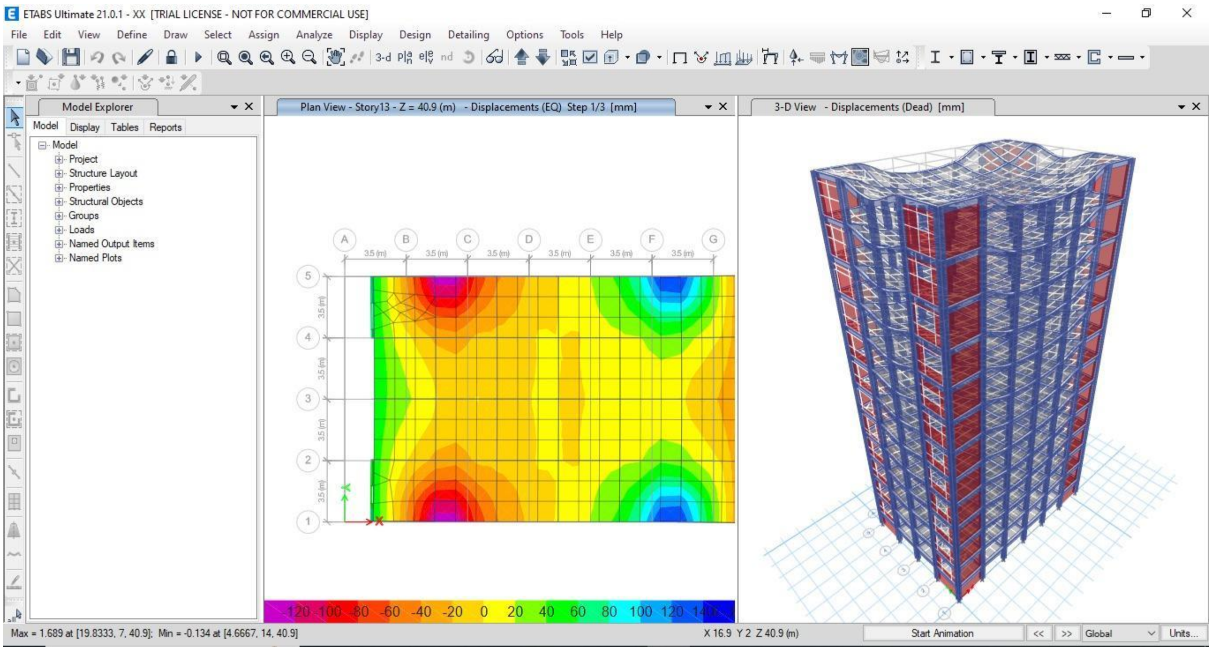


Fig 18 Stress Analysis for Dead Load

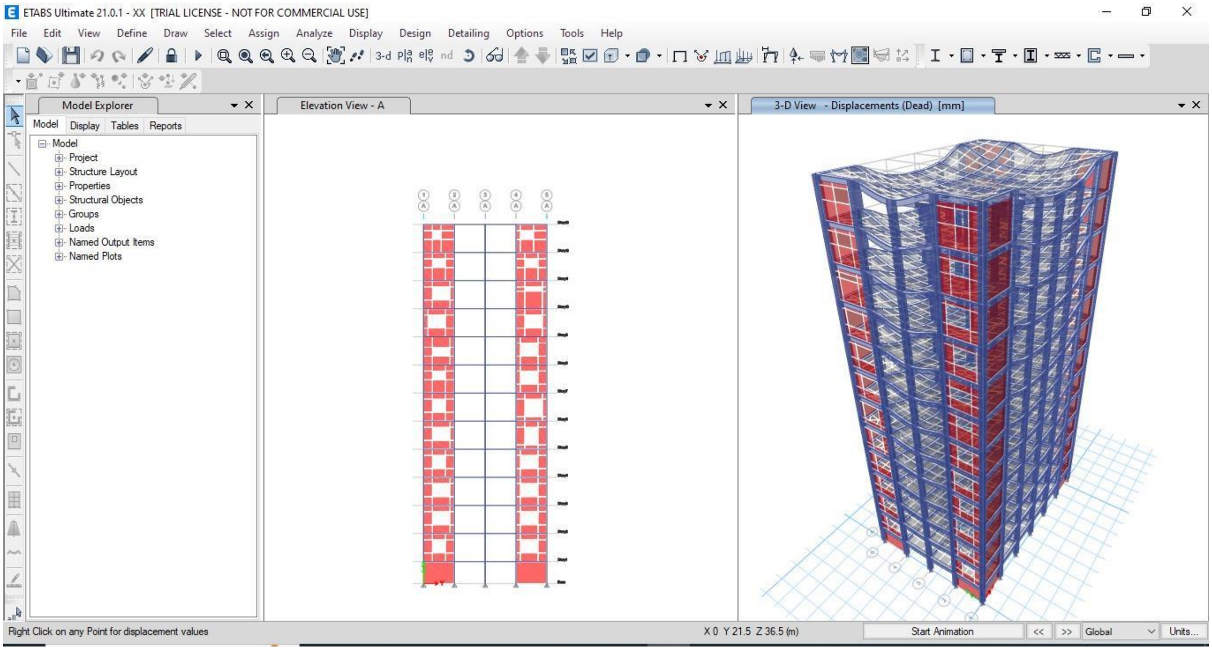


Fig 19 Storey Drift

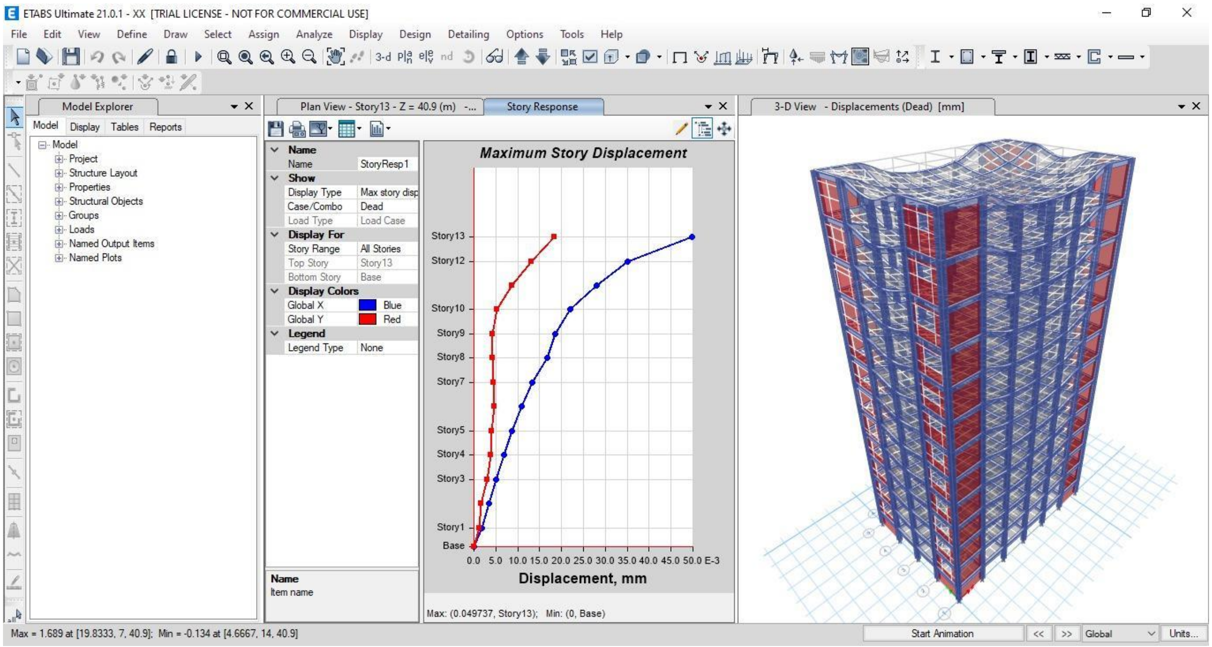


Fig 20 Storey Displacement

Model I

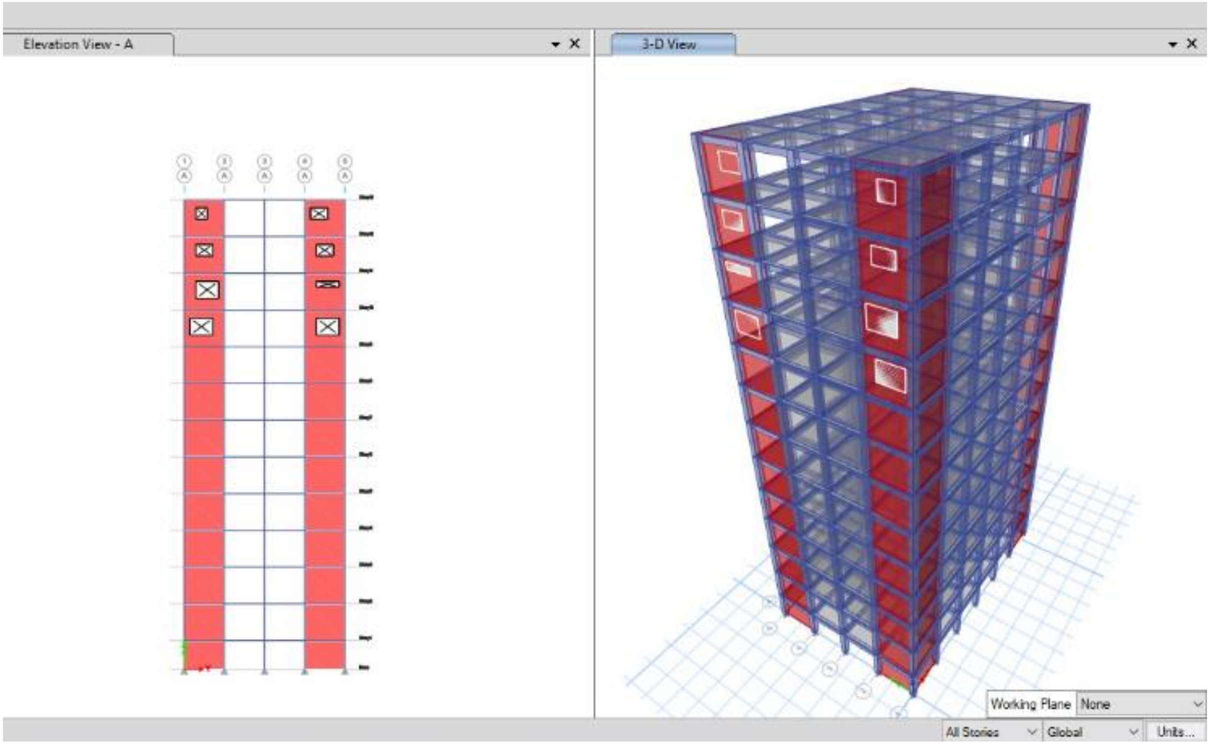


Fig Model I

Model II

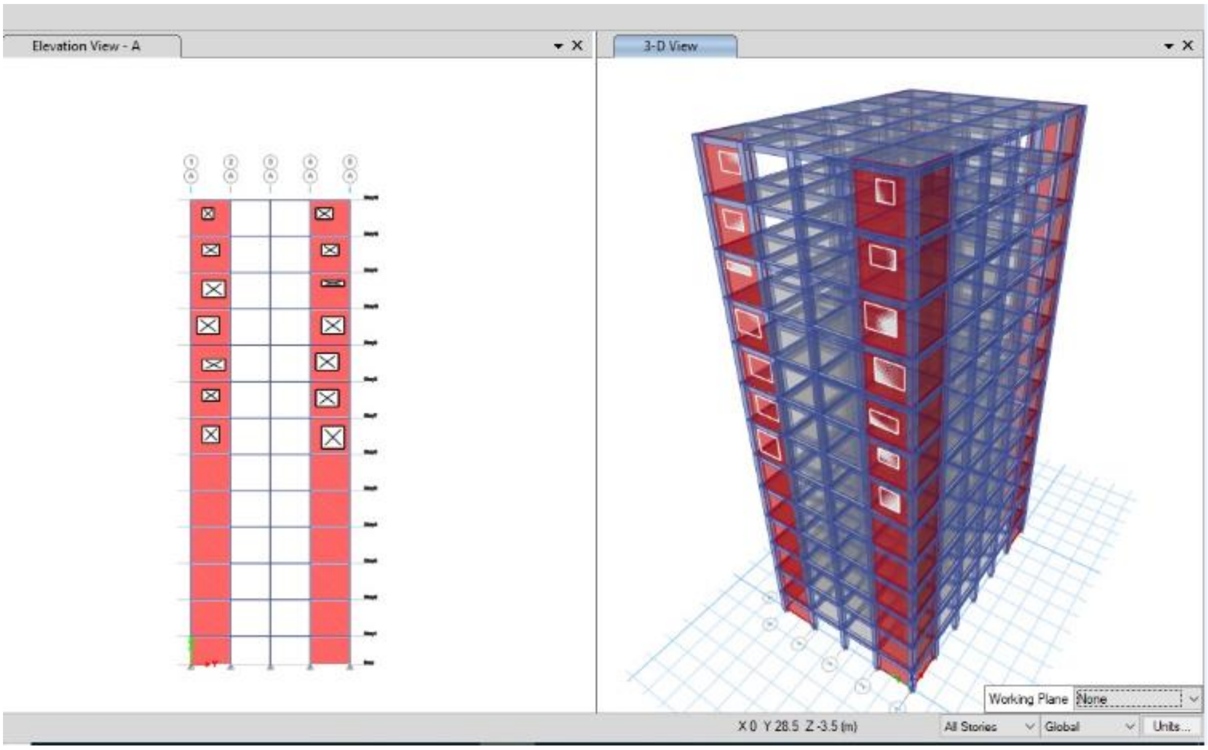


Fig Model II

Model III

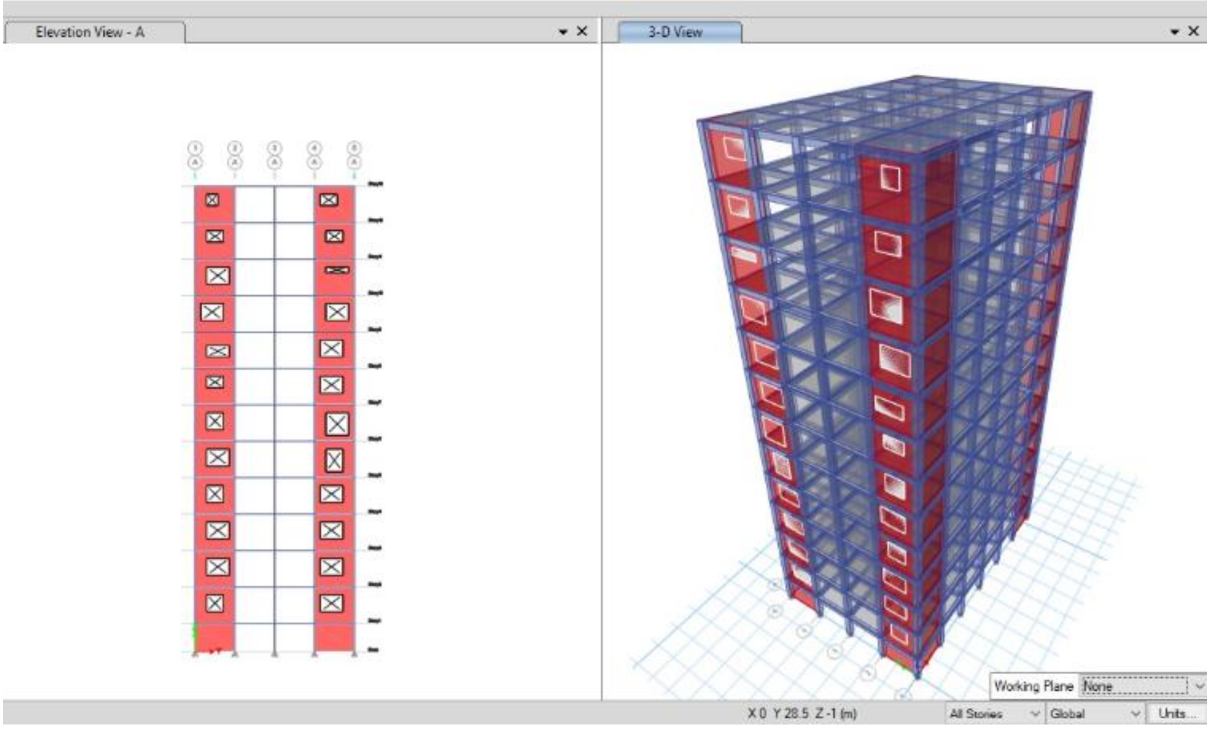
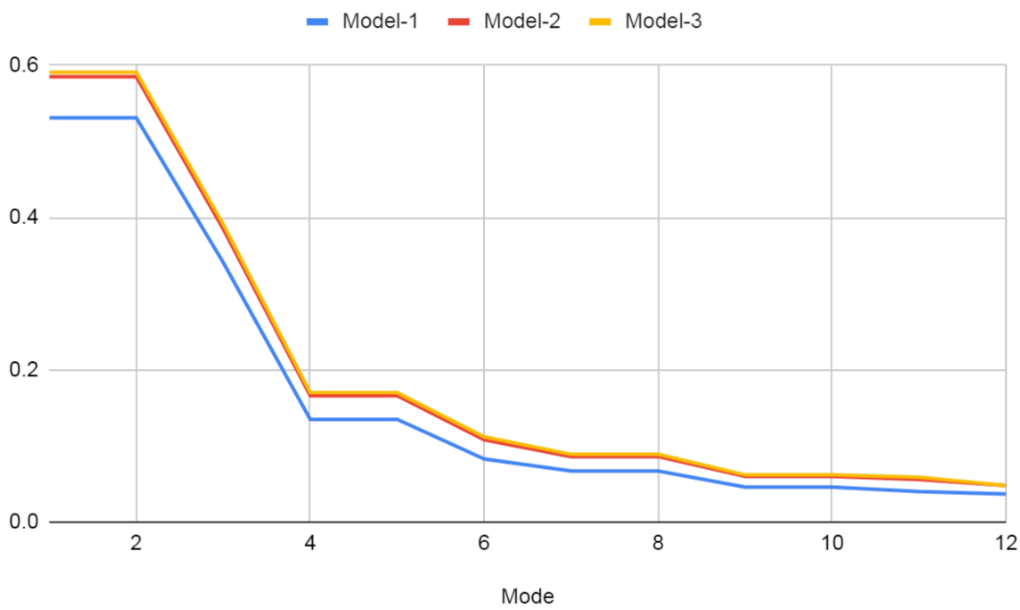
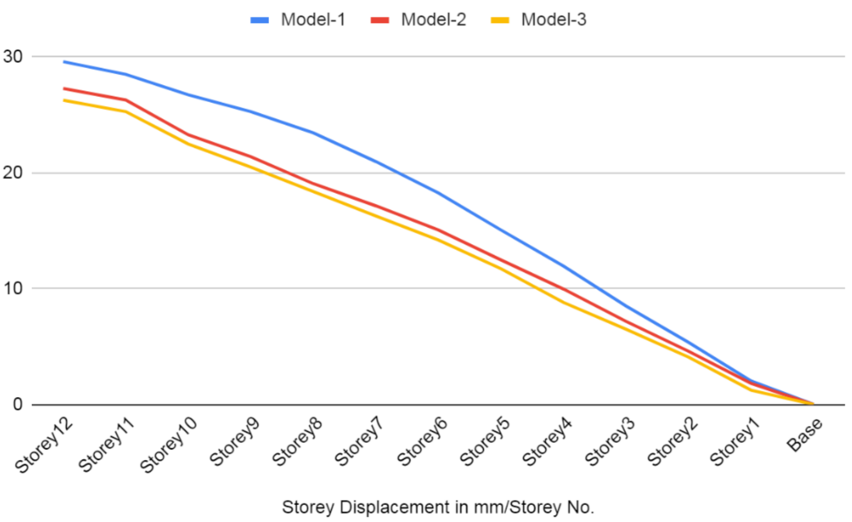
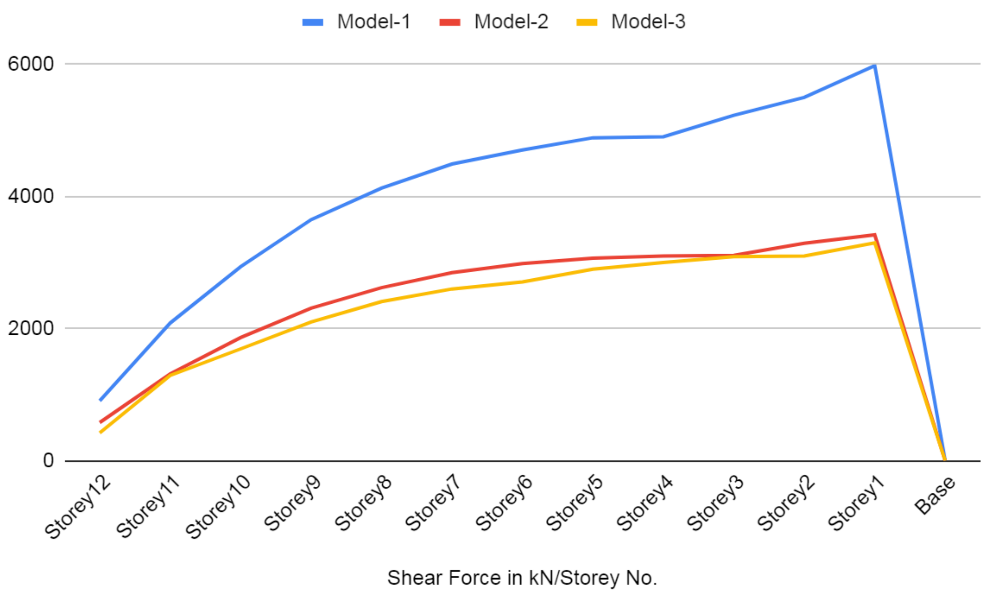


Fig Model III

IV. RESULTS AND DISCUSSION







V. CONCLUSION

With the assistance of nonlinear time history analysis carried out by ETABS software, the focus of this study is on determining the seismic behaviour of staggered shear wall considering three different cases when subjected to historical earthquake data. The following conclusions follow from the analysis study that was presented earlier:

Time Period

The results show that for all of the models, the time period is greatest for mode-1. The time period for a shear wall structure without an opening is 0.531 seconds, 0.585 seconds for a vertical opening, and 0.591 seconds for a staggered opening, indicating that the time period increases when a shear wall is provided with an opening. When compared to shear wall structures with staggered opening, the time period for shear wall structures with staggered opening is longer with vertical opening and also without opening.

Storey Displacement

Storey displacement is the lateral movement of the structure caused by lateral force. It is observed that due to the presence of staggered opened shear wall, it has less displacement compared to regular opened shear wall. By comparing the position of shear wall, the staggered opened shear wall at corner will shows the less displacement compared to shear wall at periphery for all models. The results shows that staggered frame have higher displacement compared to other models.

Shear Force

The variation of storey shear in the staggered shear wallconsidering three different models were tabulated respectively. The storey shear for staggered building in model III was found to be least by more than 48% in comparison to model I and 21% less than Model II.

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