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Analysis of a Structure Under Diaphragm Irregularities Under Dynamc Loading Using ETABS

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ABSTRACT

Many buildings in the present scenario have irregular configurations both in elevation and plan. This in future may be subject to devastating earthquakes. It is necessary to identify the performance of the structures to withstand disaster for both new and existing buildings. Now a days openings in the floors is common for many reasons like stair cases, lighting architectural etc., these openings in diaphragms cause stresses at discontinues joints with building elements. Discontinuous diaphragms are designed without stress calculations and are thought-about to be adequate ignoring any gap effects. Earthquakes are natural dangers under which catastrophes are primarily caused by destruction or fall of structures. In the current situation, the majority of buildings are planned and erected on the premise of looks which occurs to disregard the underlying concepts of earthquake resistance, where researchers come across several buildings having uneven shapes both in height and plan.

The present work cites to portrait the behaviour of G+11 multi storeyed with diaphragm having opened under non-linear static (Pushover) analysis utilizing ETABS to achieve these outcome various models with various proportion of diaphragm openings are analyzed and contrasted for seismic parameters like maximum story displacement, base shear, maximum story drifts, as well as pushover results.

Keywords: Diaphragm Discontinuity, Pushover Analysis, Maximum Story displacement, Base Shear, Story Drifts and Pushover results.

I. INTRODUCTION

In multi-storied framework structure, damages from earthquake usually starts at sites of structural flaws present in the horizontal load bearing frames. This behavior of multi-storey framework structures during powerful seismic movements relies on the arrangement of mass, rigidity, strength in both the vertical as well as horizontal lines of buildings. In few instances, these vulnerabilities may be caused by gaps in rigidity, strength or bulk along the diaphragm. Such gaps between diaphragms often are linked with abrupt changes in the frame shape along length of the structure. Structural engineers have acquired trust in the construction of structures in which the divisions of mass, rigidity and strength are largely consistent. There is a less trust about the construction of buildings having uneven physical shapes (diaphragm discontinuities) (diaphragm discontinuities).

According to IS-1893:2002: Diaphragms with sudden gaps or differences in stiffness, which encompasses some these having cut-out or uncovered sections larger than 50 percent of the total contained diaphragm surface, or changes in functional diaphragm rigidity of more than 50 percent through one level to the next. In structural engineering, a diaphragm is indeed a structural device used to transmit horizontal stresses to shear walls or frameworks mainly through in-plane shear stress. Lateral pressures are typically wind and seismic stresses. Two main kinds of diaphragm are stiff and pliable. Flexible diaphragms withstand transverse pressures based on the region, independent of the elasticity of the parts that they are transmitting force to. Stiff diaphragms transmit weight to frameworks or structural walls based on their elasticity and their position in the construction. Flexibility of a diaphragm effects the spread of lateral pressures to the vertical components of a lateral force resisting parts in a building.

OBJECTIVES OF THE RESEARCH

- To develop the RC framed structural model with varying percentage of diaphragm discontinuities.
- To study the influence of varying percentages of shear walls on performance of RC framed structural model with diaphragm discontinuities.
- To investigate variation in storey drifts, story displacements, base shear and story shear under the earthquake load and gravity loads.
- To formulate recommendations for choosing diaphragm discontinuity based on the results of the analysis performed.
- The models have developed as per static analysis as per IS 1893-2016 (Part 1).

II. LITERATURE REVIEW

To provide a detailed review of the literature related to diaphragm discontinuity in its entirety would be difficult to address here. A brief review on diaphragm discontinuity of previous studies is presented here. This literature review focuses on recent contributions related to diaphragm and past efforts most closely related to the needs of the present work.

Amruta Murali and Reni Kuruvilla (2023) research paper presented the seismic behaviour of a 20 storied building with different slab openings using response spectrum analysis in ETABS. The analysis was considered on parameters such as base shear,and story drift and compare them with the regular model. Results stated that the story drift reduced for slab opening at the center up to 53.22% compared to the corner and 64.19 % compared to the periphery position for 1% of slab opening. The base shear reduced for slab opening at the center upto 46.64 % compared to the corner and 58.91% compared to the periphery position for 1% of slab opening. Slab opening at the center was found to be more effective in resisting lateral forces. The base shear of the regular building was less compared to the base shear values of the diaphragm having openings. Maximum story drift of a regular building was less compared to the maximum story drift values of the diaphragm having an opening.

Y. Nanda Kishore et.al (2023) objective of the research paper was to investigate the behaviour of G+15 multi storeyed with diaphragm having opened under non-linear static (Pushover) analysis utilizing

ETABS to achieve these outcome various models with various proportion of diaphragm openings were analyzed and contrasted for seismic parameters like maximum story displacement, base shear, maximum story drifts, as well as pushover results.

Modal Analysis results stated that there are some unusual modes when diaphragm discontinuity modelled. However, the mass participation for those modes is found to be negligible. Provision of diaphragm opening alters the seismic behavior of the buildings. Models with symmetrical opening in both directions expressed similar response for all the parameters while models with change in the symmetry behaved different. The influence of diaphragm openings on the seismic response of multi-storied buildings played a major role in reducing the Maximum story displacement, story drift and base shear, hence attracting lesser seismic forces than the conventional structure.

Rohan V. Thakar and Jigar Zala (2022) research paper presented analysis to compare the influence of rigid and flexible diaphragm using the finite element software Midas gen. Rectangular, L shape, U shape, T shape were employed, as well as storey variation G+5, G+10, G+15. Each model examined both with and without a shear wall in place. IS 1893:2002 response spectrum analysis was used to analyse response quantities like storey drift, storey displacement, fundamental natural period, and column axial force.

Comparing the response in terms of fundamental natural period of all buildings, fundamental period was larger when flexible diaphragm is used, whereas rigid diaphragm underestimate the natural period of the building in shear wall or without shear wall resisted structure. In shear wall resisted structure ignoring the diaphragm flexibility cause large underestimate of storey drift, storey displacement, and Fundamental natural period. The response in terms of storey drift flexible diaphragm structure will give higher drift in middle storeys, as the height increases percentage difference between rigid and flexible diaphragm also increases in all shapes.

III. METHODOLOGY

Steps of the 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 different condition in diaphragm irregularity.

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.

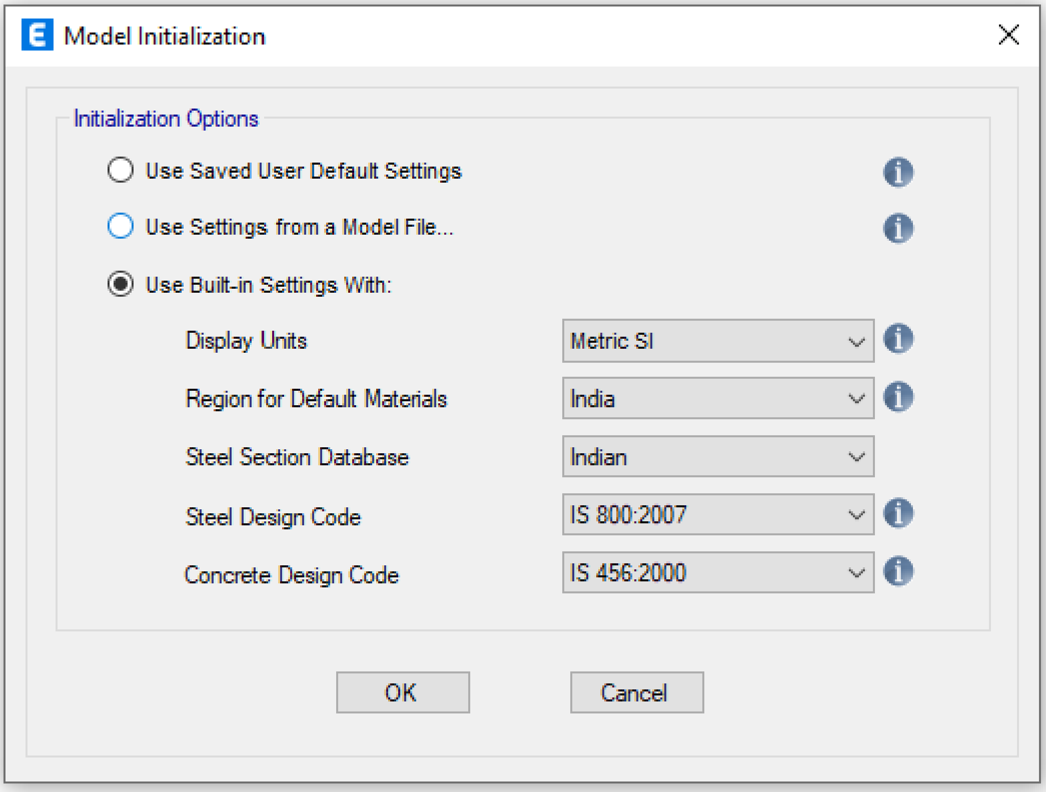

Fig 3.1 Model Initialization

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, 6 bays in considered in both X and Y direction with a constant spacing of 4m making the model symmetrical in nature. G+11 storey structure is considered with typical storey height of 3 m and Bottom storey height of 3 m.

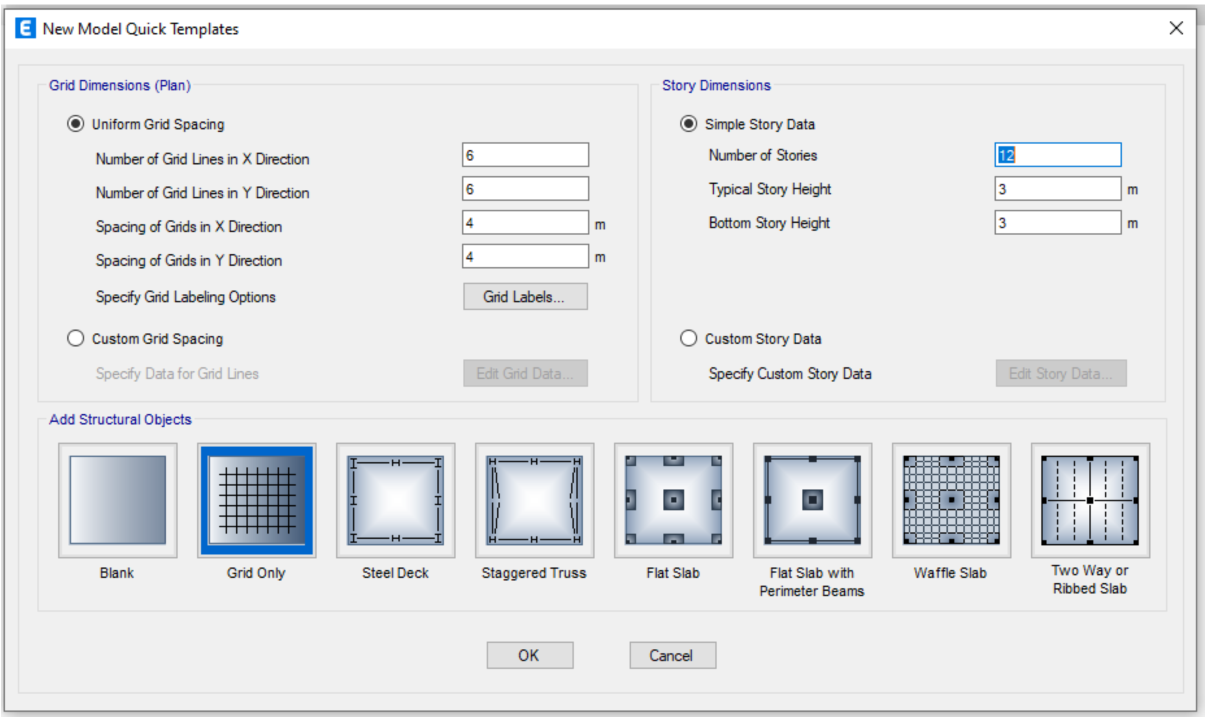

Fig 3.2 New Model Quick Template

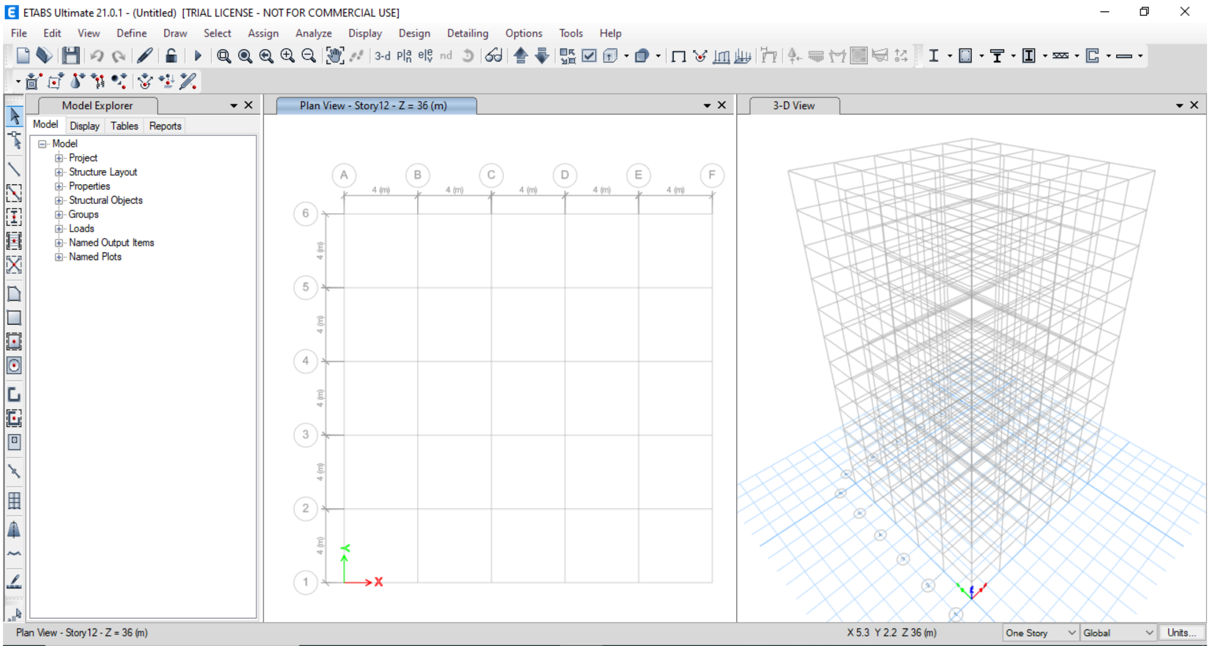

Fig 3.3 Grid Plan

Step 4: Next step is to define the material properties of concrete and steel. Here in this case study, M30 concrete and rebar HYSD 415 is considered and its predefined properties are available in the ETABS application.

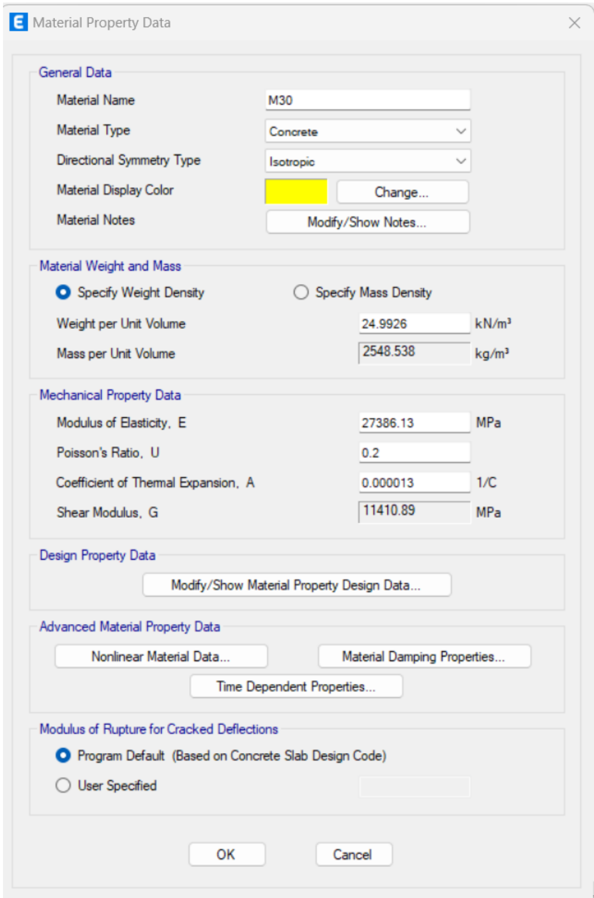

Fig 3.3 Defining Properties of Concrete M30.

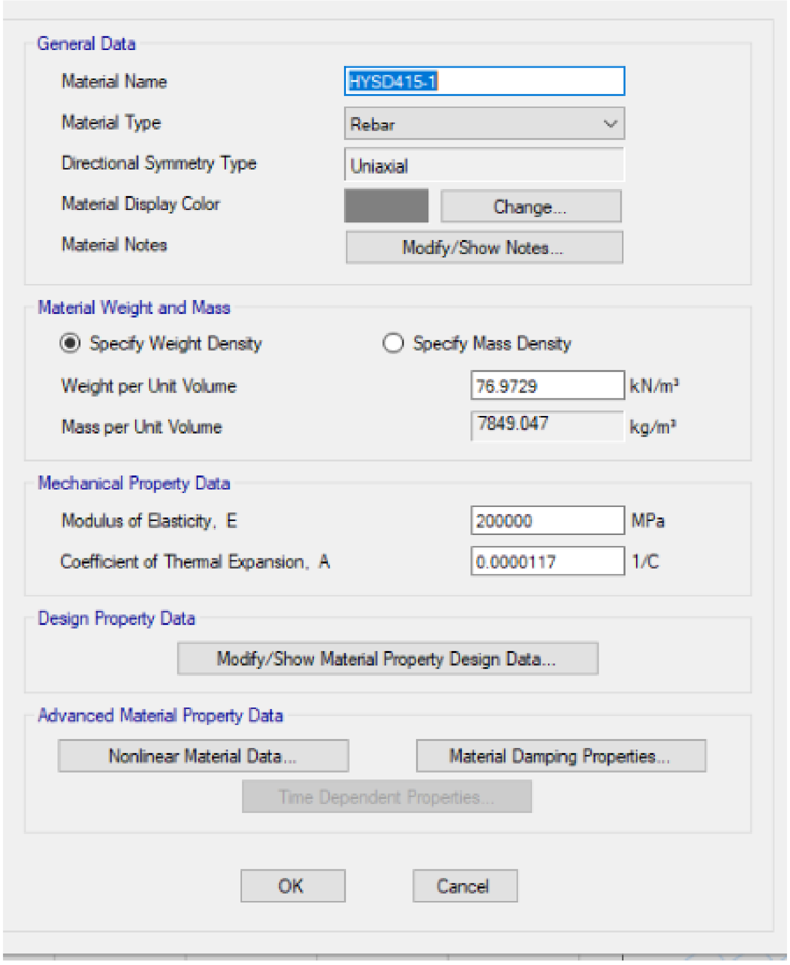

Fig 3.4 Defining Properties of Rebar HYSD 415

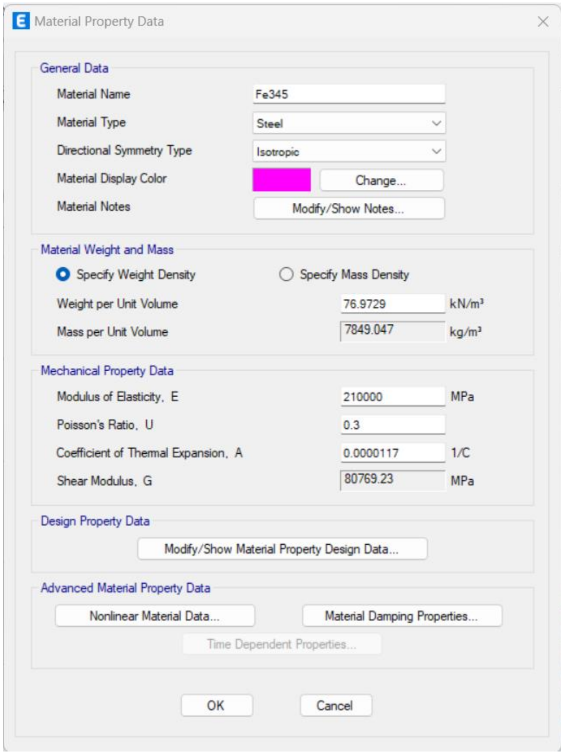

Fig 3.5 Properties of Steel

Step 5: Defining section properties for Beam, Column. Beam size of 450x300mm, Column size of 500x300mm and Slab size of 200 mm is considered in the study.

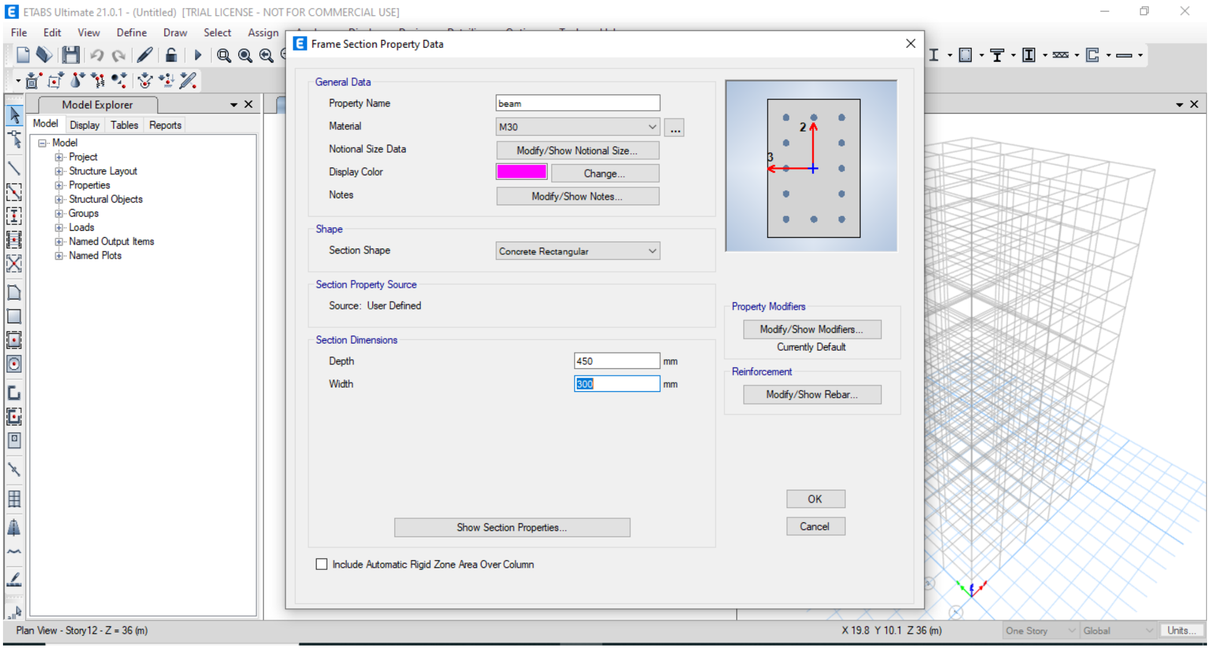

Fig 3.5 Defining the section properties of Beam

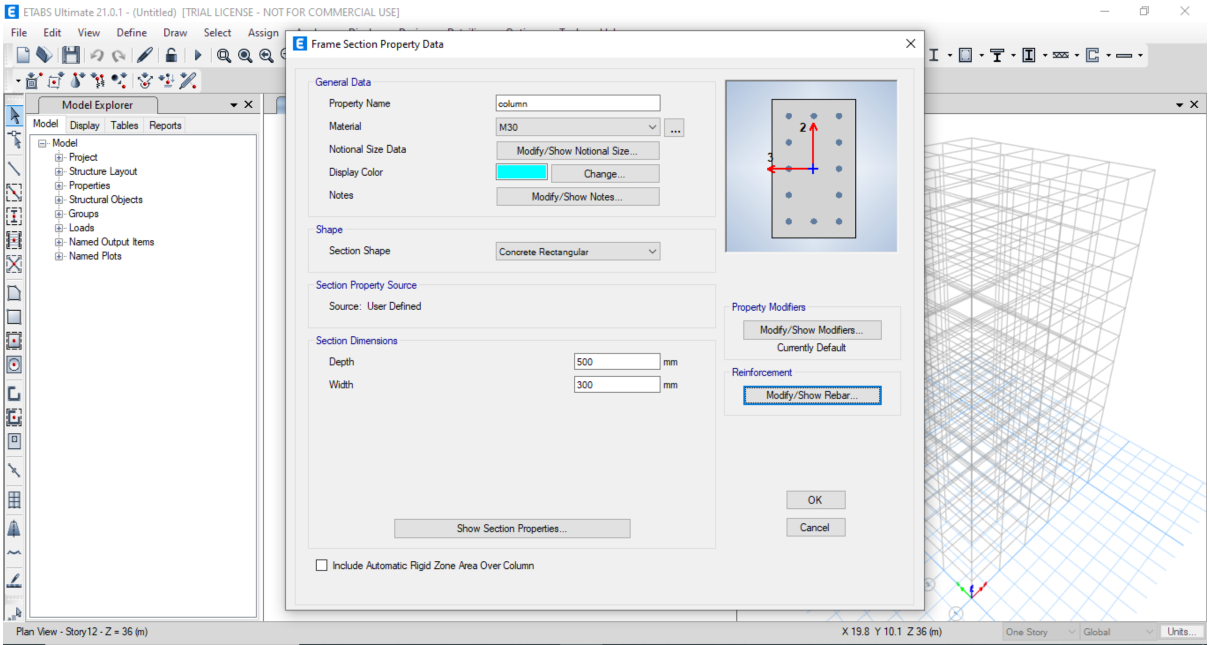

Fig 3.6 Defining Properties of Column

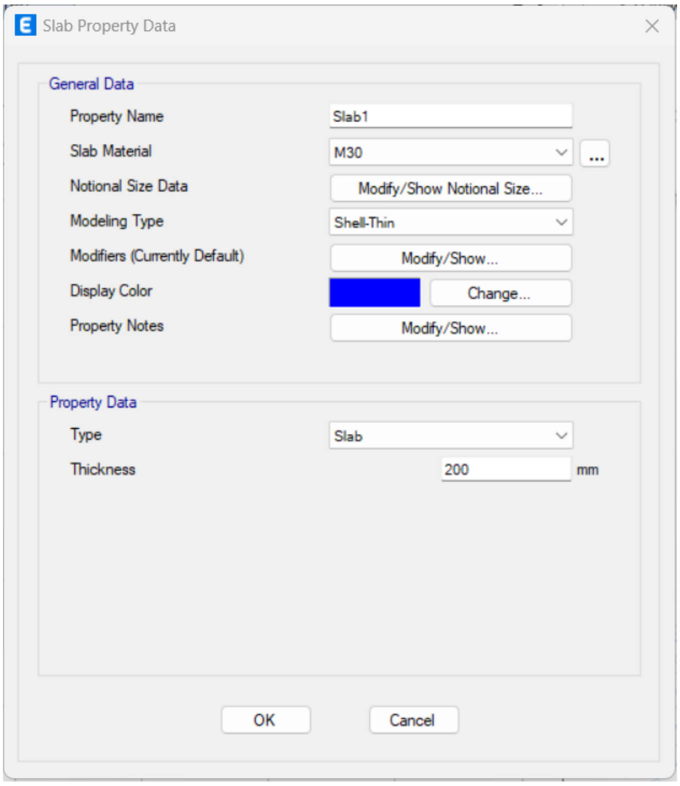

Fig 3.7 Defining the Properties of slab

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

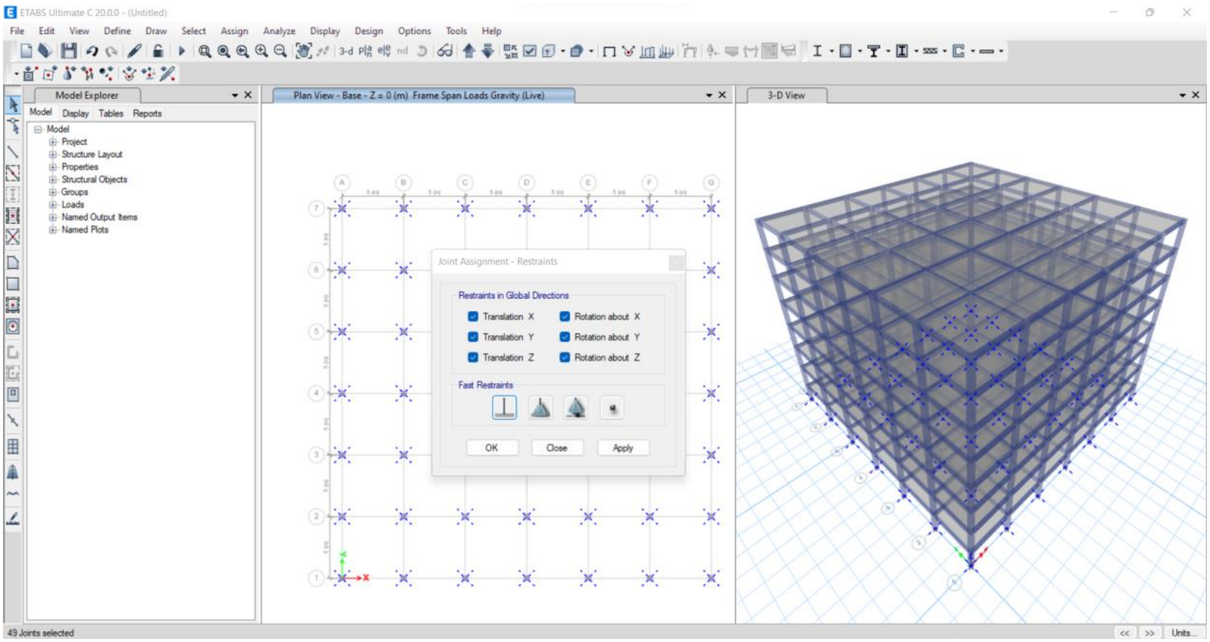

Fig 3.8 Assigning Fixed Support

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

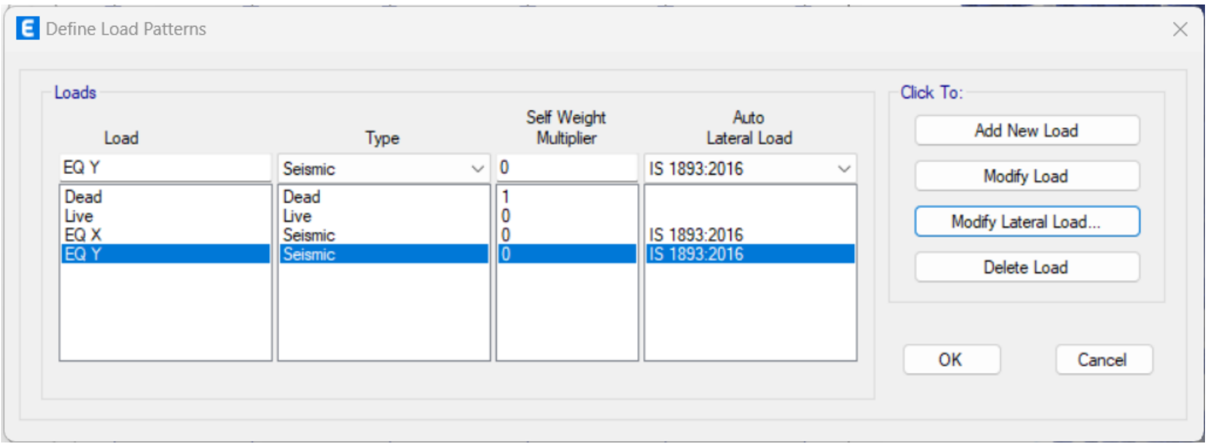

Fig 3.9 Defining Load Cases

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

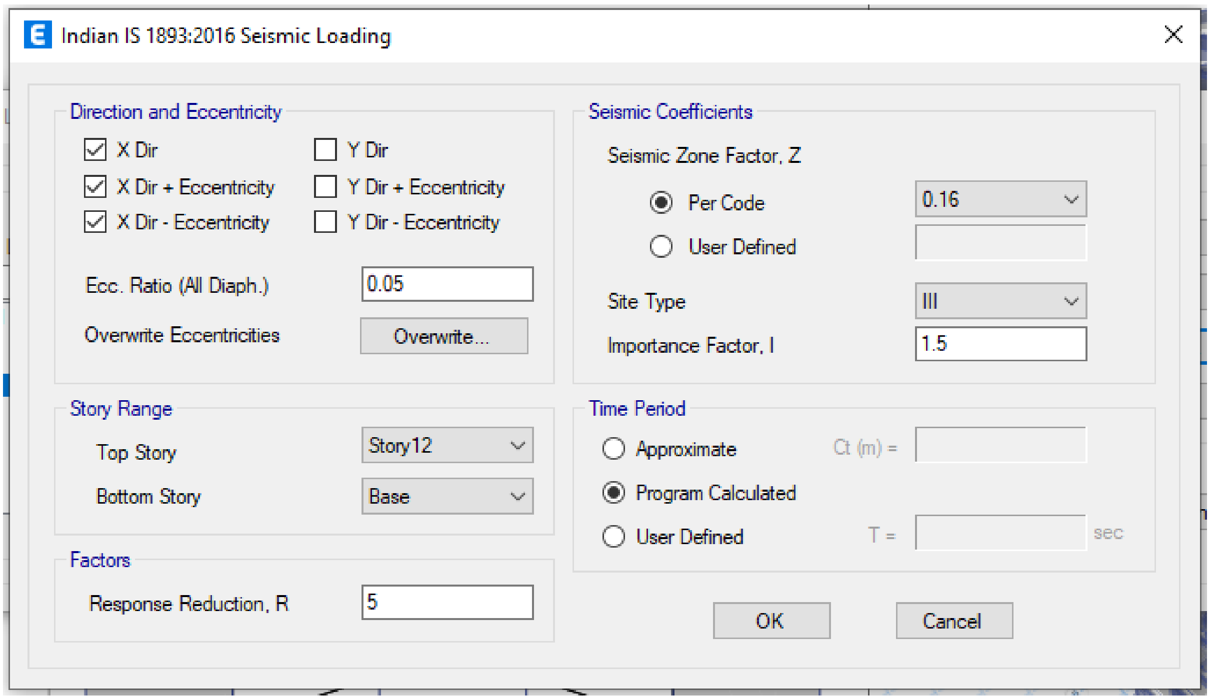

Fig 3.11 Seismic Loading as per IS 1893-2016.

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

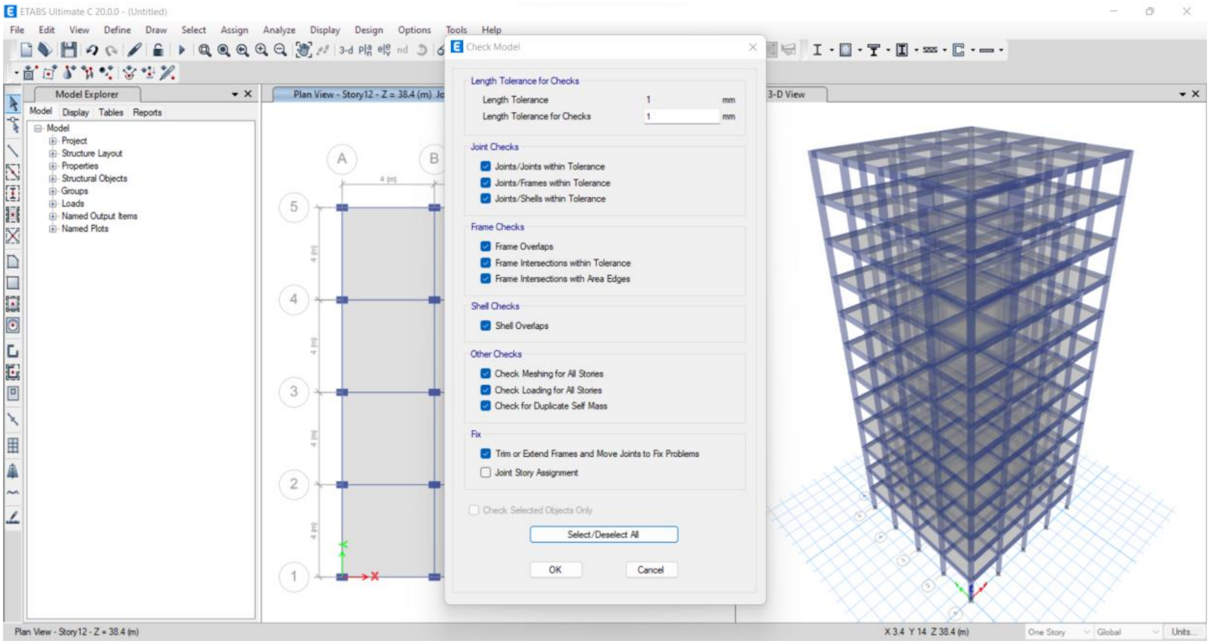

Fig 3.13 Model Check

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

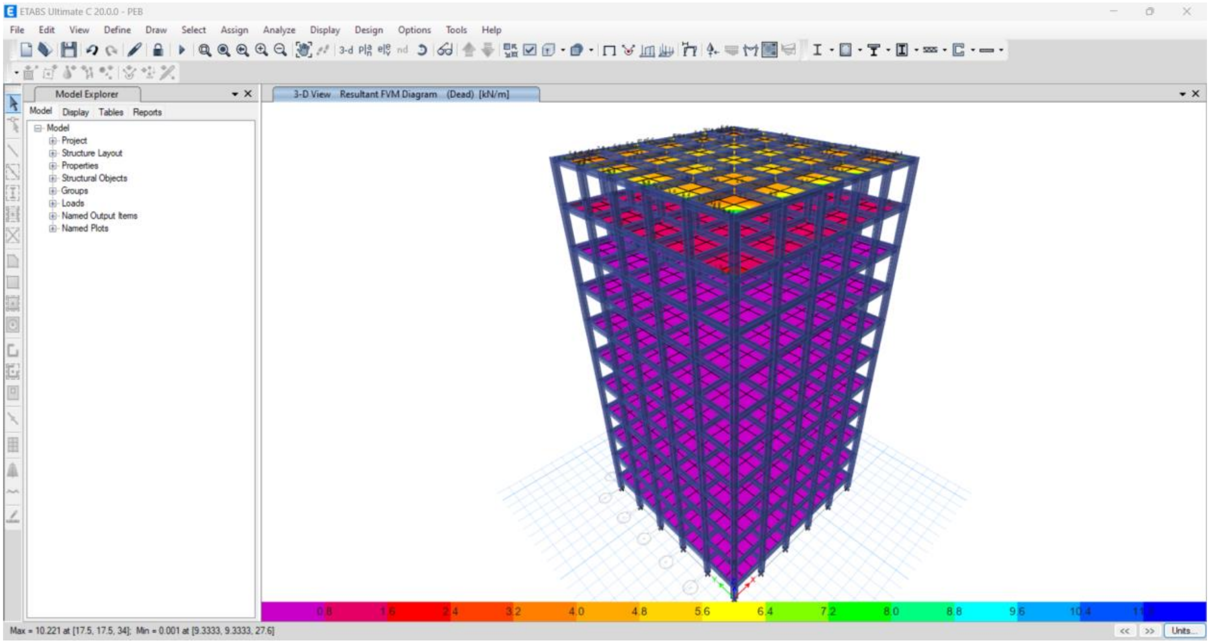

Fig 3.14 Stress Analysis for Dead Load

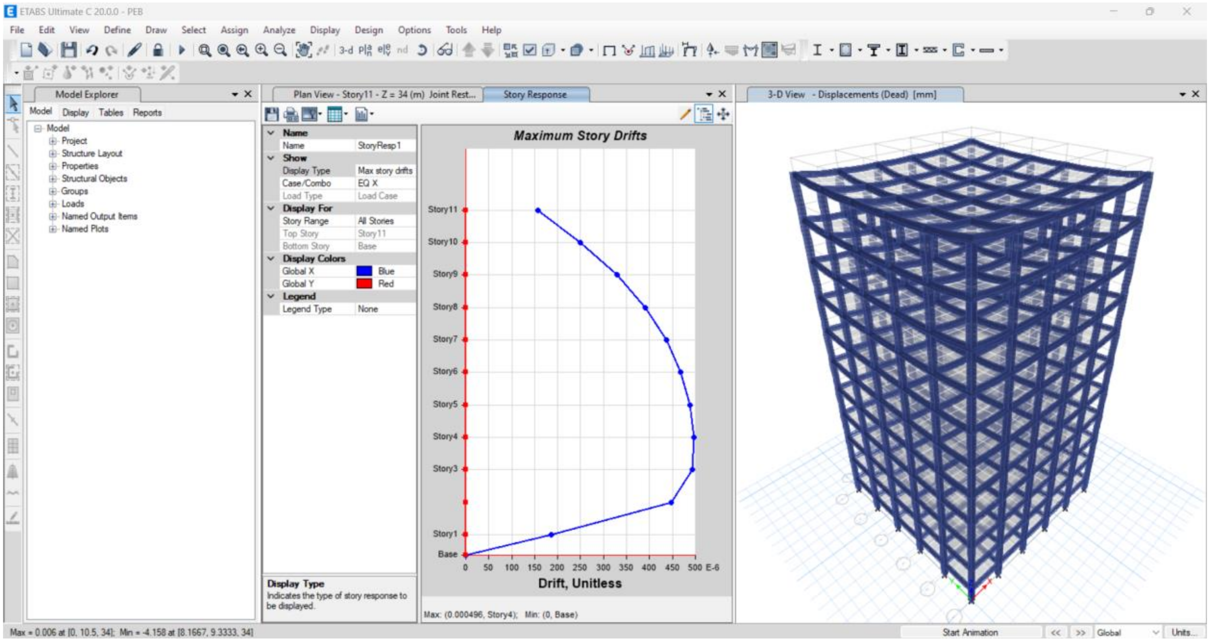

Fig Storey Drift

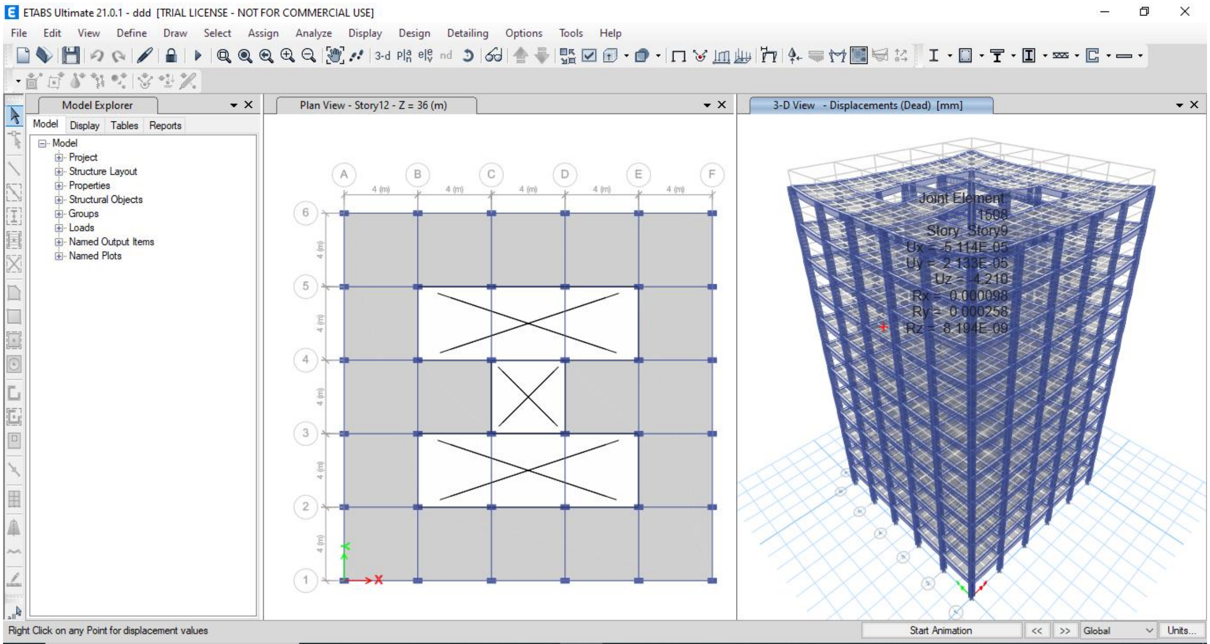

Fig Storey Displacement

ANALYSIS RESULTS:

TABLE 1: MODELLING

No of story	G+11
Plan area	20X20 m2
Number of Bays in X-Direction	16
Number of Bays in Y-Direction	7
Size of Beam	300 mmX350 mm
Size of Column	600 mmX900 mm
Each story height	3 m
Bottom Storey height	3m
Thickness of Slab	150mm
Thickness of wall	230 mm
Support Type	Fixed
Floor Diaphragm	Rigid

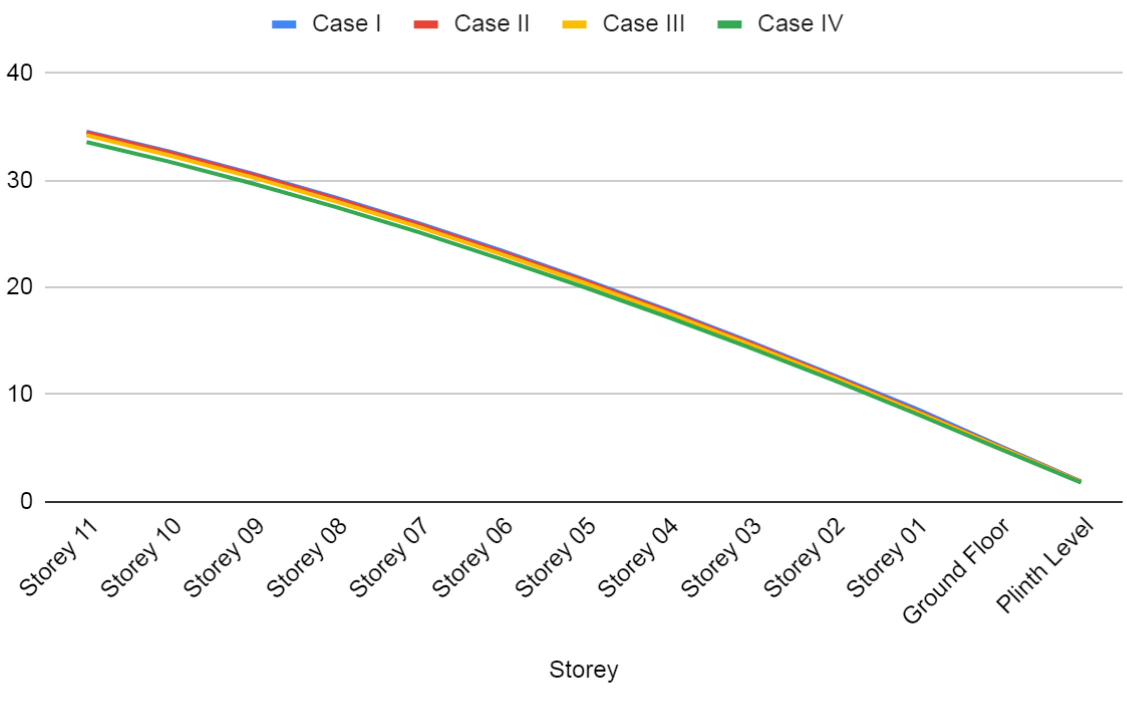

Fig 1 Storey Displacement in mm

Inference- Story displacement is the absolute value of displacement of the storey under action of the lateral forces. One can expect higher total displacement values as we move up the structure. Marginal differences were visible on the values of storey displacement as the results proved that all the case structures were found stable and while comparison storey displacement was marginally lower for case IV with wider opening diaphragm when compared to case I of conventional structure.

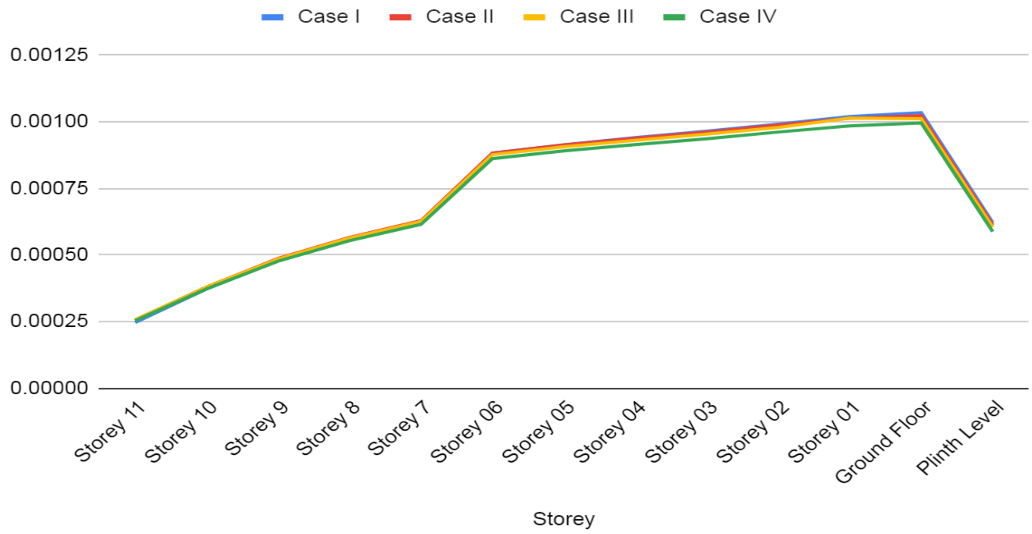

Fig 2 Storey Drift

Inference- Storey drift is the difference of displacements between two consecutive storey's divided by the height of that story. As per Indian standard, Criteria for earthquake resistant design of structures, IS 1893(Part 1): 2016, the storey drift in any story shall not exceed 0.004 times storey height. So the values of storey Drift were maxikun at second floor while the maximum resistance was visible for the case I which is a conventional structure.

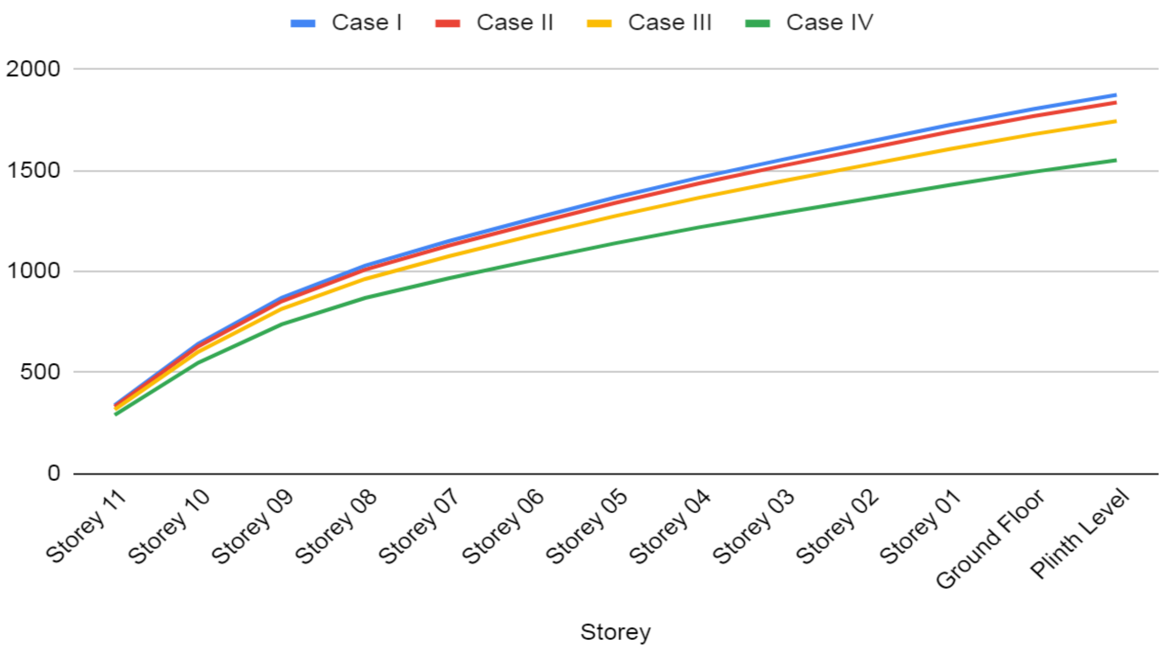

Fig 3 Storey Shear in kN

Inference- Storey shear is the lateral force acting on a storey due to the forces such as seismic and wind force. Buildings having lesser stiffness attract lesser storey shear and vice versa. storey Shear was the least for Case IV due to wider opening of the diaphragm followed by Case III, Case II and conventional structure.

IV. CONCLUSION

Storey displacement

Story displacement is the absolute value of displacement of the storey under action of the lateral forces. One can expect higher total displacement values as we move up the structure. Marginal differences were visible on the values of storey displacement as the results proved that all the case structures were found stable and while comparison storey displacement was marginally lower for case IV with wider opening diaphragm when compared to case I of conventional structure.

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