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# Comparative Seismic Performance and Cost Evaluation of RC Structures in Seismic Zone II: Bare Frame, Shear Wall System, and Diaphragm Modeling using ETABS

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***Abstract: In this thesis, a G+12 (13-storey) RC building located in Seismic Zone II with medium soil conditions is analyzed using ETABS. Three structural models are considered: a bare frame, a frame with shear walls, and a frame with diaphragm action. The seismic response of these models is compared based on key parameters including bending moment, shear force, axial force, torsion, story drift, story displacement, reinforcement quantity, and per floor cost. The inclusion of quantity and cost parameters enables a comprehensive assessment of both structural performance and economic efficiency. The analysis results indicate that the structure with shear walls and diaphragm action exhibits superior performance by significantly reducing story drift and displacement, while also requiring a lower quantity of reinforcement. Consequently, this model results in the minimum construction cost compared to the diaphragm-only and bare frame systems. This study confirms that the integration of shear walls enhances not only seismic safety but also material efficiency and cost-effectiveness, making it a preferred solution for earthquake-resistant RC building design.***

***Keywords: Earthquake resistant building, Shear wall diaphragm, cost comparison, Seismic analysis, Structural engineering, ETABS.***

## I. INTRODUCTION

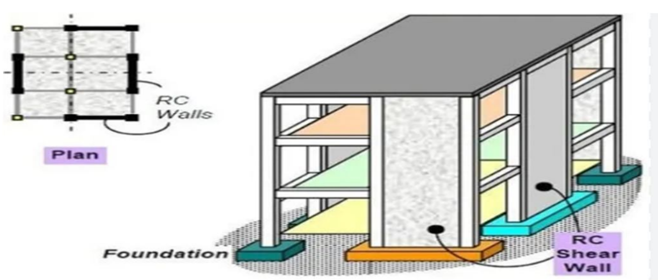
Powerful natural disasters like earthquakes have the ability to seriously harm structures. Building design that is earthquake-resistant has become essential to construction in order to reduce these risks, particularly in areas that are prone to seismic activity. A fundamental component of this design concept is the application of shear walls. A structure may encounter some of the most severe loading conditions during an earthquake, and if a structure collapses under these conditions, human life will unavoidably be in danger. A frequent site of failure for structures subjected to seismic loading is the junction of a beam and column. A loss of structural integrity and the collapse of floors, if not entire buildings, are possible outcomes of this kind of failure.

### *A. Shear Wall*

Vertical components in a building that function as rigid barriers are called shear walls. This vertical component functions as a strong buttress inside the structure and is usually composed of reinforced concrete or masonry.

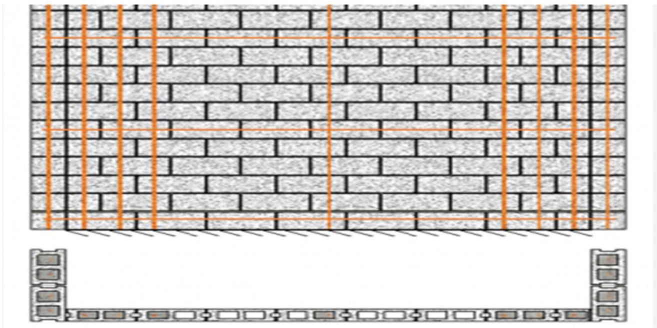
Main types of shear walls

1) Reinforced Concrete (RC) Shear Walls: The most popular kind, they have exceptional strength and ductility the capacity to bend without breaking.




RC Shear Wall

2) Masonry Shear Walls: Although they are made of concrete or brick, they need to be properly reinforced with steel components to equal the strength of RC walls.



Masonry Shear Wall

### B. *Seismic Analysis*

Seismic evaluation is a branch of structural analysis that involves estimating how an erecting or non-erecting shape would respond to an earthquake. In regions where earthquakes are considered a natural occurrence, it is a component of the structural design, earthquake engineering, or structural assessment and retrofit technique. Since its inception, earthquake engineering has advanced significantly, and many of the more intricate designs now employ unique earthquake-resistant components that are either distributed throughout the structure or located directly inside the basis (base isolation). Such systems require specialized explicit finite detail laptop code to analyze, which breaks time into extremely small slices and mimics the actual physics, much like "physics engines" are commonly found in video games.

### C. *Earthquake Resistant Structures*

Systems built to withstand earthquakes are meant to shield dwellings from damage. Although no structure can be completely safe from earthquake damage, the aim of earthquake-resistant building is to build structures that fair better under seismic activity than their conventional counterparts. Building rules state that earthquake-resistant structures should be able to withstand the biggest earthquake that is very likely to occur in the area. This strategy reduces the number of fatalities by keeping structures from collapsing in the event of an exceptional earthquake but restricting functionality in the case of more regular ones.

### D. *Objective Of The Research*

1) To design an earthquake resistant structure.
2) To analyze the structure with shear wall.
3) To evaluate the cost effectiveness of a structure with shear walls in comparison to other models.
4) To compare the structure with and without shear wall on the parameters such as Story displacement, shear force, overturning moment and story drift, quantity etc.
5) To analyze the structure for dead load, displacement, shear force, overturning moment, story drift etc.

## II. LITERATURE REVIEW

P. Sai Kumar Reddy et at (2025), In this paper, it is emphasized that the use of advanced structural analysis techniques significantly enhances the seismic performance of buildings in earthquake-prone areas. As the demand for safer and more resilient infrastructure grows, shear walls are recognized as effective lateral load-resisting elements that improve structural stability during seismic events. The study showcases the ETABS software as an essential tool for modeling, analyzing, and optimizing shear wall systems under seismic loads. The literature indicates that variations in shear wall configuration such as location, cross-sectional dimensions, material properties, and reinforcement detailing have a marked impact on the overall structural response. Comparative evaluations across various building heights and seismic regions demonstrate that optimized shear wall placements lead to reduced lateral displacements and enhanced structural durability, all while maintaining material efficiency. Previous research provides critical insights for structural engineers in developing performance-based, economical, and code-compliant designs using advanced software like ETABS. Overall, the findings advocate for the creation of safer, smarter, and more sustainable urban structures in regions susceptible to seismic activity.

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Amit Chauhan et al (2024), In this paper, it was found that a significant number of modern buildings exhibit irregularities in both plan and elevation, which may increase their vulnerability to severe seismic events in the future. Evaluating the seismic performance of such structures is essential for ensuring adequate safety in both newly constructed and existing buildings. In contemporary architectural practice, floor openings have become increasingly common to accommodate functional requirements such as staircases, lighting, and architectural features. However, these openings interrupt diaphragm continuity and introduce stress concentrations at the interfaces with structural elements.

The research indicates that discontinuous diaphragms are often designed without detailed stress evaluation, with the effects of openings frequently underestimated or neglected. This oversight can adversely influence the overall seismic response of buildings during earthquake excitation. Since earthquakes are natural hazards that cause widespread damage primarily through structural failure, it is critical to incorporate seismic-resistant principles during the planning and design stages. Nevertheless, current construction trends often prioritize architectural aesthetics over seismic performance, leading to the development of structures with irregular configurations that may not adequately resist earthquake forces. These findings highlight the need for rigorous seismic assessment and design consideration for buildings with plan and vertical irregularities.

B S Shamana et al (2023), In this paper, it is emphasized that seismic effects are crucial in the structural design of buildings, particularly in earthquake-prone regions. Earthquakes result from the sudden release of energy in the Earth's crust, presenting substantial risks to human life and infrastructure, especially in areas classified as seismically active. The adoption of structural systems designed to withstand horizontal forces and enhance strength, stiffness, and overall stability is essential.

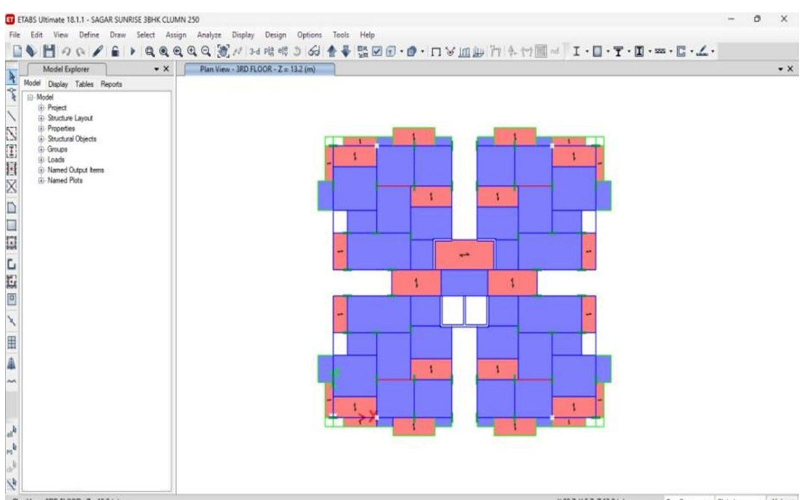
The study explores the seismic performance of multi-storey structures that integrate various earthquake-resisting components. Specifically, it examines the use of shear walls and bracing systems within moment-resisting frames to bolster lateral load resistance. A comparative seismic evaluation of high-rise buildings both with and without these structural elements was conducted using ETABS 2019, employing response spectrum analysis to assess key performance parameters: natural frequency, fundamental time period, base shear, storey stiffness, storey displacement, and storey drift. The results indicate that incorporating shear walls and bracings markedly improves seismic behavior, validating their role in enhancing structural performance when subjected to earthquake loads.

That the design force Multiplication factor was significantly less than 2.5. Base shear is underestimated as a result of seismic analysis of the bare frame structure. Underestimating base shear causes a structure to collapse when an earthquake is occurring. As a result, it's crucial to take the infill walls into account when doing a structural seismic analysis. The Multiplication factor for (G+4) varies 41.2 % (Column) and 42.8 % (Beam) less than what is required by IS Code of 2.5 Value, according to the ESA and RSA results. Comparably, it is 36% and 40% for (G+7) and 32.4 and 40% less for (G+12 ) than what the IS Code of 2.5 indicates.

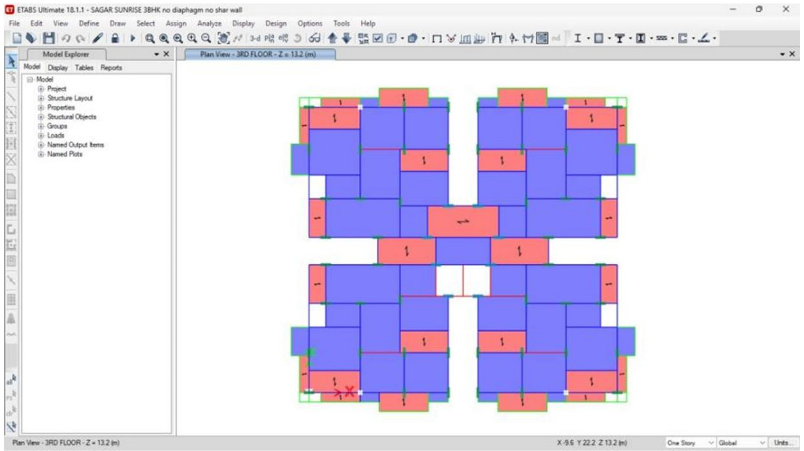
## III. METHODOLOGY

### A. *Steps Involved In Methodology And Design*

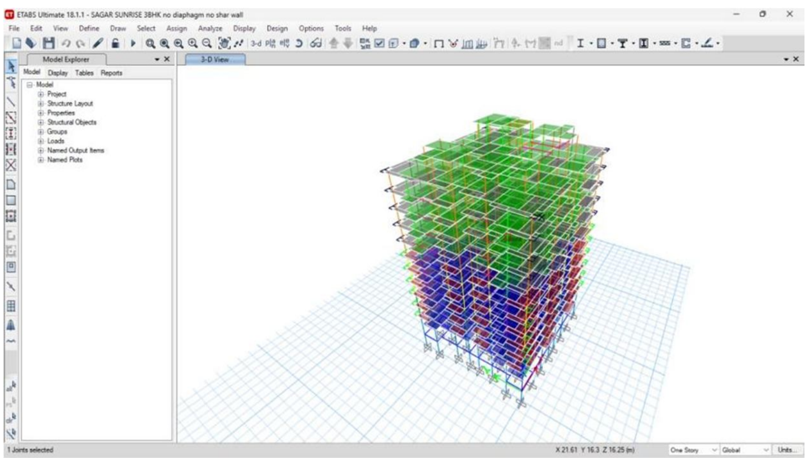
*1)* Step 1: The G+12 story structure, which has 13 stories.



Plan view of model (I)



Plan view of model (II)



3D view of model

2) Step 2 Assigning Fixed Support at the bottom of the structure in X, Y and Z direction.
3) Step 3 Defining section properties of beam and column. Here, we have considered 200x350mm beam size and 200X500 column size.
4) Step 4 Assigning the properties of Shear wall in 1st model.
5) Step 5 Defining Loading conditions for dead load, live load and seismic load data for the considered structure, here Zone II and medium soil condition is taken.
6) Step 6 analyzing the structure for dead load.

## IV. PROBLEM STATEMENT

### A. *Geometrical Data*

| Structural parameters | Structural data |
|---|---|
| Total stories | (G+12) |
| Size of column | 200x500mm |
| Size of beam | 200x350mm |
| Thickness of slab | 150,175,200 mm |
| Thickness of shear wall | 200 mm |
| Floor height | 3 m |
| Live load | 4 kN/m2 |

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| | |
|---|---|
| Dead load | 4.375 kN/m2 |
| Seismic zone | II |
| Soil Type | Medium soil |
| Importance factor | 1 |
| Response reduction factor | 5 |
| Damping ratio | 5% |

*B. Load Calculation*

*1) Dead load (DL)*

According to IS 875-1987 (Part I-Dead loads), the "Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures," the dead load is taken into account.
Total dead load = 4.375 kn/m2

*2) Imposed weight (LL)*

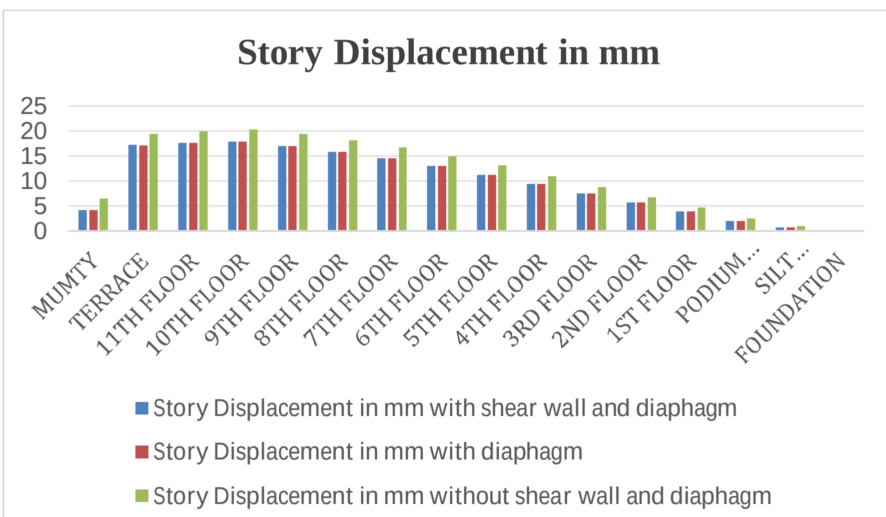
Live load is also known as imposed load. The imposed load is evaluated in accordance with the "Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures," IS 875-1987 (Part II-Imposed loads).
Floor live load = 4 kn/m2

*3) Seismic load (EL)*

The seismic load is evaluated in accordance with IS 1893-2025 (Part I). The elements taken into account are
Zone factor = 0.1 (Zone II)
Importance factor = 1
Response reduction factor = 5
Soil Type = Medium soil (II)
Hard soil Damping = 5 %

## V. RESULTS & DISCUSSIONS

*A. Story Displacement (mm)*




Story Displacement

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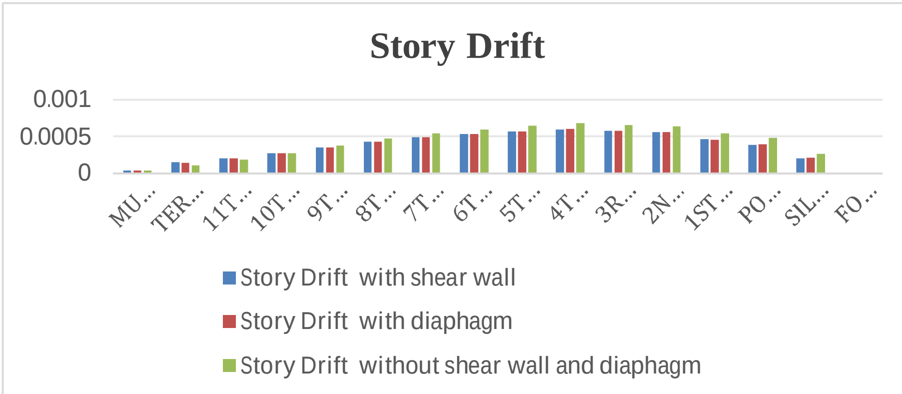
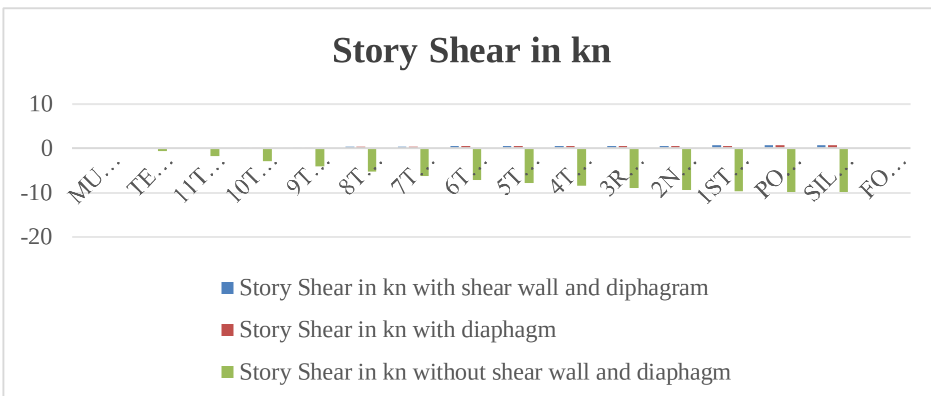
### B. *Story Drift*



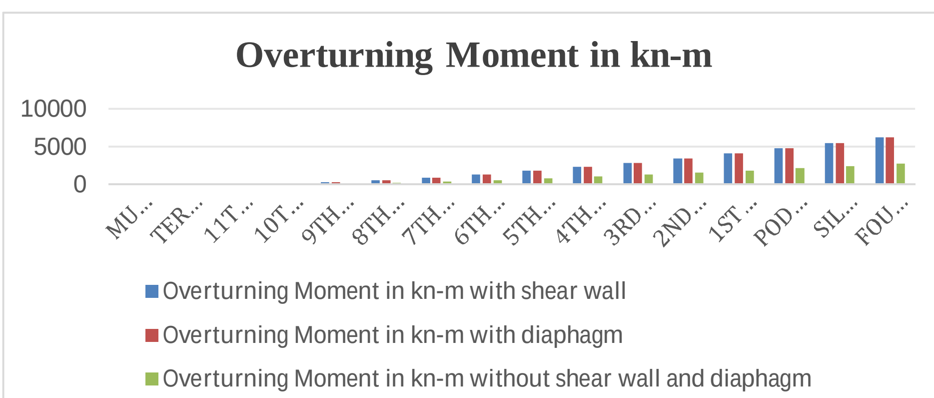

Story Drift

### C. *Story Shear*



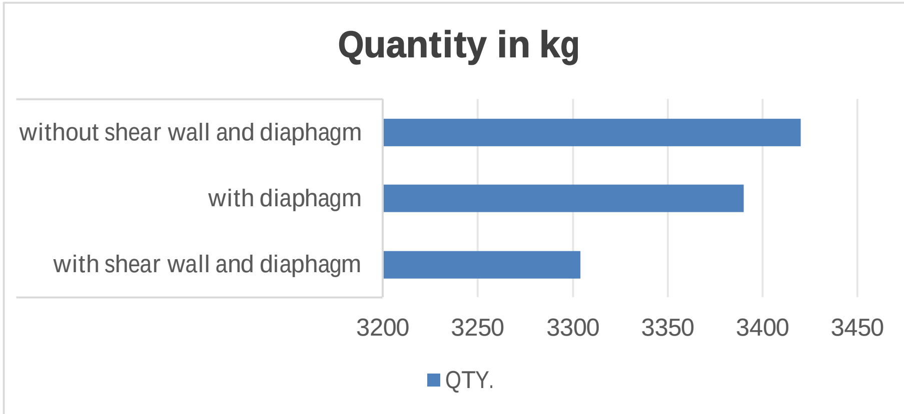

Story Shear

### D. *Overturning Moment (kN-m)*



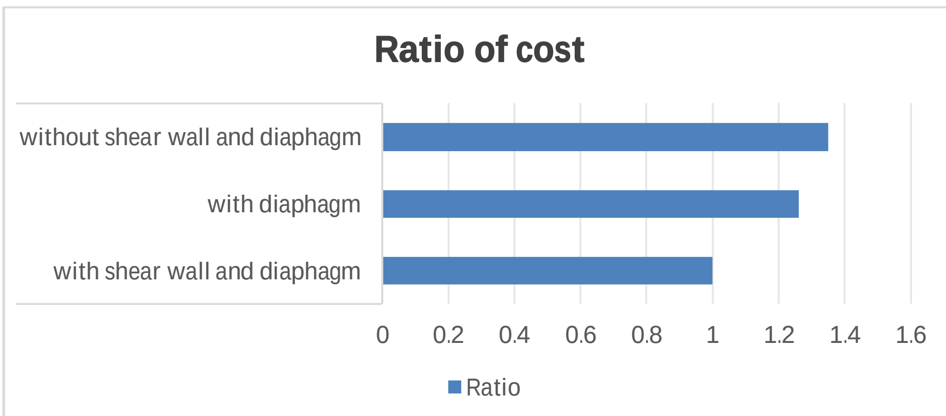

Overturning Moment (kN-m)

### E. *Quantity in kg*




Quantity in kg

### F. *Ratio of Cost*




Ratio of cost

## VI. CONCLUSION

1) The comparison of story displacements for all three structural systems shows a clear improvement in lateral stiffness when shear walls are included. The model with shear wall and diaphragm consistently records the lowest displacement at every level, while the model without shear walls and diaphragm exhibits the highest values throughout the height. In contrast, the diaphragm-only model shows displacement values close to the shear-wall case but remains slightly higher at most stories.
2) The comparison of story drift for all three structural systems clearly indicates the advantage of incorporating shear walls in enhancing lateral stability. The model with shear walls consistently shows the lowest drift values across the height, while the structure without shear walls and diaphragm records the maximum drift at almost every level.
3) The comparison of story shear for all three structural systems highlights a strong improvement in lateral force resistance when shear walls are used. The structure with shear walls and diaphragm consistently shows the highest positive shear values, indicating better stability against lateral loads. The diaphragm-only model follows closely with slightly lower values at each level.
4) The comparison of overturning moments for all three structural configurations clearly demonstrates the effectiveness of shear walls in enhancing the building's resistance against lateral overturning forces. The model with shear walls consistently exhibits the highest overturning moments at every level, followed closely by the diaphragm-only model with a slight reduction. In contrast, the structure without shear walls and diaphragm shows drastically lower moment values across the height.
5) The comparison of material quantity for all three structural systems highlights the efficiency achieved by incorporating shear walls. The model with shear wall and diaphragm consistently requires the least quantity of material, indicating better load distribution and structural optimization. In contrast, the model without shear wall and diaphragm shows the highest material requirement, reflecting reduced efficiency and greater demand to resist loads.

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*6)* The cost comparison of all three structural systems clearly highlights the economic benefit of incorporating shear walls. The model without shear wall and diaphragm results in the highest construction cost, whereas the structure with shear wall and diaphragm requires the least cost due to reduced reinforcement demand.

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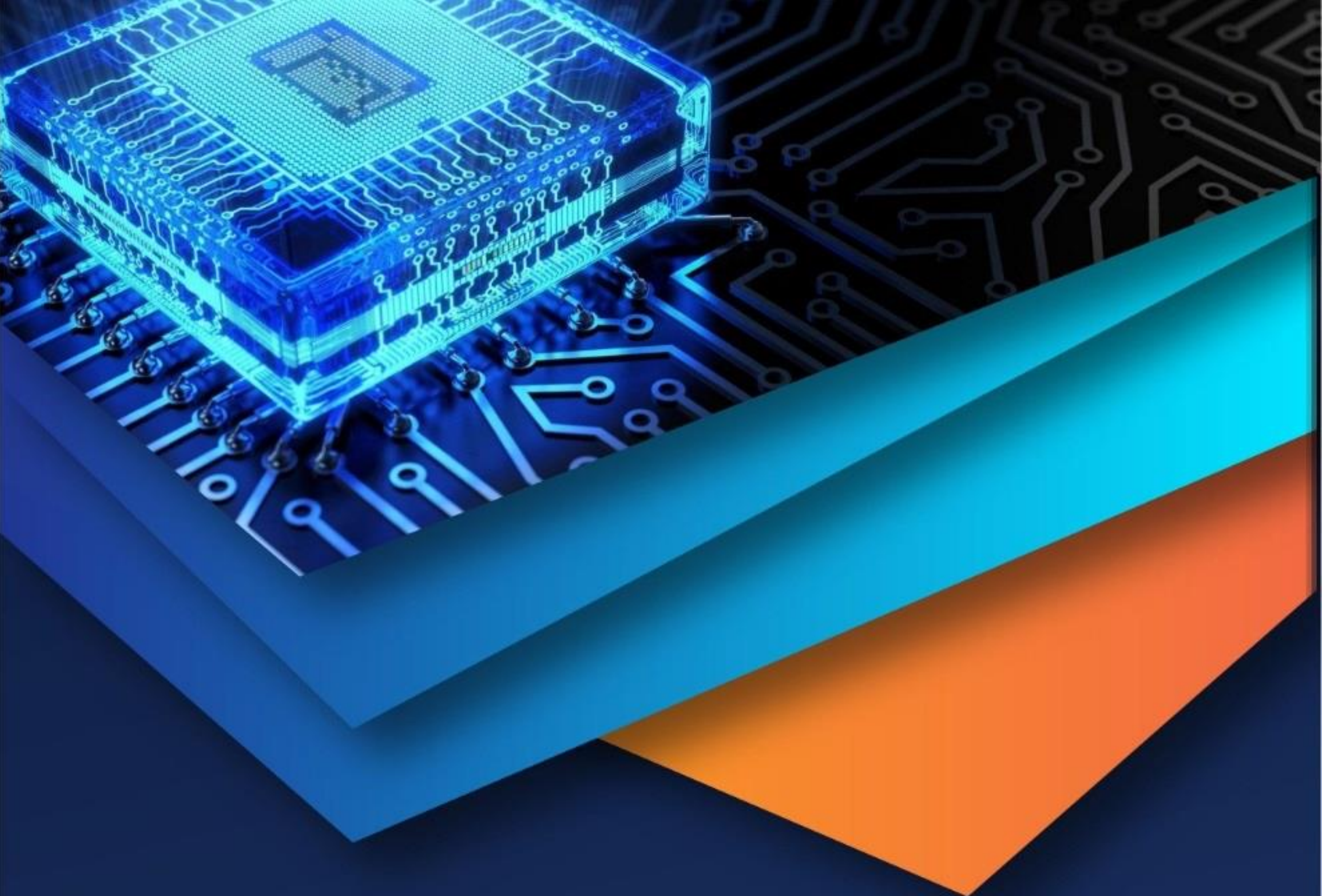


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