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Seismic Analysis of Tall Multistorey Structure Considering Variable Column Condition Using ETABS

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ABSTRACT

One important factor that affects the project's or building's economy is the distance between columns. Because of this relationship between column spacing and panel size, the cost of raw materials can vary in reinforced concrete buildings. When column spacing is smaller, panels are smaller, and when column spacing is larger, panels are larger. The influence of column spacing on economy is examined in this study through a comparison of the construction of G+14 R.C. Moment Resisting Frames. Three scenarios of column spacing—C1 (300x300mm), C2 (400x400mm), and combination (C1 and C2)—are taken into consideration in order to assess the impact of column spacing on economy. Using E-TABS, the structure is modelled, examined, and designed in accordance with IS 456:2000. The amount of concrete, steel, and shuttering is calculated using the E-TABS. These models are examined to determine the relation for the ideal column dimension or combination taking into account the same building loading conditions. The building's aspect ratio is set at 1.5, and the most cost-effective structure is determined by adding the costs of the shuttering, steel, and concrete together.

Keywords : Aspect Ratio, Optimum Column size, E – TABS, Multi – Storey Building, Quantity Modelling

I. INTRODUCTION

The population and land requirement for residential and commercial purposes is continuously increasing in urban areas, multistoried buildings are becoming common in construction industry. The low rise, high – rise buildings, apartments and multistorey buildings can be compared on the basis of required area for people but it also compared on the basis of required material for construction or cost. The cost is analyzed for sub – structure and super – structures. In this research, the cost is analyzed only for super – structural components. These components are column, beam and slab. The quantity of steel, concrete and shuttering is determined for each component. For multi-storey building, there are various forms of structure configuration possible. Depending upon the height of building, the form of structure is decided. The economy of such a structure is governed by many factors like, form of structure, selection of material, construction technique, time required for different work to execute. Spacing of column in a Reinforced concrete building is an important factor to determine the dimensions of columns itself, beams, slab etc. Therefore, cost of the material is also influenced by span length. In multi-story buildings, it has been discovered that the column spacing can be a significant factor in determining how economically efficient the structure is. The goal of the current study is to determine how column spacing affects building costs. Based on those crucial findings, the right column spacing for multi-story buildings will be chosen.

Objectives behind the Research

The objectives of research are stated below:

a) Seismic Analysis of G+14 building by IS 1893(Part-I):2002 Criteria for Earthquake Resistant Design of Structures.
b) Seismic Analysis of G+14 building considering two different column size and its combinations.
c) Comparing the results of Indian standards.
d) To carry out Linear Dynamic Analysis method such as Response Spectrum Analysis method for different sizes of Column using software ETABS.

II. LITERATURE SURVEY

Himanshu Krishna and Prince Yadav (2022) An analysis of the seismic performance of multistory G+4 buildings with rectangular columns and buildings with unique shaped columns was the goal of the research work. The proposed buildings are examined using comparable static analysis for zone III in soil condition in accordance with IS Code 1893 (part 1):2016. The models were analysed using ETABs. According to the findings, buildings with unique columns exhibit the fewest deflections, drifts, and shear forces when compared to buildings with standard columns. Buildings with unique columns displayed more rigidity than buildings with standard columns. Even using customised columns when construction is safer than using conventional ones.

Mohammed Rady and Sameh Youssef Mahfouz (2022) The goal of the study article was to examine how concrete grades and column spacings affect reinforced concrete (RC) building design. For buildings with three alternative floor systems—flat plates (FS), flat slabs with drop panels (FSDP), and solid slabs—cost design optimization was carried out with this goal in mind (SS). Because the evolutionary method offered by the Excel solver can handle the complexity of structural design issues, it was chosen as the optimization process. The goal was to reduce the building's overall construction costs while still adhering to the requirements of the Egyptian Code of Practice, which included charges for labour, formwork, reinforcement bars, and concrete (ECP-18). In terms of direct construction costs for low-rise RC residential buildings, the results showed that low concrete grades (i.e., characteristic strength up to 40 MPa) and column spacings up to 5 m are recommended.

III. Steps involved in the Analysis

Step 1- Firstly research papers from different authors were studied to identify the scope of research and have an elaborate study about the research done till date. Authors have studied the structure behaviour with change in size of column and this led us to identify the research topic as such research are still untouched for high rise structures.

Step 2: The first step is to define the units in ETABS for the purpose of modelling.here the display units as metric SI and the further values are defined as per the indian standards for different material involved in the process of construction. The pre-defined properties as per the categories are defined in the software where the different country codes are available as ASI standards, Chinese standards, Indian standards and Australian standards.

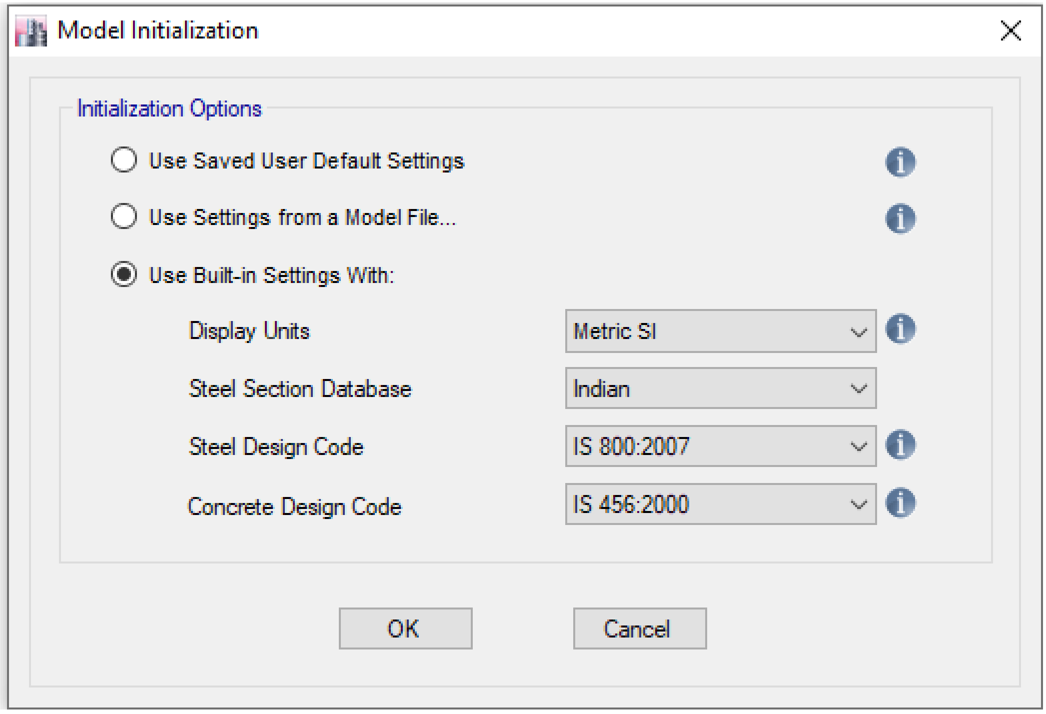


Fig 1 Model Initialization

Step 3: This step involves defining the grid as ETABS provides the provision to choose from the predefined grid system proving its ease for modelling the structure.

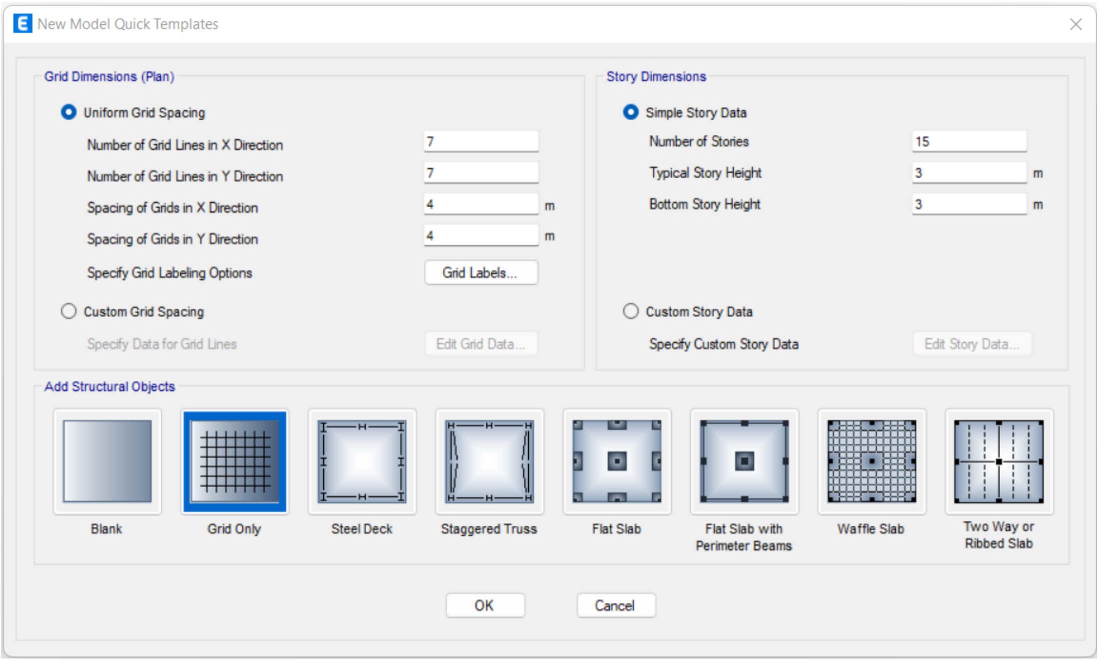


Fig 2 Model Quick Template

Step 4: Defining material properties for concrete, steel, infill and rebar. In this study, M30 concrete is considered along with HYSD500 rebar.

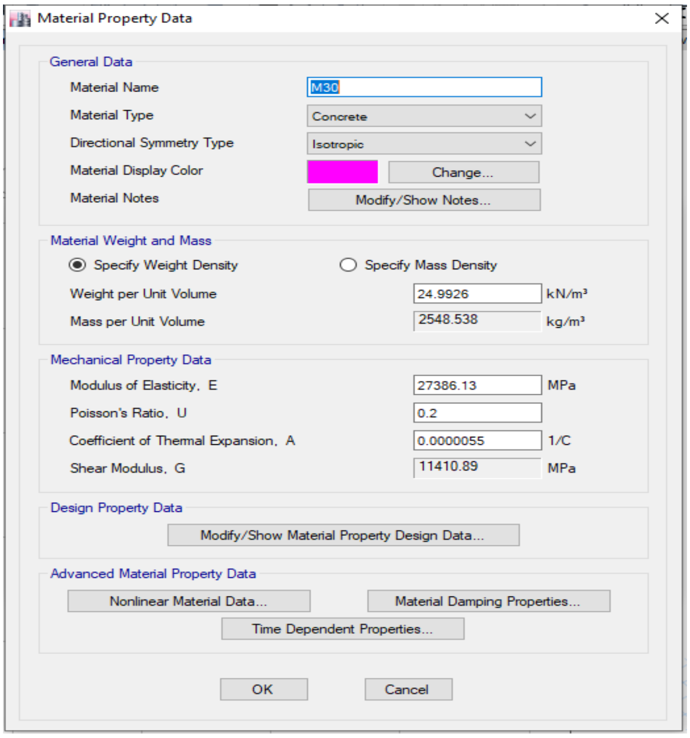


Fig 3 Concrete Property

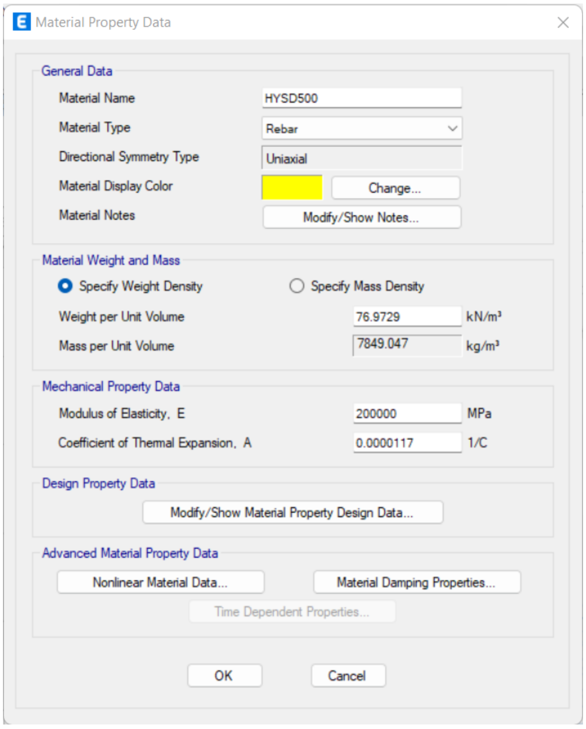


Fig 4 Rebar Property

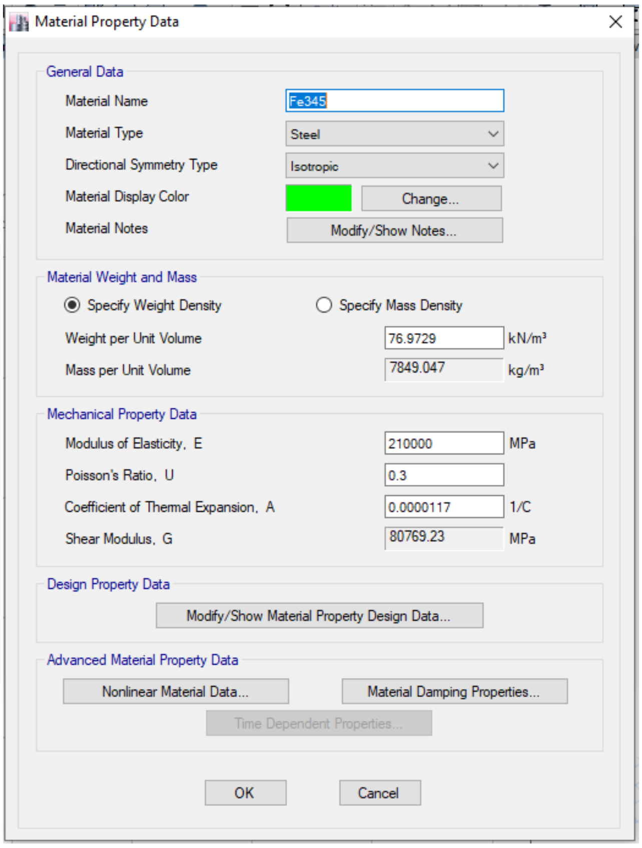


Fig 5 Properties of Steel

Step 5 Defining sections properties for column, beam and slab.

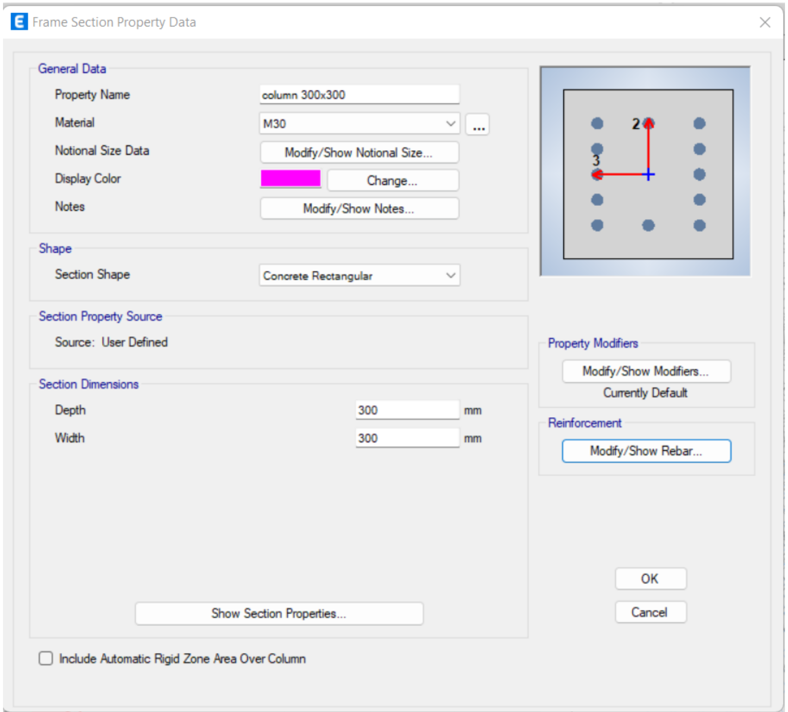


Fig 6 Section properties of beam

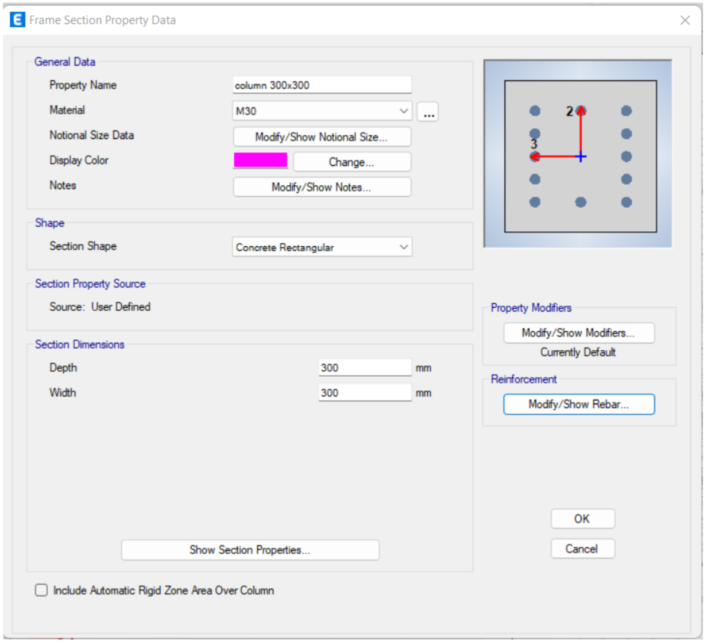


Fig 7 Section Properties of Column 300x300mm

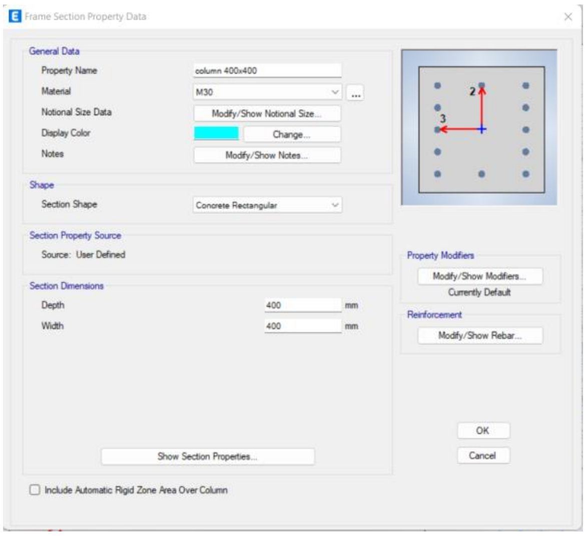


Fig 8 Section Properties of Column 400x400mm

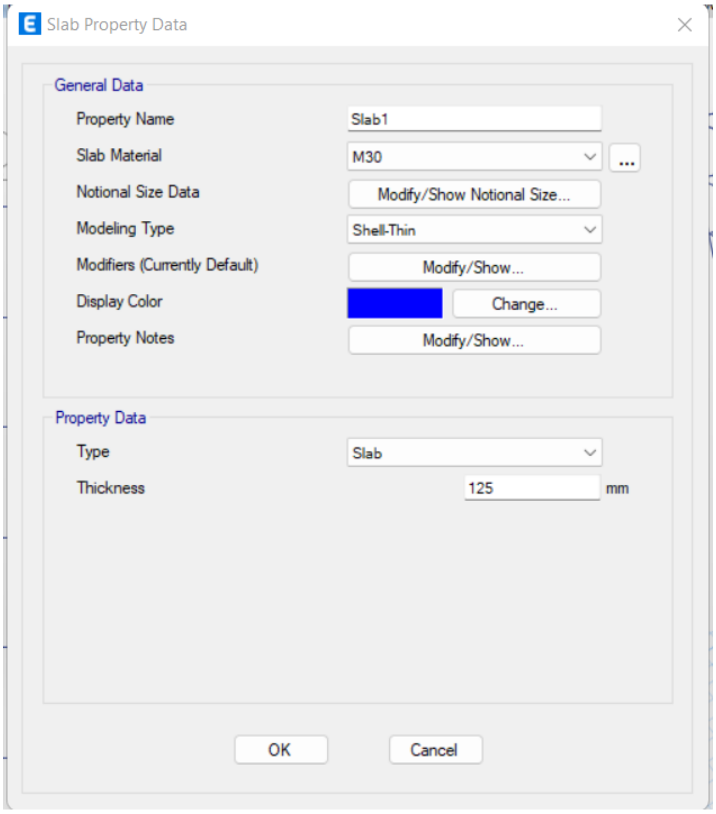


Fig 9 Section Properties of Slab

Step 6 Assigning Fixed Support at bottom of the structure for X, Y and Z-direction.

Step 7 Defining Loading conditions for live load, dead load and seismic loads.

Step 8 Checking the model for the analysis

Step 9 Results were generated on parameters of storey displacement, shear force, bending moment and axial force.

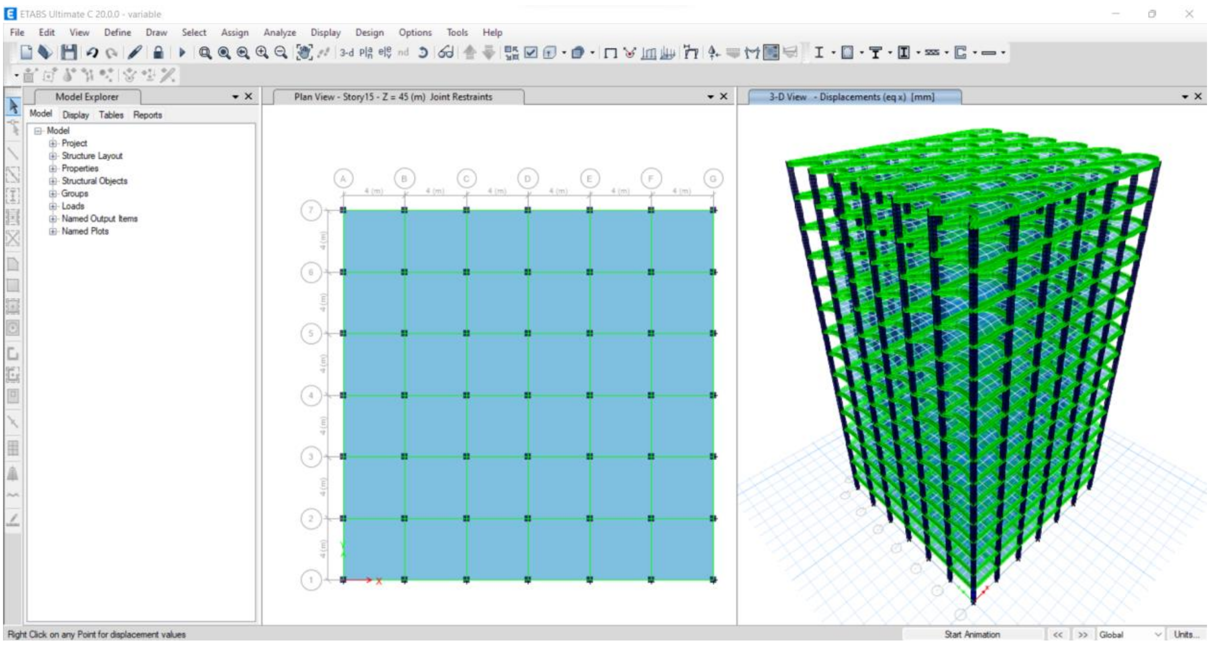
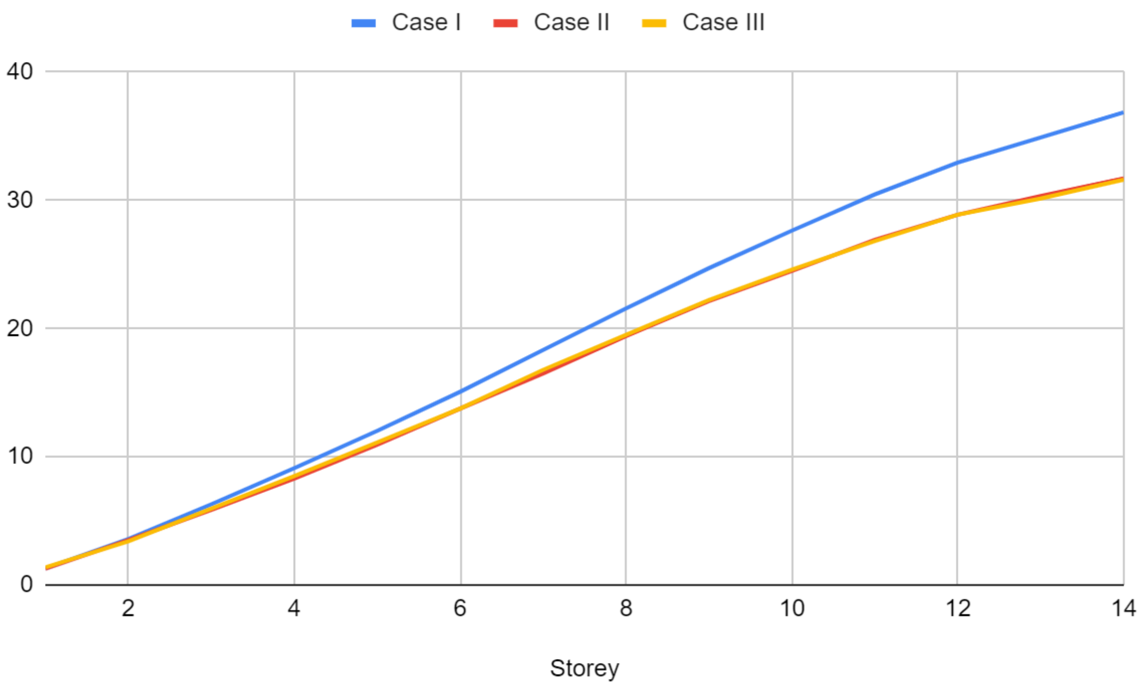
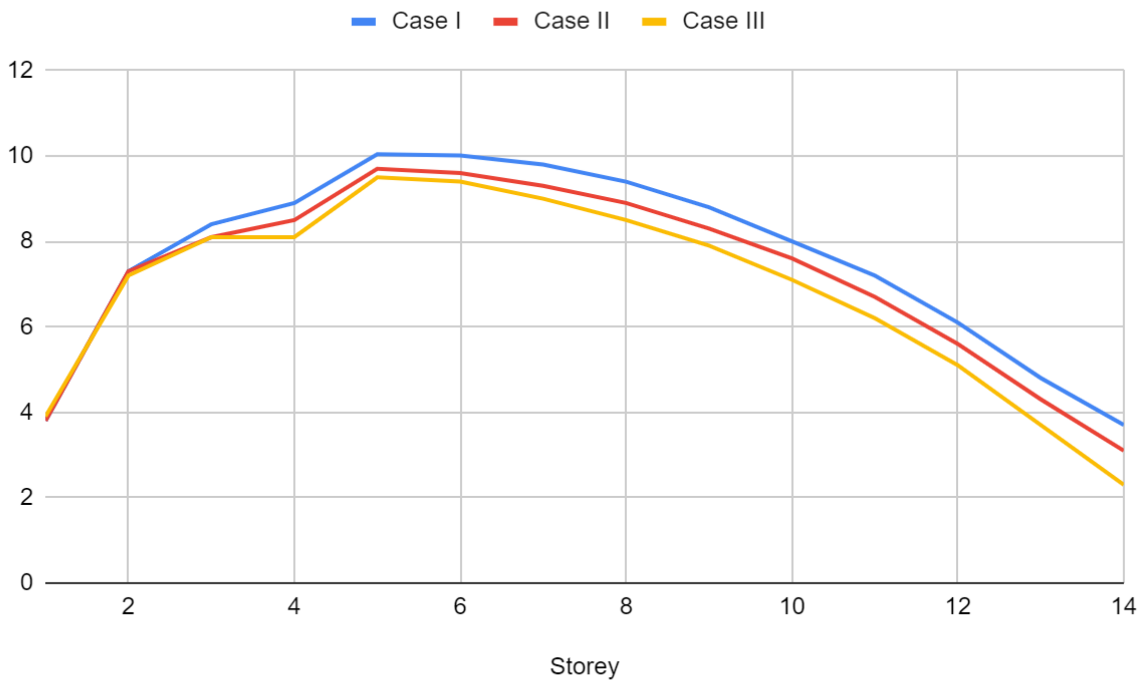
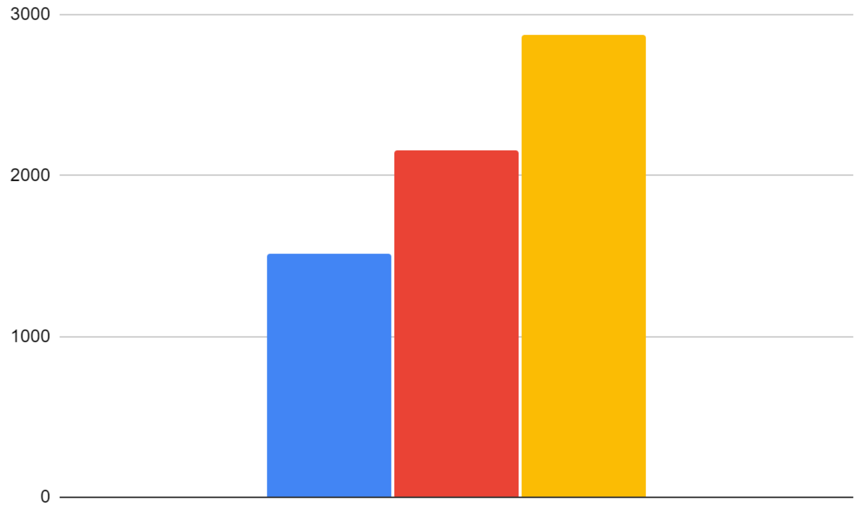


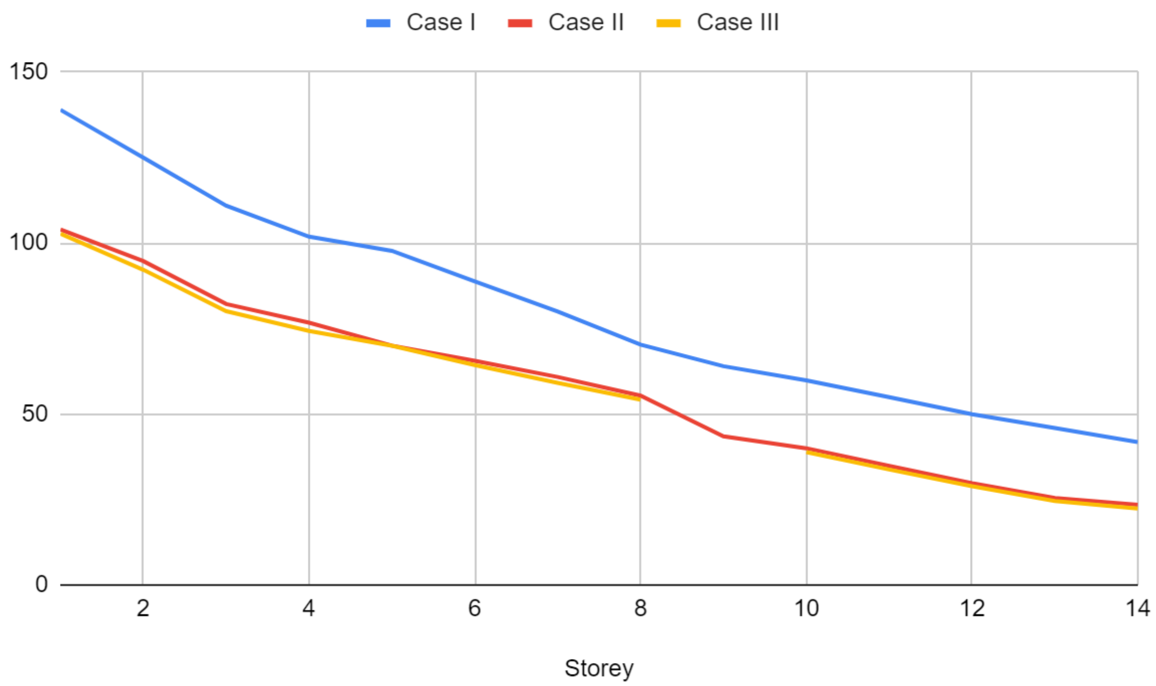
Fig 1 10 Stress Analysis of structure

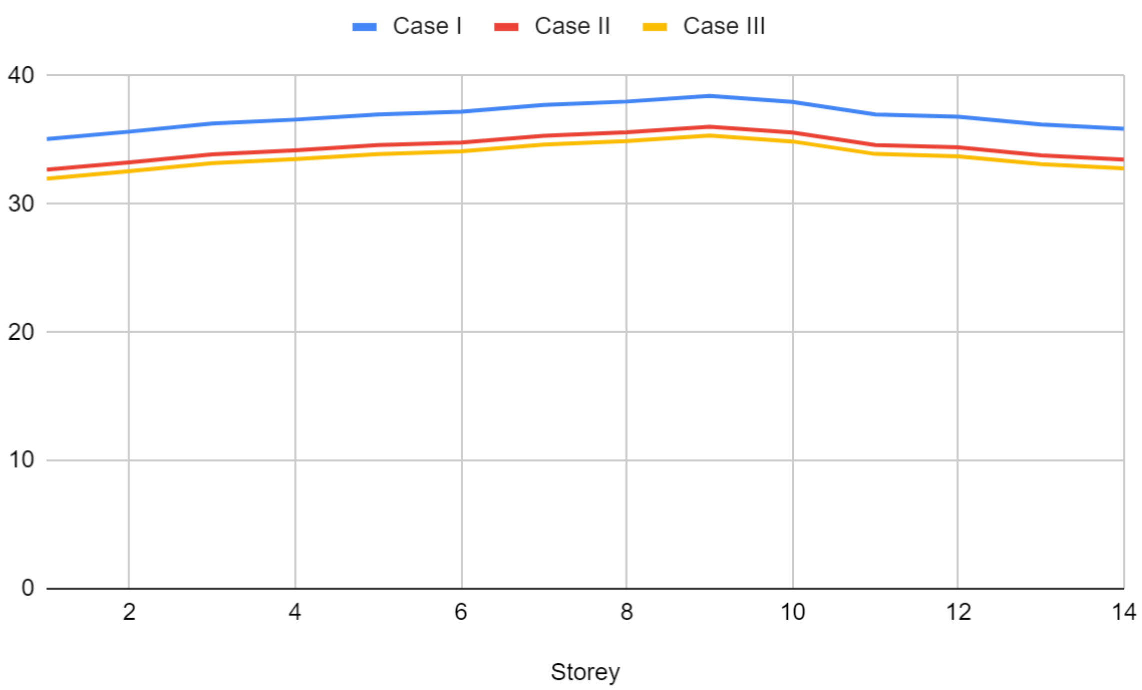
IV. ANALYSIS RESULT






3000
2000
1000
0


Case I
Case II
Case III
150
100
50
0
2
4
6
8
10
12
14
Storey



V. CONCLUSION

To ascertain the impact of column spacing on economy, a comparative study of the construction of G+14 R.C. Moment Resisting Frames was conducted. Three scenarios of column spacing—C1 (300x300mm), C2 (400x400mm), and combination (C1 and C2)—are taken into consideration in order to assess the impact of column spacing on economy. The structure is modelled, examined, and created using E-TABS in accordance with IS 456:2000. The amount of concrete, steel, and shuttering is calculated based on the E-TABS. In order to determine the relation for the ideal column dimension or combination taking into account the same loading conditions of the buildings, these models are analysed. The building's aspect ratio is set at 1.5, and the most cost-effective structure is determined using the entire cost of the materials used—concrete, steel, and shuttering.

Storey Displacement

Lateral displacement is important when structures are subjected to lateral loads like earthquake and wind loads. Lateral displacement depends on height of structure and slenderness of the structure because structures are more vulnerable as height of building increases by becoming more flexible to lateral loads. Lateral displacement was maximum for case I where the column size was 300mmx300mm and case II and Case III were found stable in handling lateral forces. Marginal difference was seen of 0.2% in case II and Case III.

Storey Drift

The amount of sideways movement between two adjacent stories of a structure brought on by lateral (seismic and wind) loads is known as lateral (story) drift. The amount of horizontal roof displacement for a single-story building is equal to the amount of lateral drift. Lateral drift was found least in Case III proving to be 2.3% less than Case II and 4.5% less than Case I. Maximum storey drift was visible in storey 5 and storey 6.

Storey Shear

Storey shear factor is the ratio of the story shear force when story collapse occurs to the story shear force when total collapse occurs. Through a series of dynamic analyses, simple equations are provisionally proposed to calculate the necessary story shear safety factor that can be used to prevent story collapse. Storey shear was maximum for Case III 12% higher when compared to Case II and 18% higher than case I. Maximum Storey shear for case III was 2876.87 kN.

Axial Force

Axial force refers to a load whose line of action runs along the length of a structure or perpendicular to the structure's cross-section. Moreover, the line of force goes through the center of gravity of the member's cross-section. When this load tends to compress the member along its line of action, it is an axial compression load and carries a negative sign by convention. While if the load extends the member along its line of action, it is an axial tension load, carrying a positive sign. Axial force was 7.12% higher in Case I when compared to Case II and Case III.

Storey Stiffness

The bottom of the storey is the only part that is restricted from moving laterally; the remainder of the storey is free to rotate. Storey stiffness is calculated as the lateral force causing unit translational lateral deformation in that storey. Storey stiffness was 3.1% higher in case I when compared to case II and case III.

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