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A Seismic Study on Shear Wall Location in a 12-Storey Building Using STAAD.Pro V8i

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Abstract: The rapid growth of urban infrastructure in seismically active regions has increased the demand for resilient mid-rise reinforced concrete (RC) buildings, particularly those around twelve storeys where structural response is highly influenced by stiffness, flexibility, and dynamic characteristics. Ensuring adequate seismic performance in such buildings requires an appropriate combination of gravity-resisting and lateral load-resisting elements. Traditional RC moment-resisting frames often exhibit excessive lateral displacement and insufficient stiffness under strong ground motions, making the integration of shear walls essential for improved performance. However, the efficiency of shear walls depends greatly on their location within the structural layout, as improper placement may induce torsion, stress concentration, or stiffness irregularity.

This study investigates the seismic behavior of a G+12 RC building with and without shear walls in Seismic Zone III on medium soil using the Response Spectrum Method as per IS 1893 (Part 1): 2016. STAAD.Pro V8i is used to evaluate key response parameters such as natural period, storey displacement, storey drift, storey shear, and lateral load distribution. Three analytical models—bare frame, shear wall at selected locations, and optimally placed shear walls—are compared to determine the most effective configuration. Results show that storey displacement increases with height and is greater in the Y-direction for all models. The inclusion of shear walls significantly reduces displacement, drift, and base shear, with Model III exhibiting superior stiffness and lateral resistance. The findings provide practical insights for optimizing shear wall configuration in mid-rise buildings to enhance seismic performance and structural safety.

Keywords: Shear Wall Optimization, Seismic Analysis, Response Spectrum Method, STAAD.Pro V8i, Storey Drift, Storey Displacement, Lateral Load Resistance;

I. INTRODUCTION

The increasing demand for vertical urban expansion in seismically active regions has placed reinforced concrete (RC) mid-rise buildings at the center of modern structural engineering discourse [1]-[3]. Among these, 12-storey buildings represent a critical height range where the structural response is strongly influenced by both stiffness and flexibility, making them highly sensitive to earthquake-induced lateral forces [4], [7]. Ensuring seismic resilience in such buildings requires a comprehensive understanding of load paths, stiffness distribution, and the interaction between gravity-resisting and lateral-resisting systems. Traditional RC moment-resisting frames, while effective under moderate loading, often exhibit inadequate stiffness and excessive inter-storey drift during strong ground motions [5], [9]. Consequently, the strategic integration of shear walls has emerged as a prominent solution to enhance lateral resistance, reduce structural irregularities, and improve overall building performance [6], [10].

Shear walls act as primary lateral load-resisting elements capable of dissipating seismic energy, reducing deformation demand on beams and columns, and controlling torsional effects arising from asymmetric mass or stiffness distribution. However, the seismic efficiency of shear walls is highly dependent on their placement within the building plan. Inappropriately positioned walls can introduce torsional imbalances, concentrate stresses, or over-stiffen local regions, while optimally placed walls can significantly improve drift control, base shear distribution, and global structural stability. Therefore, determining the optimal shear wall location is a key parameter in the seismic design of mid-rise RC structures, especially in scenarios involving soft soils, moderate to high seismic zones, or irregular architectural layouts.

Recent advancements in computational tools such as STAAD.Pro V8i allow engineers to perform sophisticated seismic evaluations using response spectrum, modal analysis, and load-combination optimization [8], [14], [17]. The software's compatibility with IS 456:2000 and IS 1893:2016 enables accurate assessment of structural responses such as natural period, storey drift, storey shear, modal participation factors, and displacement patterns [7], [15], [16]. These capabilities make STAAD.Pro V8i a reliable platform for evaluating shear wall placement and its influence on seismic performance.

This study focuses on a detailed seismic evaluation of a 12-storey RC building model by examining the influence of different shear wall configurations on key seismic parameters. Special emphasis is placed on identifying the most effective shear wall location to minimize drift and displacement, reduce base shear, enhance stiffness distribution, and ensure compliance with codal limits as shoen in TABLE I. By integrating numerical simulation with codal provisions, this research aims to contribute to the development of rational guidelines for shear wall optimization in mid-rise buildings. Such insights are crucial for engineers and researchers striving to design cost-efficient, structurally robust, and earthquake-resistant buildings in seismic zones.

1) Zone I

In the current seismic zoning system of India, Zone I is not used. According to IS 1893 (Part 1): 2002 [19], no region in the country is classified under Zone I, meaning the classification begins from Zone II onwards.

2) Zone II – Low Seismic Risk

Zone II represents areas with low earthquake hazard. The IS code assigns a zone factor of 0.10, indicating that the maximum expected horizontal ground acceleration is roughly 10% of gravitational acceleration (0.1g). Buildings in this zone require basic seismic design precautions[19].

3) Zone III – Moderate Seismic Risk

Zone III is categorized as a moderate-risk seismic zone. With a zone factor of 0.16, this area faces noticeably higher seismic activity than Zone II. Structures here must incorporate significant earthquake-resistant design measures as per IS 1893[19].

4) Zone IV – High Seismic Risk

Zone IV is considered a high-damage risk zone, with a zone factor of 0.24. Several regions fall within this classification, including:
Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim
Portions of North Punjab, Chandigarh, Western Uttar Pradesh, the Terai belt, North Bengal, and the Sundarbans
Parts of Maharashtra and northern Bihar (especially near Raxaul along the India–Nepal border)
These areas require rigorous seismic-resistant structural design.

5) Zone V – Very High Seismic Risk

Zone V is the most severe seismic zone in India, with a zone factor of 0.36, representing the highest level of potential ground motion. This zone includes: Kashmir, Western and Central Himalayas, North and Central Bihar, Entire North-Eastern region, Rann of Kutch, Andaman and Nicobar Islands
Structures in Zone V must be designed to withstand intense earthquake forces, as the risk of severe ground shaking and structural damage is the highest here.

TABLE 1 Response Reduction Factor[1]), R, for Building Systems

Sl. No. (1)	Type of Lateral Load–Resisting System (2)	R-Value (3)
Building Frame Systems		
i)	Ordinary RC Moment-Resisting Frame (OMRF)	3.0
ii)	Special RC Moment-Resisting Frame (SMRF)	5.0
iii)	Steel Frames with:	
	a) Concentric Bracing	4.0
	b) Eccentric Bracing	5.0
iv)	Steel Moment-Resisting Frame (Designed as per SP: 6)	5.0
Buildings with Shear Walls		
v)	Load-Bearing Masonry Wall Systems:	
	a) Unreinforced Masonry Walls	1.5
	b) Masonry with Horizontal RC Bands	2.5

	c) Masonry with Horizontal RC Bands and Vertical Reinforcement at Corners and Openings	3.0
vi)	Ordinary RC Shear Walls	3.0
vii)	Ductile RC Shear Walls	4.0
Buildings with Dual Systems		
viii)	Ordinary Shear Wall Combined with OMRF	3.0
ix)	Ordinary Shear Wall Combined with SMRF	4.0
x)	Ductile Shear Wall Combined with OMRF	4.5
xi)	Ductile Shear Wall Combined with SMRF	5.0

About STAAD.Pro V8i

STAAD.Pro is a go-to software for structural engineers working on tall buildings. It packs a lot under the hood: advanced modeling tools, templates you can tweak, and it covers a ton of design codes—Indian, European, American, you name it. You can throw just about any loading scenario at it: static, dynamic, wind, temperature changes, earthquakes. When it comes to seismic analysis, STAAD.Pro handles modal analysis and direct-integration time-history, and it doesn't skip details like P-Delta or large-displacement effects. If you need to dig into material nonlinearity, you've got options—nonlinear links, PMM hinges, fiber hinges—so you can capture how materials really behave, whether you're looking at one-time loads or repeated cycles. The workflow feels smooth and unified, so even complicated projects don't get bogged down. Plus, you can connect it with other design and documentation tools, which saves time and hassle. Whether you're working on a simple 2D frame or a cutting-edge skyscraper, STAAD.Pro gives you the flexibility and depth you need. [8], [10], [14], [17].

II. METHODOLOGY

This research investigates the seismic behaviour of a G+12 RC building with and without shear walls, located in Seismic Zone III and resting on medium soil. The analysis follows the Response Spectrum Method as per IS 1893 (Part 1): 2016. The study evaluates key seismic response parameters, including maximum storey displacement, storey shear, and critical bending moments. The overall investigation is carried out through the following steps.

A. Step-I Selection of the configuration of the building with and without shear wall.

The configuration of the building is selected in two forms—one model without shear walls and another with shear walls—to compare their seismic behaviour and evaluate how the presence and placement of shear walls influence structural performance.

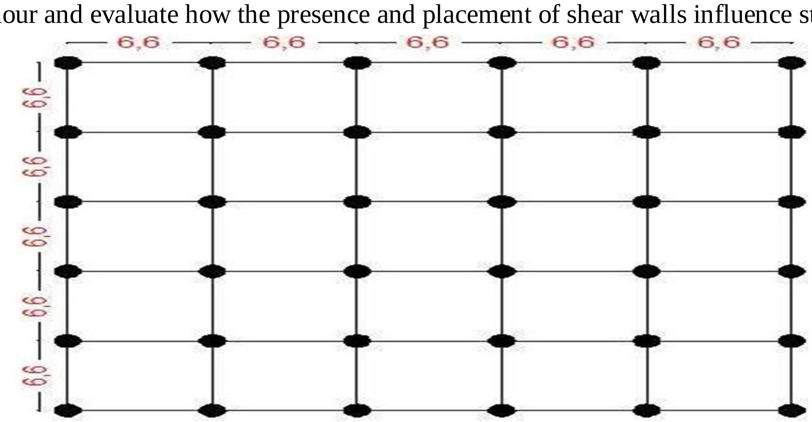

Fig. 1 Building plan

B. Step-II Selection of the Material properties

Selection of material properties involves defining the essential physical and mechanical characteristics of concrete, reinforcement steel, and masonry—such as density, modulus of elasticity, Poisson's ratio, and grade of materials—to ensure accurate structural modelling and realistic seismic analysis of the building

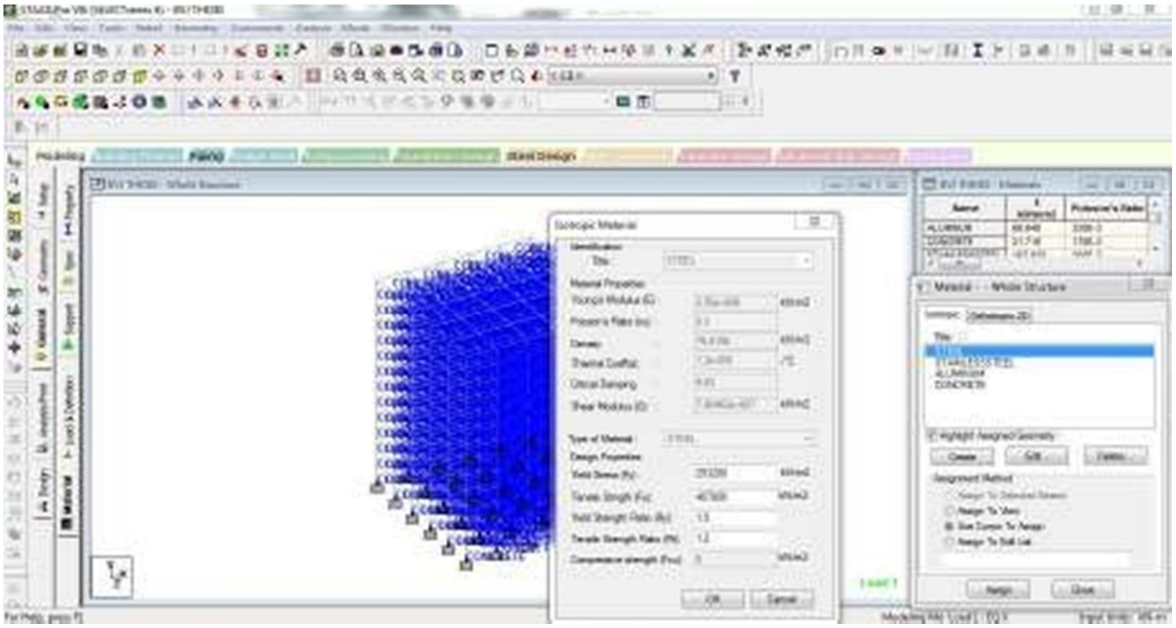

Fig. 2 Rebar materials Data

C. Step-III Selection of Frame Properties

Selection of frame properties involves defining the dimensions and reinforcement details of structural members such as beams, columns, slabs, and shear walls, ensuring that their stiffness, strength, and load-carrying characteristics are accurately represented in the analytical model.

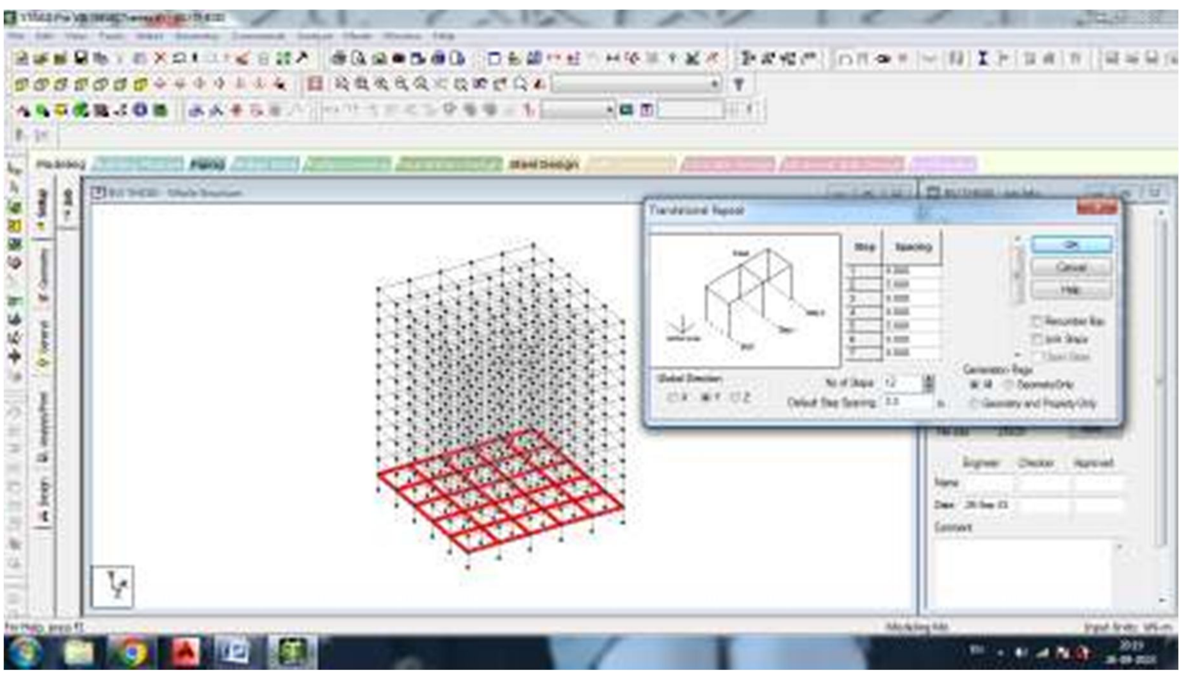

Fig. 3 Frame section Property Reinforcement Data

D. Step-IV Assign of all the Frame Section property

Assigning all the frame section properties involves applying the predefined beam, column, slab, and shear wall dimensions and material characteristics to the structural model so that each element behaves according to its actual stiffness and strength during analysis.

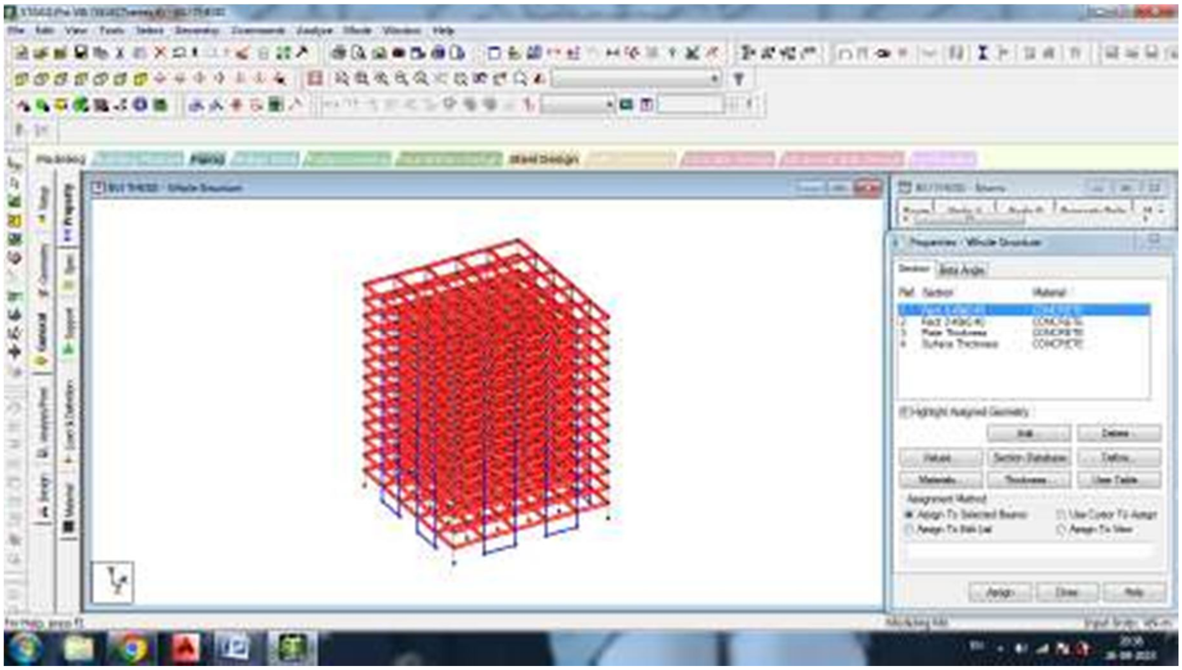

Fig. 4 Beam and column property

E. Step-V Apply Fixed Supports at Base of the Structure.

Applying fixed supports at the base ensures that all translational and rotational movements are restrained at the foundation level, allowing the building model to behave realistically by simulating a fully fixed connection between the structure and the ground during seismic analysis.

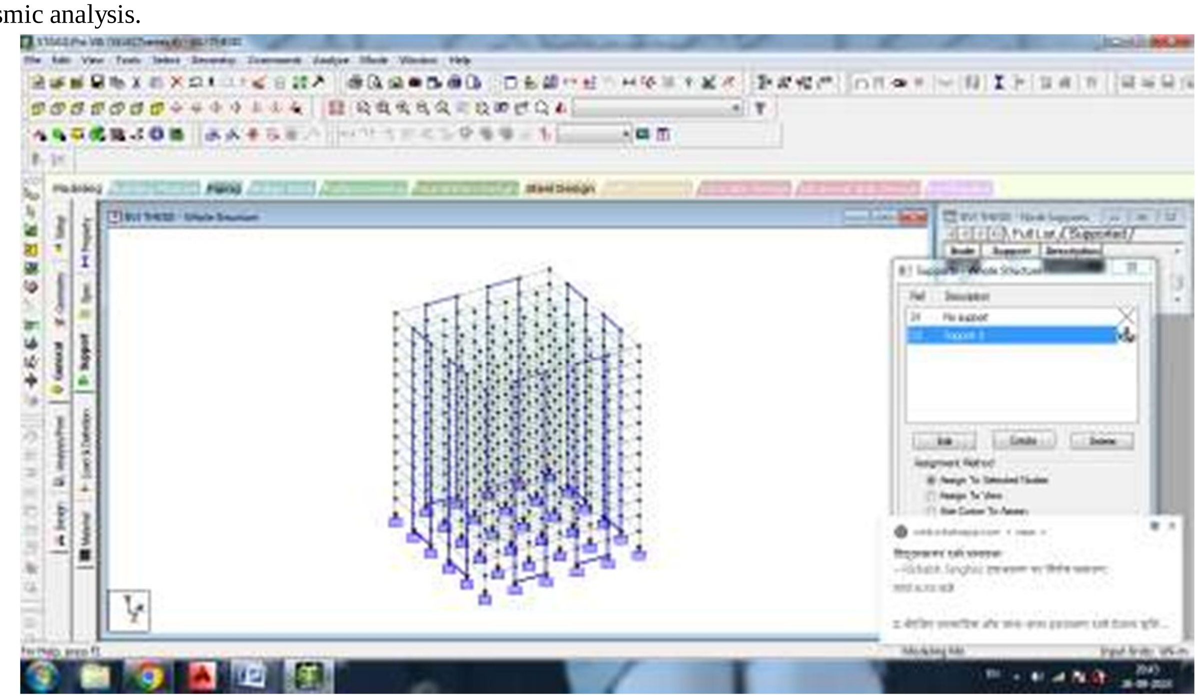

Fig. 5 Support Assign at base

F. Step-VI Define, Apply Various Loads and Load Combinations

Defining and applying various loads and load combinations involves specifying all relevant forces acting on the structure—such as dead load, live load, wind load, and seismic load—and combining them as per IS 875 and IS 1893 guidelines to ensure that the building is evaluated under the most critical and realistic loading conditions during analysis.

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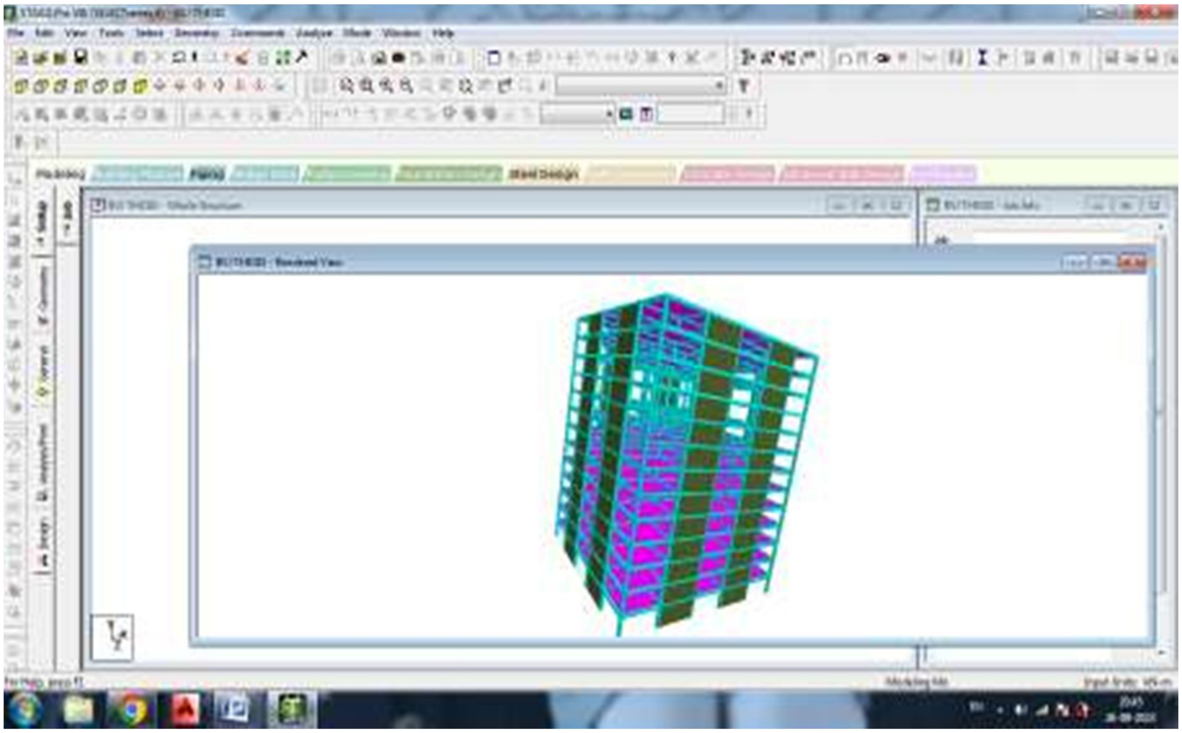

Fig. 6 Selection Response Spectrum Method

G. Step-VII Apply Check for all Models

Applying check for all models means verifying each structural model for errors or inconsistencies—such as missing assignments, connectivity issues, or undefined properties—so that the geometry, loading, and member definitions are correct before running the final seismic analysis.

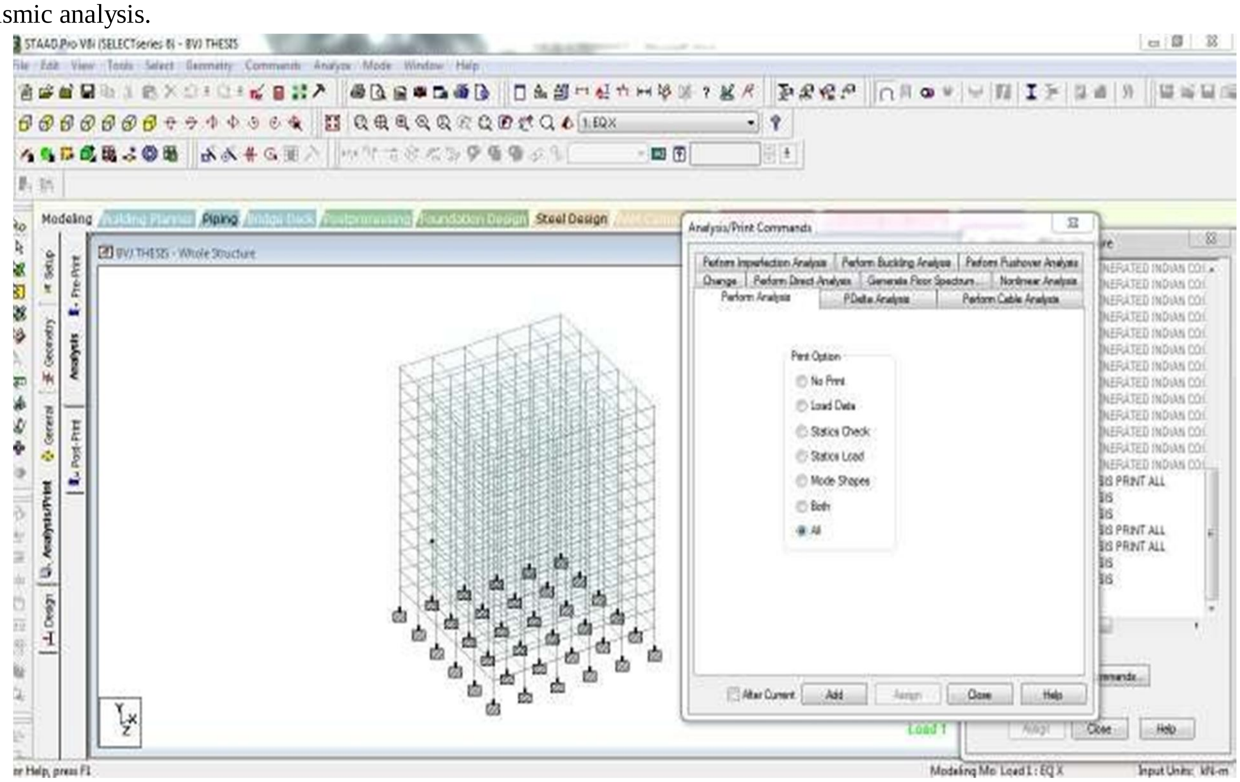

Fig. 7 Check Model

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H. Step-VIII Apply Run Analysis for model analysis.

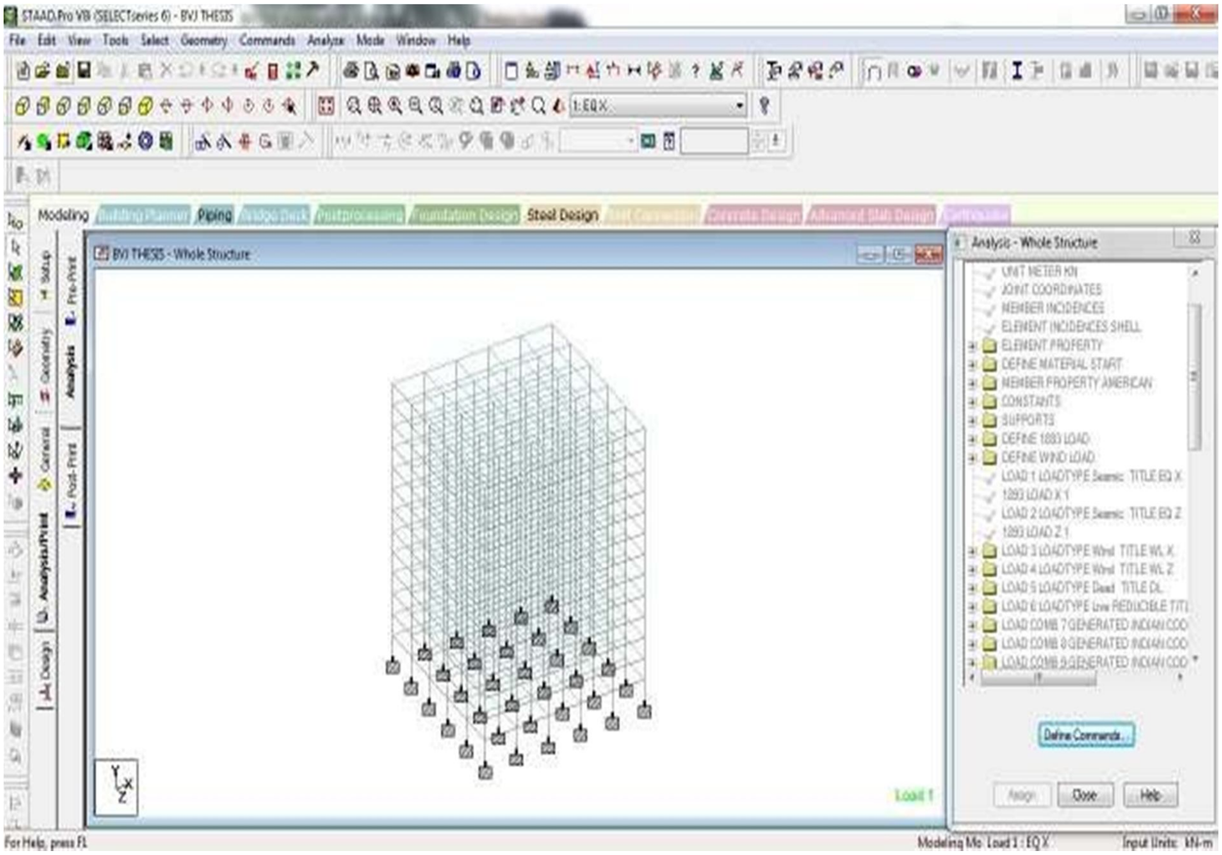

Fig. 8 Run Analysis

1) Material And Geomerical Properties

The following material and geometric properties were used in the structural modeling:

The density of reinforced concrete (RCC) is taken as 25 kN/m³, while the density of masonry is considered as 20 kN/m³. The structural plan is symmetrical, measuring 33 m × 33 m in the X and Y directions for all models, both with and without shear walls. Each storey has a floor height of 3.3 m. The RC beam sections are designed as 450 mm × 400 mm, and the column sections as 400 mm × 400 mm for all configurations, irrespective of the presence of shear walls.

Parameters Used:

Type of Building: RC Framed Structure (with and without shear wall)

Number of Floors: G+12 (symmetrical layout)

Column Size: 400 mm × 400 mm

Beam Size: 450 mm × 400 mm

Shear Wall Thickness: 230 mm

Floor Height: 3.3 m

III. EXPERIMENTAL RESULTS

There are the following cases for analysis of different Building Frame**.**

A. Storey Displacement

Storey displacement is zero at the base and increases with height, reaching its maximum at the top storey—greater in the Y-direction than in the X-direction.

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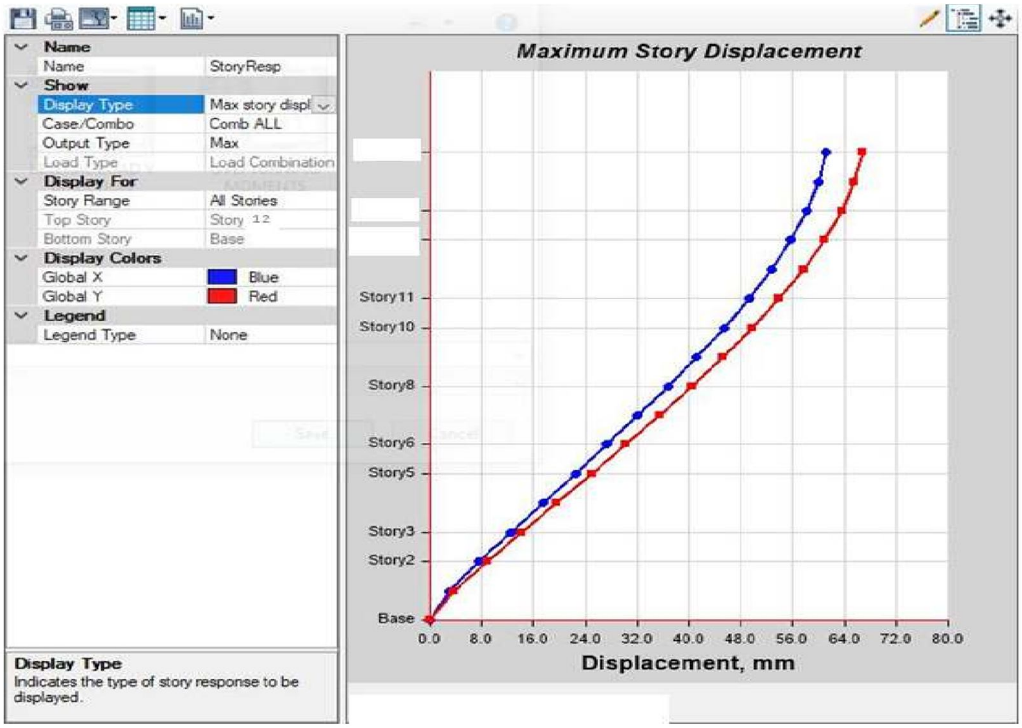

Fig. 9 Displacement in Model-I without Shear Wall

B. Storey Displacement In Model-Ii With Shear Wall

Storey displacement is zero at the base and reaches its maximum at the top storey in both X and Y directions, with the Y direction showing higher displacement; this confirms that displacement increases progressively with building height**.**

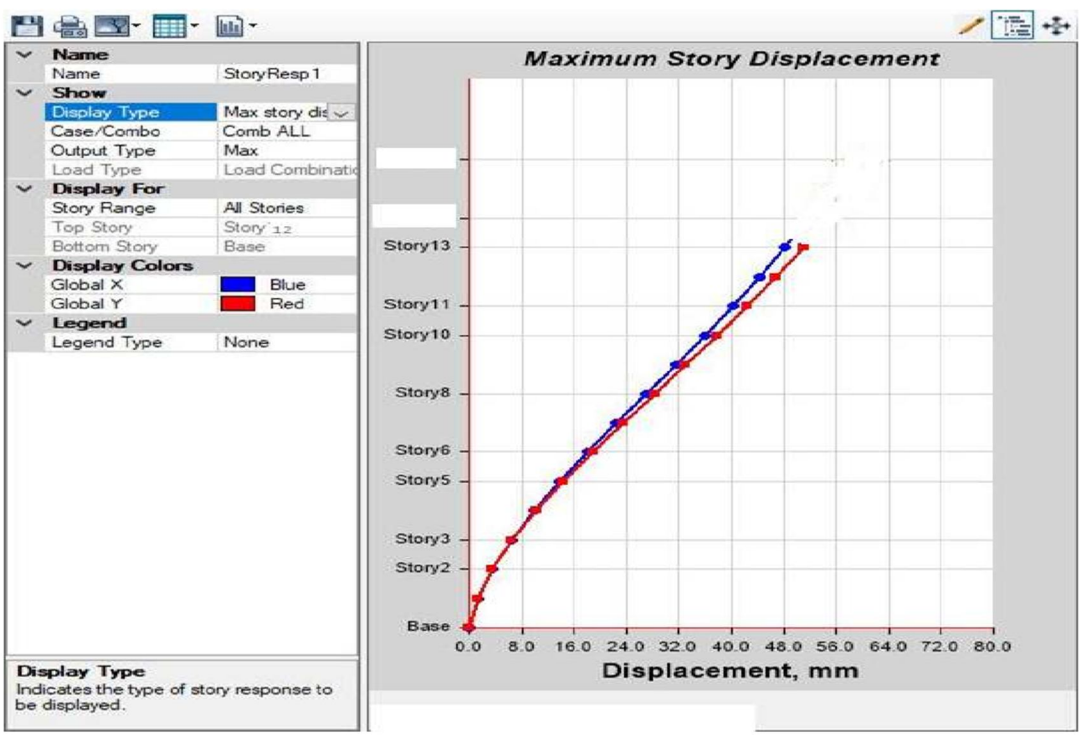

Fig. 10 Displacement in Model-II with Shear Wall

C. Storey Displacement In Model-Iii With Shear Wall

Storey displacement is zero at the base and increases progressively with height, reaching its maximum at the top storey in both X and Y directions, with the Y direction exhibiting a greater displacement than the X direction.

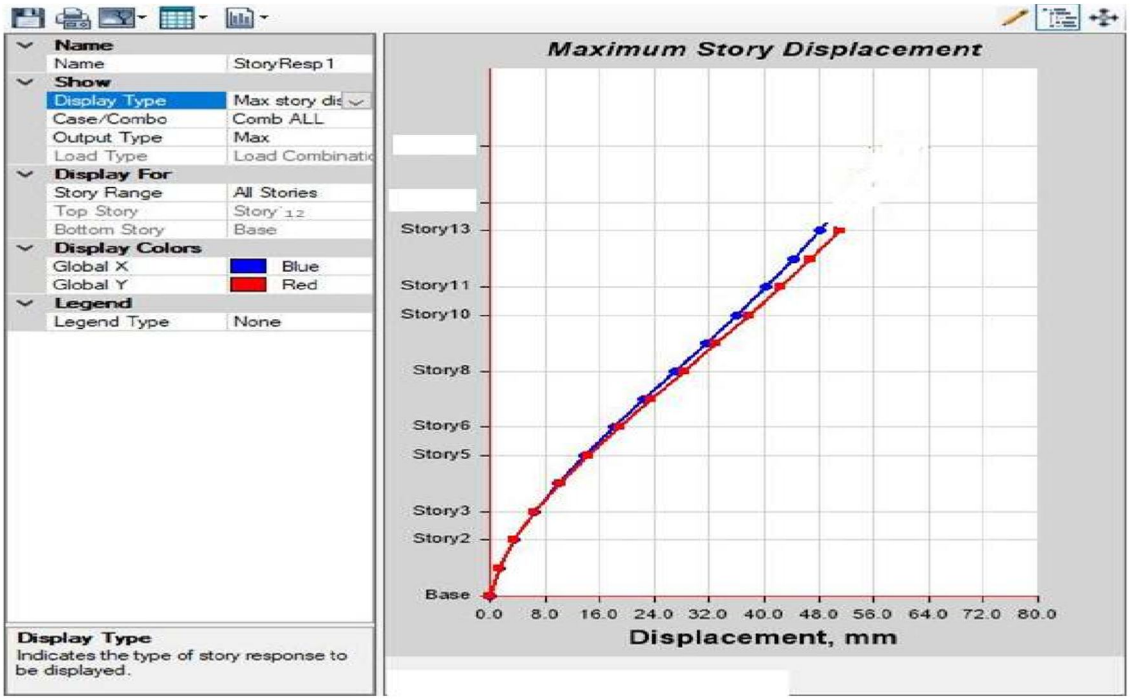

Fig. 11 Displacement in Model-III with Shear Wall

D. Storey Drift In Model-Iii With Shear Wall

It is found that maximum storey drift at eleventh store of the building and storey five while zero at the base of the building.

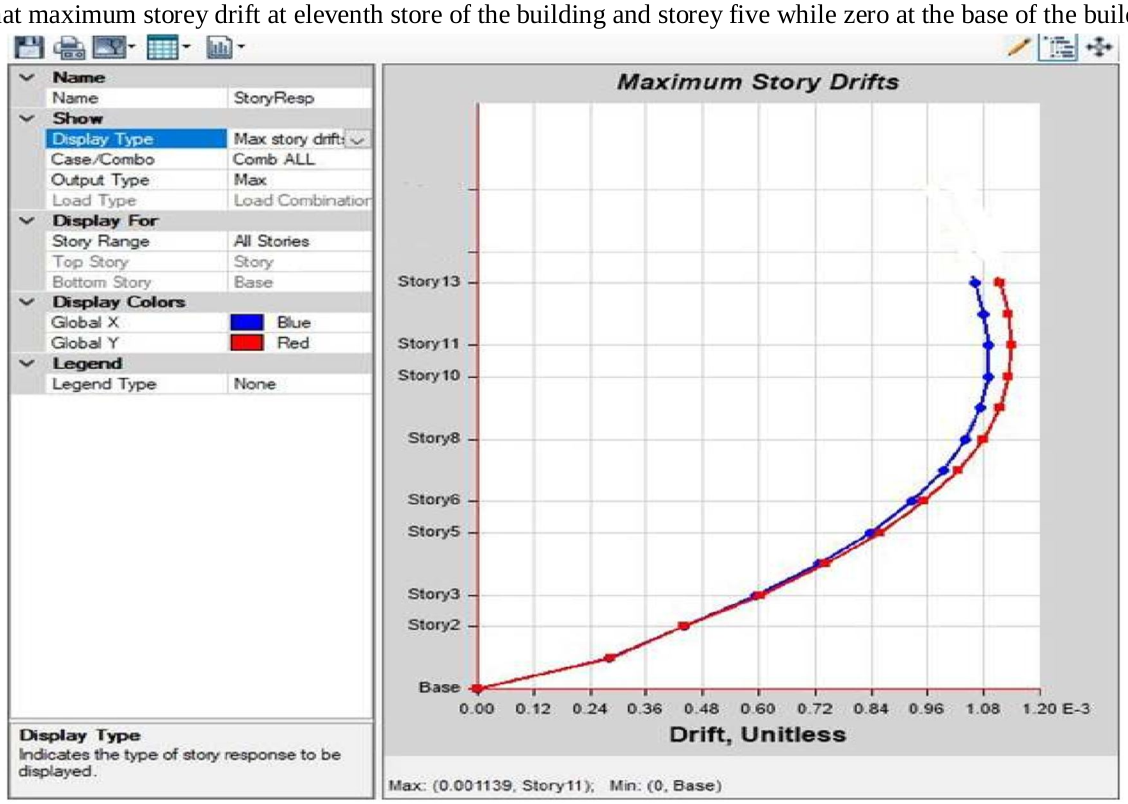

Fig. 12 Storey Drift in Model-III with Shear wall

IV. CONCLUSION

A. *Storey Displacements*

Storey displacement is zero at the base and maximum at the top storey in both X and Y directions. The maximum displacement occurs in the Y-direction. Model I shows the highest displacement due to the absence of shear walls, while Model III shows the minimum because shear walls improve stiffness.

B. *Lateral Loads*

Lateral loads are minimum at lower storeys and maximum at upper storeys, especially in the X-direction. The lateral load increases with building height. Model III experiences the highest lateral load resistance, followed by Model II, and Model I shows the least resistance. Hence, Model III performs best for earthquake resistance due to proper shear wall placement.

C. *Storey Shear*

Storey shear is highest at the base and decreases toward the top storeys. Maximum shear occurs in the X-direction. Buildings with shear walls show higher base shear capacity, while the model without shear walls shows the lowest.

D. *Storey Drift*

- Model I: Maximum drift occurs between 3rd–5th storey.
- Model II: Maximum drift occurs between 8th–10th storey.
- Model III: Maximum drift occurs near the 11th storey.

Overall, Model III shows the highest drift control due to shear wall provision, while Model I shows the maximum drift due to lack of lateral stiffness.

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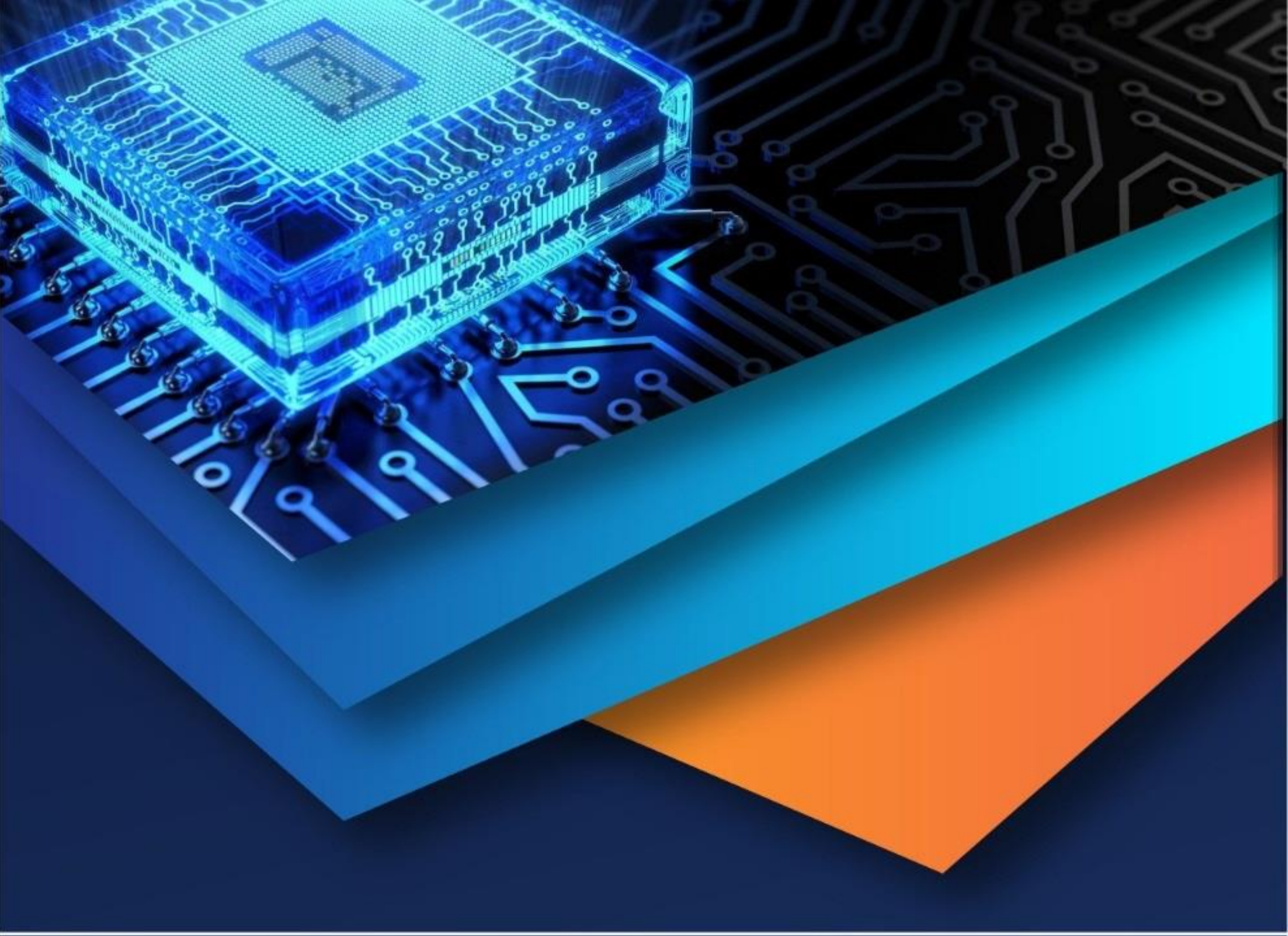

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