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LINEAR DYNAMIC ANALYSIS OF VERTICAL IRREGULAR BUILDING WITH AND WITHOUT USING OF SHEAR WALLS

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Abstract:
This study delves into the seismic response of vertically irregular buildings using linear dynamic analysis method. Comparing those equipped with shear walls against those without. Seismic irregularities pose significant challenges to building safety and stability during seismic events. Utilizing computational analysis through advanced software like ETABS, this research evaluates the effectiveness of shear walls in reducing seismic forces and enhancing structural integrity. The primary goal is to provide valuable insights into the behavior of irregular buildings under seismic loading, aiding in the design and improvement of resilient structures in seismically active regions. Structural members are designed according to IS456-2000 standards, and the analysis is carried out using ETABS version 9.7.1 software, with load considerations following the Indian code. Multi-story building plans, specifically a G+12 structure, are examined, focusing on vertical irregular models with and without shear walls under Zone IV seismic conditions. The study emphasizes the evaluation and comparison of storey displacements and drifts.
Keywords: Seismic behaviour, Vertical irregular buildings, Shear walls, Seismic forces, Structural performance, Computational analysis, ETABS software, Building safety, Structural stability.

I. Introduction:

Vertical irregularities in buildings can significantly impact their seismic response during earthquakes. These irregularities encompass variations in mass and stiffness along both vertical and horizontal axes, resulting in a misalignment between the center of mass and center of rigidity (Suwondo & Alama, 2020). This misalignment can induce excessive lateral displacements and rotations, thereby elevating the building's susceptibility to seismic forces.

The Influence of Shear Walls on Seismic Behavior:

Incorporating shear walls can substantially improve the seismic performance of vertically irregular buildings. Acting as vertical cantilevers, shear walls are engineered to withstand lateral forces generated by seismic events, furnishing the structure with enhanced stiffness and strength **(Yang & Zhang, 2020)**. The integration of shear walls in vertically irregular buildings facilitates the redistribution of seismic forces, mitigating structural deformations and fortifying overall stability.

Given the prevalence of seismic activity in certain regions, ensuring the resilience of building structures is paramount. As urbanization continues to surge, accompanied by the erection of towering structures, understanding the intricate dynamics between building configurations and their response to seismic forces becomes imperative. The presence of vertical irregularities in building layouts presents formidable challenges to structural stability and safety, particularly in seismic environments. Shear walls, renowned for their efficacy in mitigating seismic forces, emerge as indispensable components in the pursuit of earthquake-resistant structures. This study aims to comprehensively investigate the seismic behavior of vertically irregular buildings, meticulously analysing the nuanced impact of shear walls on structural performance. Leveraging rigorous analysis and computational simulations facilitated by advanced software tools, the complex interplay between building irregularities and seismic loading conditions will be elucidated. By scrutinizing diverse building configurations, encompassing both those with and without shear walls, this research endeavours to provide invaluable insights into the efficacy of shear walls in bolstering structural resilience.

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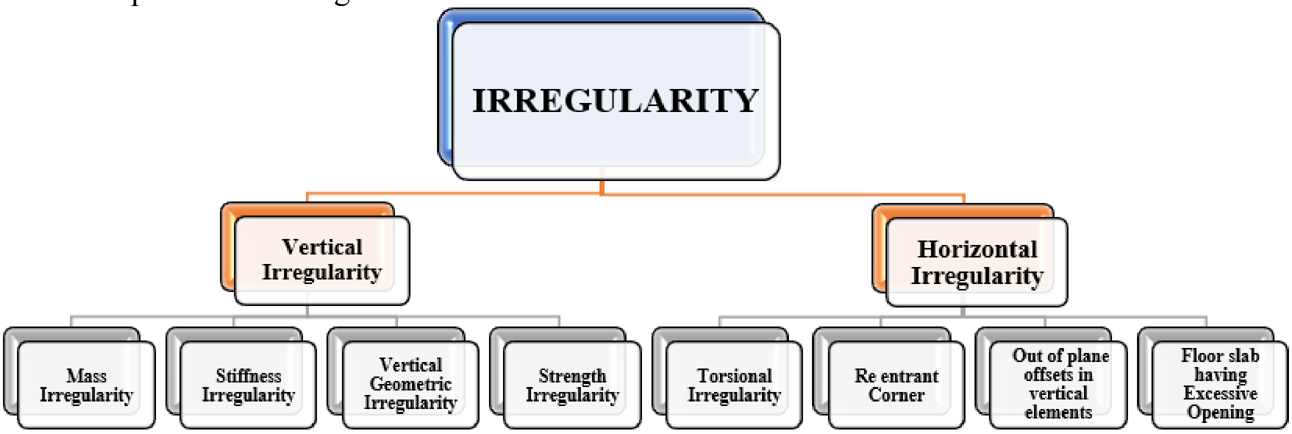
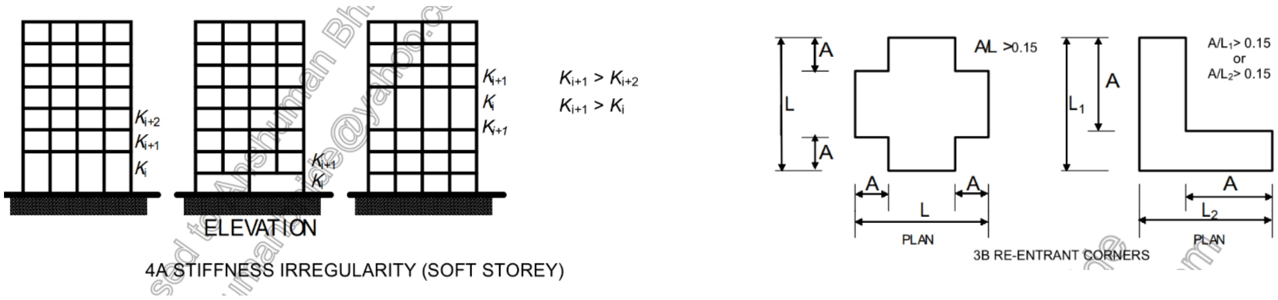
The Significance of the Inquiry: The significance of this inquiry lies in its potential to inform and refine contemporary seismic design practices, offering crucial guidance to engineers and stakeholders involved in the construction of resilient structures. By unravelling the intricate relationships between building irregularities, shear wall integration, and seismic response, this research aims to contribute to the advancement of seismic design principles and the construction of safer built environments." response, this research strives to advance seismic design methodologies, ultimately fostering safer and more robust built environments in seismic-prone regions.

In line with IS 1893, structures with Vertical Irregularity are identified by non-uniform distributions in mass, strength, and stiffness along their height. Erecting such buildings in regions prone to high seismic activity substantially complicates the process of analysis and design. Similarly, Horizontal Irregularity, as defined by IS 1893, refers to uneven distributions in lateral stiffness, strength, and mass across the horizontal plane of building structures.





Shear Wall- Vertical structural components known as shear walls are designed to withstand lateral forces from wind or seismic activity. The placement and design of these walls are crucial for their ability to resist these forces effectively. Lateral loads, acting like a horizontal diaphragm, are distributed throughout the structure, with shear walls taking the brunt of these forces aligned parallel to their direction. With stiffness akin to deep beams, shear walls effectively counteract shear and flexural stresses, resisting overturning. However, if a building's core is positioned off-centre, it must withstand tensile, bending, and direct shear forces.

Symmetrically arranged shear walls can induce torsional effects, especially when wind interacts with facade features or deviates from the building's central mass. Compared to horizontal rigid frames, shear walls offer substantially greater stiffness, making them cost-effective solutions for structures up to 35 stories tall. In low to medium-rise buildings, integrating shear walls with frames can allow the walls to absorb all lateral loads, leaving the frames to handle only gravity loads. The resistance of a shear wall increases with its thickness, although the impact of width is more significant.

Another common design is the coupled shear wall structure, where two or more shear walls are closely positioned or on the same plane, interconnected at various floor levels through stiff beams or slabs. This arrangement provides significantly higher horizontal stiffness compared to separate, uncoupled cantilevered walls.

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Study Objective:

1. Study how multi-story buildings react to earthquakes using the IS 1893:2016 guidelines.
2. Compare buildings with and without shear walls in terms of their stability during earthquakes, especially in irregular vertical configurations.
3. Analyse differences in Story Drift, Story Displacement, Overturning Moment, and Story Shear between buildings with and without shear walls in various vertical configurations.
4. Use ETABS V9.7.4 for Response Spectrum Analysis to understand how the buildings respond structurally to seismic forces.

II. LITERATURE STUDIES:

The inclusion of shear walls in irregular buildings has been found to significantly improve their seismic performance. **Kadakia (2017) and Khatri (2021)** both observed enhanced lateral load carrying capacity, reduced lateral displacement, and improved storey drift and drift ratio in buildings with shear walls. **Majeed (2014)** reported a reduction in maximum relative displacement and twist values, while **Farghaly (2016)** found that the behaviour of the structure is influenced by the height and location of shear walls. These findings collectively suggest that the use of shear walls is beneficial in enhancing the seismic behaviour of irregular buildings. Additionally, the use of end walls in tall buildings with torsional irregularity has been shown to further improve their seismic behaviour, reducing drifts, roof displacement, and the first period of the structure **(Salmassi 2020).** However, the presence of openings in shear walls can also influence the seismic behaviour of the structure, as shown by **Kodappana (2017)**. These findings collectively suggest that shear walls play a crucial role in enhancing the seismic performance of vertically irregular buildings.

3. METHODOLOGY:

Response Spectrum Analysis

The seismic assessment of structures is crucial for ensuring their stability and resilience during seismic events. In modern structural engineering, response spectrum analysis techniques have become prominent for examining how structures respond to seismic forces. This study focuses on applying response spectrum analysis methods for seismic evaluation using Etabs, a widely used software for structural analysis and design. By employing response spectrum analysis in Etabs, our aim is to conduct a thorough assessment of structural dynamics under seismic loading conditions. This research seeks to advance seismic analysis methods, enhancing our understanding and mitigation of seismic risks in structural engineering frameworks.

Model Parameters:

For the current investigation, we undertake an analysis of a G+12 multi-story commercial edifice situated in seismic zone 4, employing the ETABS software. The building exhibits a typical scale, with dimensions characterized by-

Primary factors incorporated for the analysis encompass:

1. Building Type: Residential building
2. Number of stories: G+12
3.Geometric details
   a. Ground floor: 3 m
   b. floor to floor height: 3m
   c. Height of the building: 39m
4.Material details
   a. Grade of Concrete: M35 (COLUMNS AND BEAMS)
   b. Grade of Steel: HYSD 500
   c. Bearing Capacity of Soil: 200 KN/m2
5. Type of Construction: R.C.C FRAMED structure
7. Column: 0.5m X 0.5m

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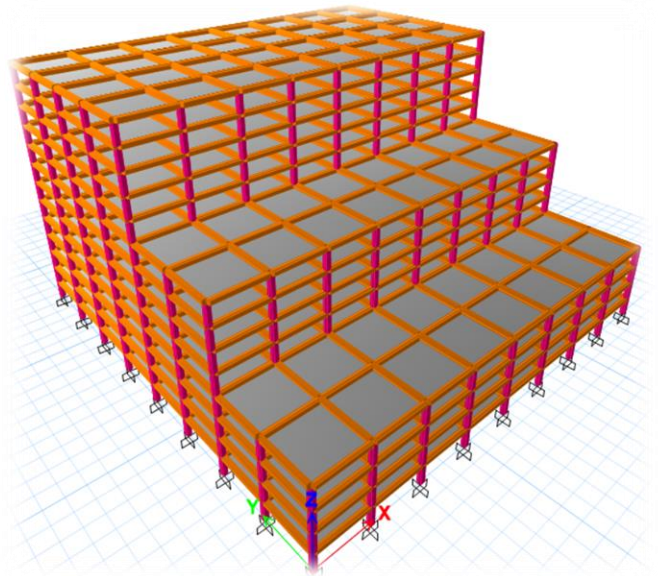
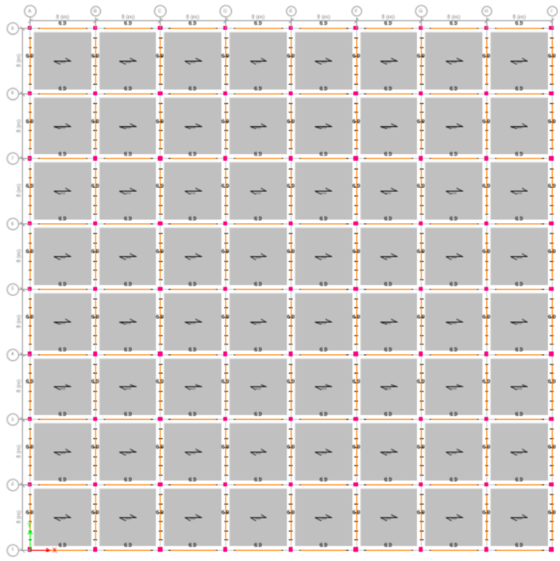
8. Beams: 0.45m X 0.5m
9. Slab: 150mm
10. Shear wall: Thickness 150mm
11. Concrete code: IS 456-2000
12. Seismic code: IS 1893:2016 (1)
13 For loading: IS 875:1987 (I, II, III)

III. MODELING IN ETABS:

1.<u>Vertical Irregularity Without Shear Walls-</u>



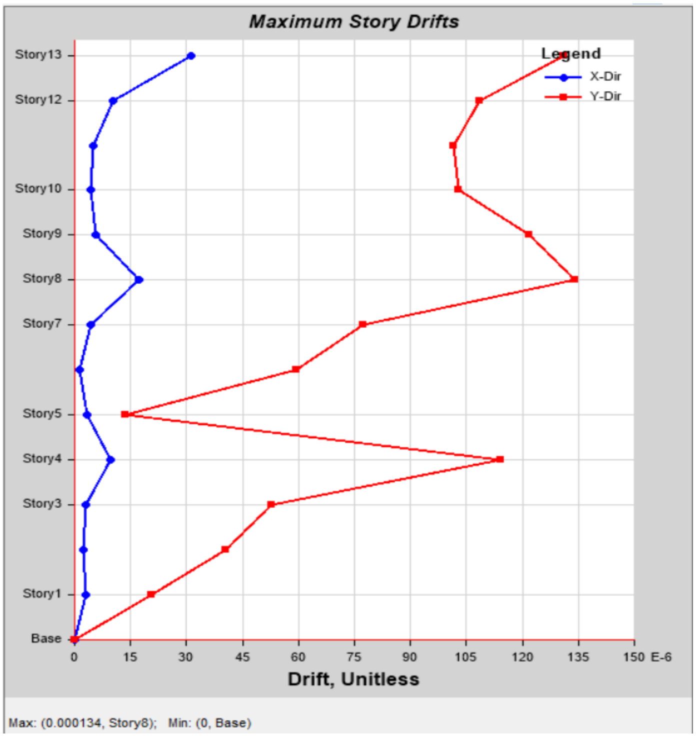
3D View



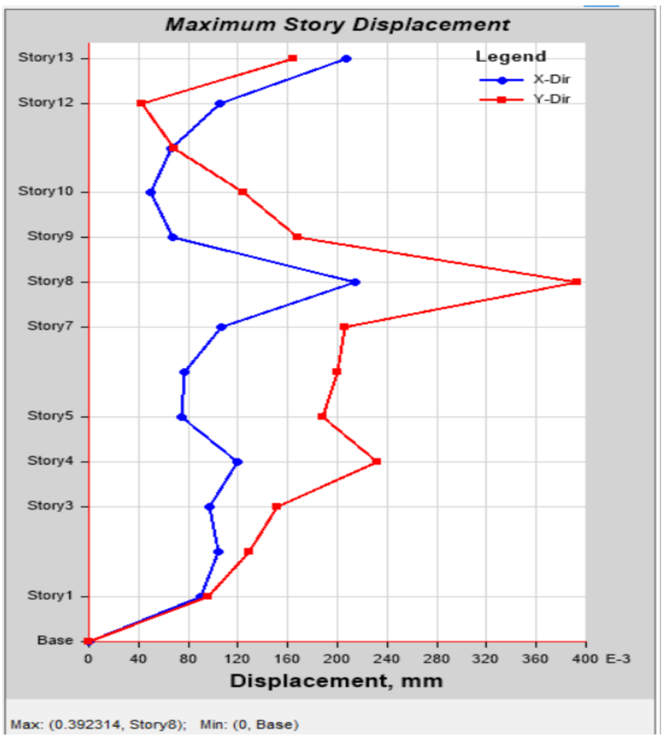
Plan View

ANALYSIS RESULTS: -

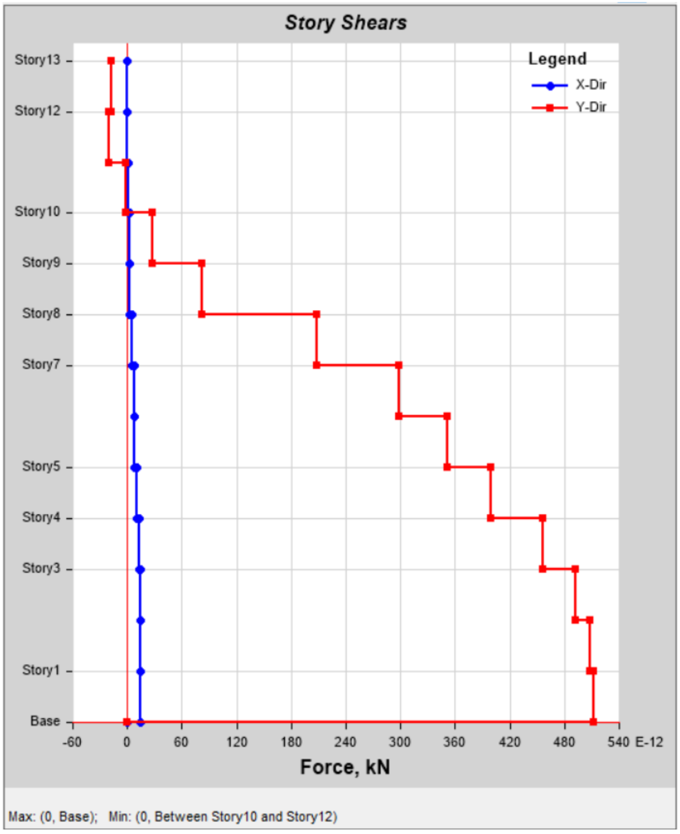
1. Max Story Drift



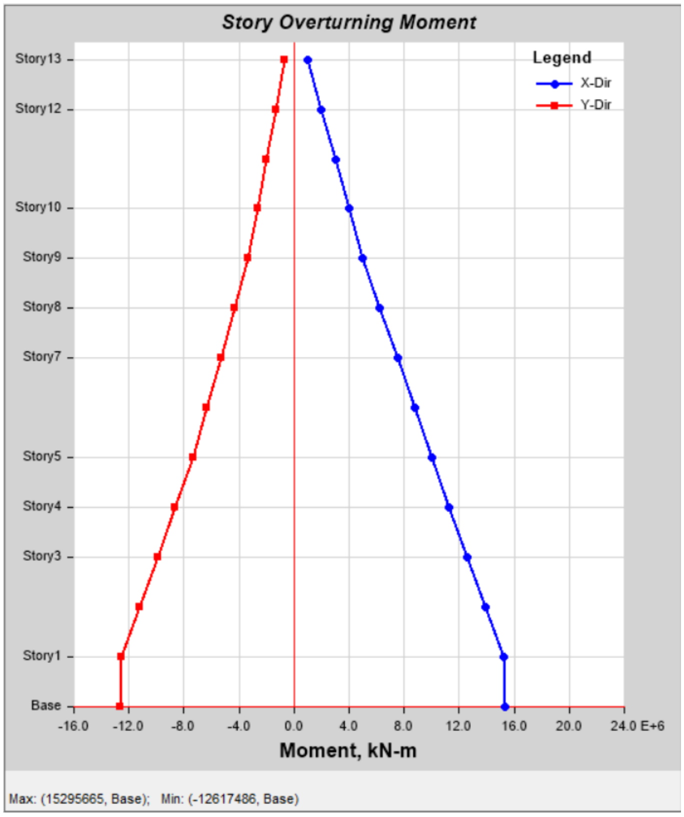
2. Max Story Displacement



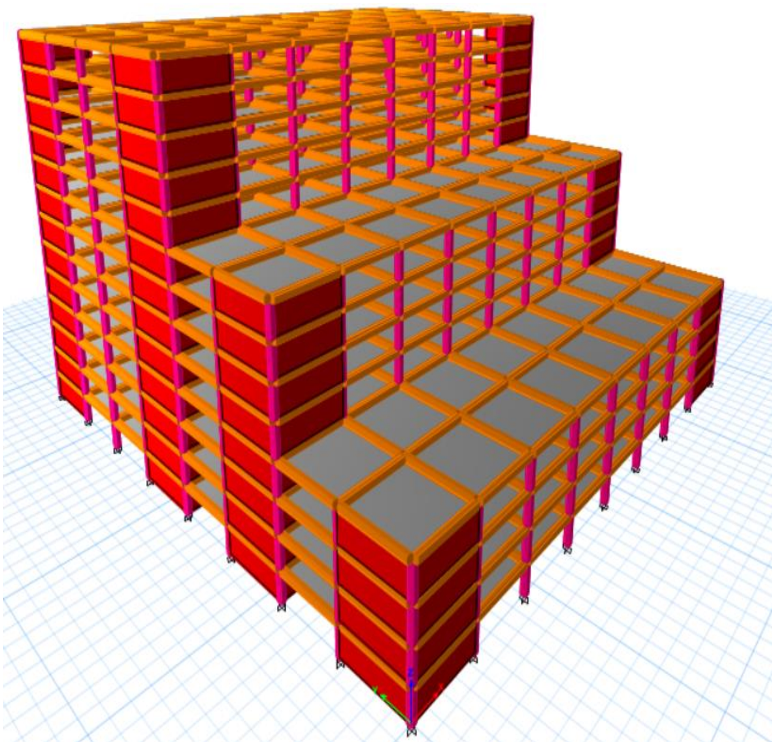
3.Story Shear



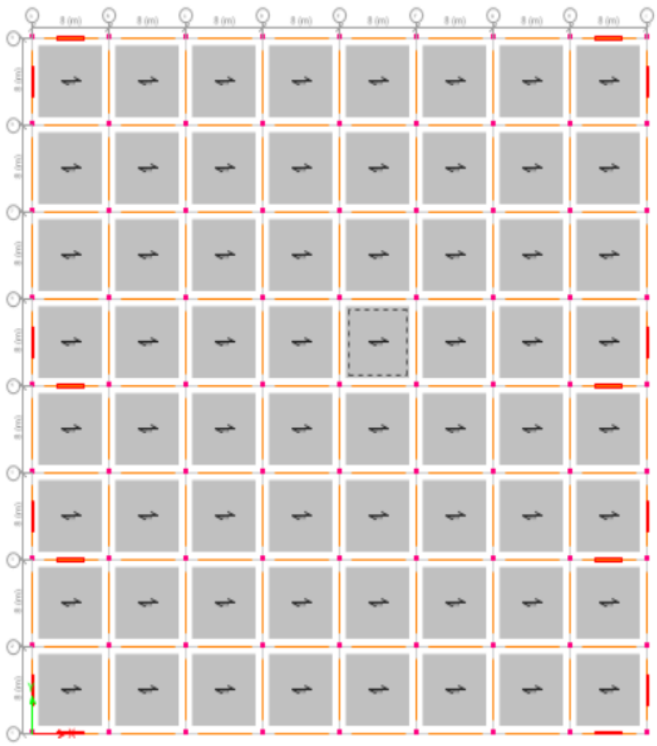
4. Story Overturning Moment



2.<u>Vertical Irregularity with Shear Walls-</u>



3D View



Plan View

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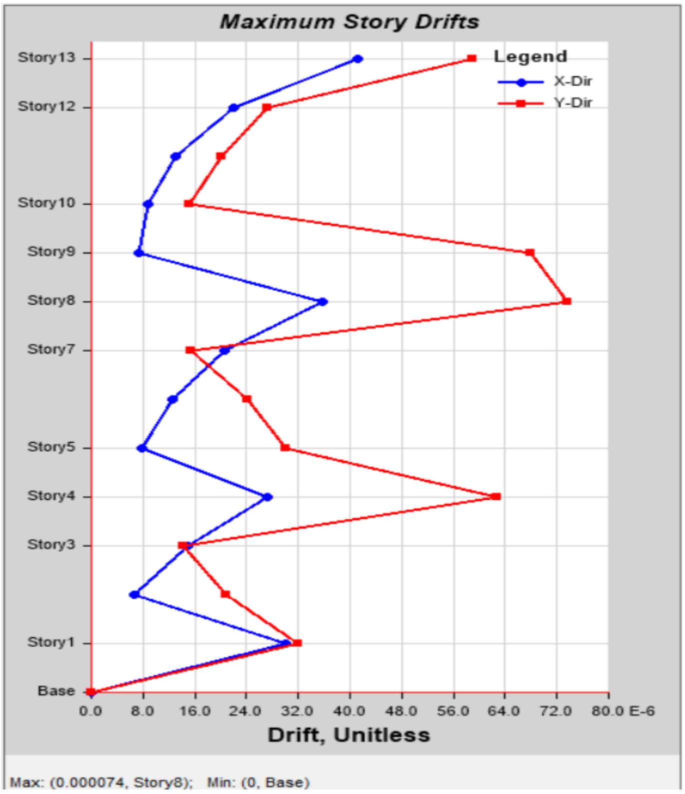
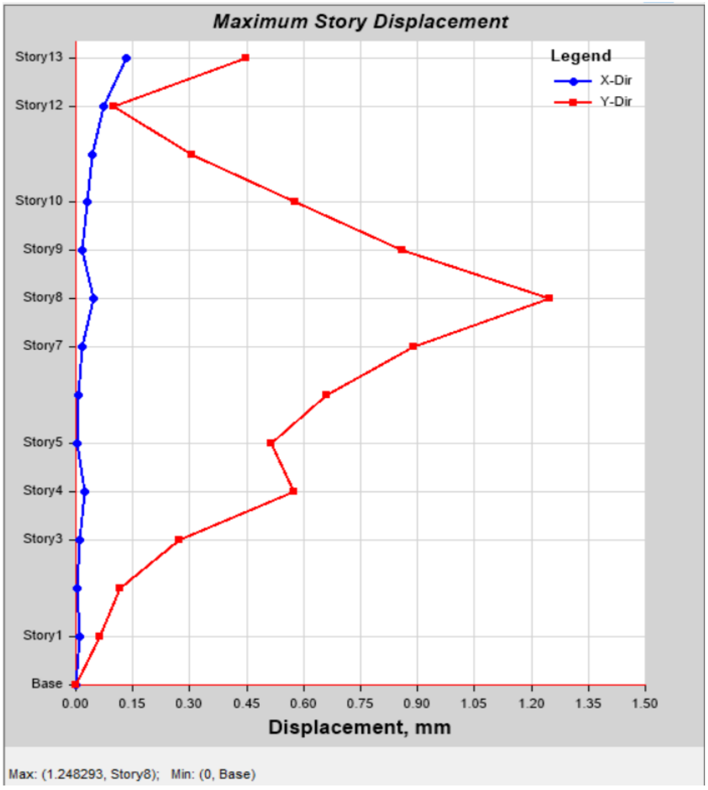
ANALYSIS RESULTS: -

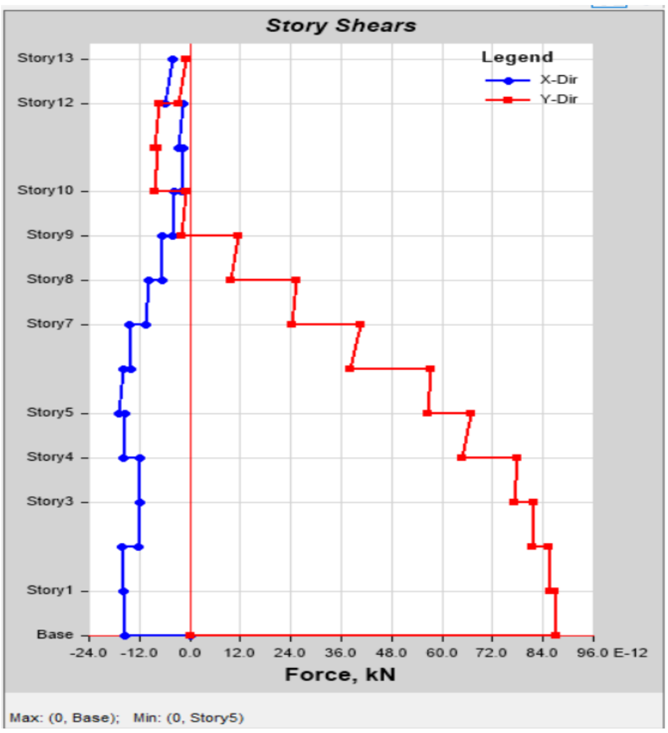
1. Max Story Drift



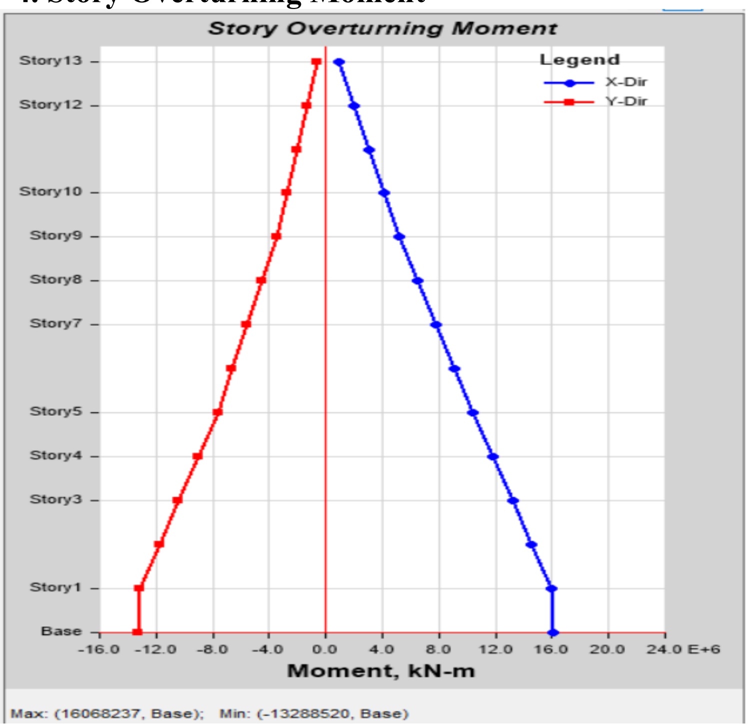
2. Max Story Displacement



3.Story Shear



4. Story Overturning Moment



CONCLUSIONS:

From this study the following conclusions were made

1. This study implemented a seismic-resistant building design to address vertical irregularities, focusing on the incorporation of shear walls.
2. Shear walls, vertical structural elements, are commonly employed to mitigate lateral loads induced by seismic and wind forces.
3. In buildings with vertical irregularities and lacking shear walls, notably elevated story drift values were observed.
4. Story drift values exhibited greater magnitudes in buildings without shear walls when compared to those with irregular vertical structures.
5. Story displacement values demonstrated higher magnitudes in buildings lacking shear walls compared to those with irregular vertical structures.
6. Notably, buildings lacking shear walls exhibited higher story shear values when compared to those with irregular vertical structures.
7. Following the installation of shear walls at building corners, a 55 TO 60% reduction in displacement along the X direction was observed compared to models without shear walls.
8. The building exhibits its maximum time period without a shear wall model, whereas its minimum time period is observed when a shear wall is incorporated."

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