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Comparative Analysis on Symmetric and Asymmetric Structure Subjected to Seismic Load - Using ETAB

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Abstract: ***Earthquakes can badly affect buildings, especially in places where earthquakes occur often. How a building reacts during an earthquake depends on its shape, weight distribution, and strength. In this study, symmetric and asymmetric buildings were compared using ETABS software to understand how theybehave during earthquake conditions.***
Different building shapes such as rectangular, L-shaped, and T-shaped buildings were analysed. Important factors like storey displacement, storey drift, base shear, and twisting effects were studied. The results showed that symmetric buildings perform better during earthquakes because the earthquake forces get distributed evenly throughout the structure. On the other hand, asymmetric buildings experience more movement and twisting due to their irregular shape and uneven stiffness.
This study shows the importance of proper building planning and structural design for earthquake safety. It also explains how ETABS helps engineers analysebuildings and design safer structure in earthquake- prone.

I. INTRODUCTION

Nowadays, reinforced cement concrete (RCC) framed buildings are commonly used because they are strong, long-lasting, and can be constructed in different shapes and sizes. During their service life, these buildings are subjected to various loads such as dead load, live load, wind load, and earthquake load. Amongthese, earthquake forces are considered the most dangerous because they occur suddenly and can cause heavy damage or even collapse of buildings if they are not designed properly.

For this reason, earthquake-resistant design has become very important in structural engineering, especially in earthquake-prone areas. The behaviour of a building during an earthquake depends on factors like building shape, stiffness, material strength, and structural arrangement.

Symmetric buildings usually perform better during earthquakes because their weight and stiffness are distributedevenly. This allows earthquake forces to spread uniformly throughout the structure, Reducing displacement and twisting effects. As a result, symmetric buildings are generally more stable and safer during seismic activity.

In contrast, asymmetric buildings such as L-shaped and T-shaped structures have irregular shapes and uneven stiffness distribution. Because of this, they experience twisting during earthquakes, which increases displacement, storey drift, and stress in structural members.

With the help of advanced software like ETABS, engineers can easily model and analyse buildings under earthquake loading conditions. The software helps in understanding the structural behaviour and identifying weak areas in the building.

This study compares the seismic performance of symmetric and asymmetric structures using ETABS analysis. The main aim is to understand how the shape and configuration of a building influence its behaviour and during earthquakes

II. OBJECTIVES

1) To create modelsof symmetrical and asymmetricalbuilding using ETABS and study their behaviour under earthquake and wind loads. According to IS 456 and IS 1893 Codes.
2) To compare important structural responses such as displacement, storey drift, and base shear in both types of building.
3) To study the effect of irregular buildings shapes including twisting (torsion) and how loads are distributed in different parts of the structure.
4) To identify which type of building is safer and more stable during earthquakes and to provide simple suggestions for designing safer irregular building

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III. LITERATURE REVIEW

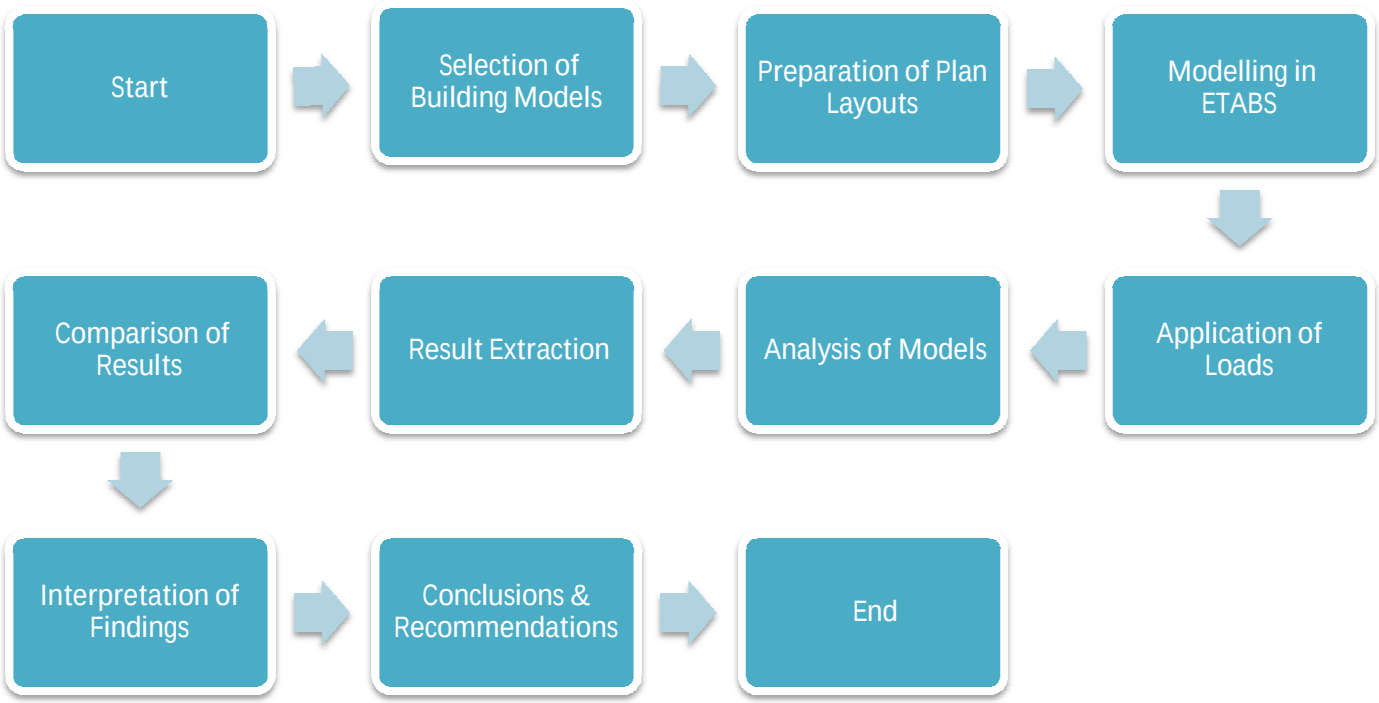
Previous studiesshow that the shape and arrangement of a building play an important role in its behaviour during earthquakes. Symmetric buildings generally perform better because their weight and stiffness are distributedevenly. Throughout the structure, due to this earthquake forces spread uniformly which reduces displacement, storey drift, and twisting effects. Since the center of mass and centre of rigidity are nearly at the same location, these buildings move in a more balanced manner during earthquakes. Therefore, symmetric buildings are considered safer and more stable in earthquake prone areas.

In contrast, asymmetric buildings have irregular shapes and uneven distribution of mass and stiffness. Because of this, they experienced torsional effects during earthquakes, which causes twisting of the structure. This twisting creates uneven force distribution and increases displacementand storey drift in some parts of the building.As a result, certain beams and columns may be subjected to higher stress, which can lead to cracks, excessive deformation, or even structural failure if proper design is not provided.

To improve the earthquake resistance of asymmetric buildings, researchers recommend using shear walls, bracings, and other strengthening systems. These methods help increase stiffens of the structure, reduce torsion, and improve the overall stability.

Modern software like ETABS is widely used for analyzing and designing buildings under earthquake loads. It helps engineers study important structural parameters and identify weak areasin the structure.

Overall, previous studies conclude that structural irregularities greatly affect earthquake performance, and proper planning, analysis, and design are necessary to ensure the safety of building.



IV. METHODOLOGY

STRUCTURALMODELSDESCRIPTION

In this study, four different building models are selected to compare their behaviour during earthquakes.

Model 1 is a rectangular building with a symmetric shape. In this building, the mass and stiffness are distributed evenly in both directions. Because of this balanced arrangement, the building remains more stable and experiencesvery little twisting during earthquake. Therefore, this model is taken as the reference model for comparison with other irregular building.

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Model 2, Model 3, and Model 4 are asymmetric buildings with irregular shapes such as L-shape, T-shape, and other uneven layouts. These models are used to study how irregular building shapes affect earthquake performance.

In asymmetric buildings, the mass and stiffness are not distributed evenly. Due to this, twisting occurs during earthquakes, causing the structure to twist. This results in uneven load distribution, grater displacement, and higher storey drift in some parts of the building. Because of these effects, asymmetric buildings are more vulnerable to earthquake damages than symmetric buildings.

For accurate comparison, all four models are designed with the same height of G+7 storeys (about 21 m), similar material properties, and the same loading conditions such as dead load, live load, and earthquake load according to IS codes.

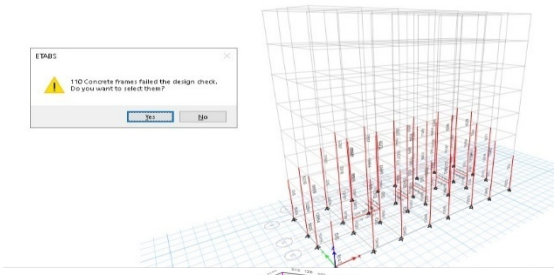
The analysis is carried out using ETABS software where only the building shape changed while all other parameters are kept the same. This helps in clearly understanding the effect of symmetry and asymmetry on the seismic behaviour buildings.

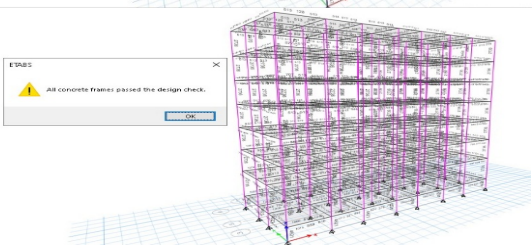
V. RESULTS AND DISCUSSION

1) MODEL 1 – SYMMETRIC BUILDING

Problem Statement:

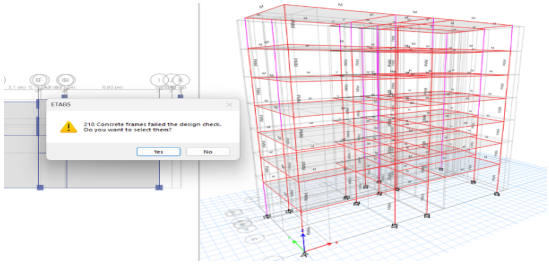
The symmetric building showed better performance during earthquake because its mass and stiffness were distributed evenly throughout the structure. However, the assumed sizes of beams and columnsresulted in higher forces, displacement, and storeydrift under earthquake loading conditions according to IS 1893 (Part 1):2016.





Solution:

To improve structural performance, the concrete grade was changed to M30 and Fe500 steel was used. The sizes of Beams and columns were also increased as a result, the building showed lower displacement, betterstiffness, controlled storeydrift, and all design checks were successfully satisfied in ETABS.



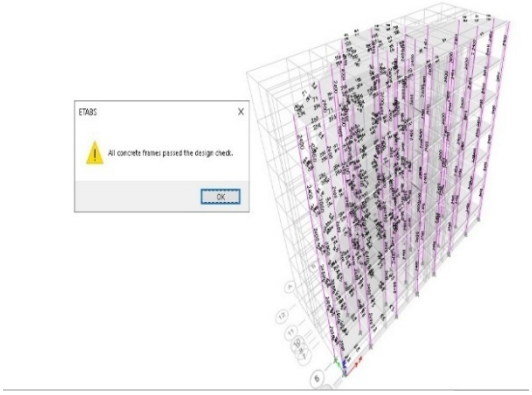
2) MODEL 2 – ASYMMETRIC BUILDING

Problem Statement

The asymmetric building experienced twisting effect, uneven load distribution, and higher displacement because the mass and stiffness were not distributed evenly throughout the structure. Due to earthquake loading some structural members failed during the analysis.

Solution

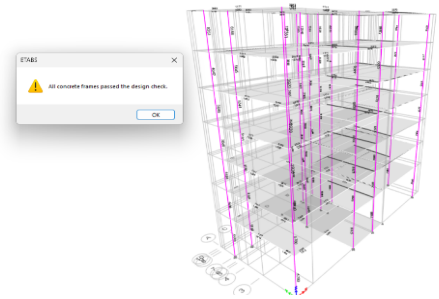
The sizes of Columns and beams were improved, additional corner columns were provided, and M30 concrete with Fe500 steel was used. These changes increased the stiffness of the building, reduced twisting effects, and improved the earthquake performance of the structure in ETABS.



3) MODEL 3 – ASYMMETRIC BUILDING

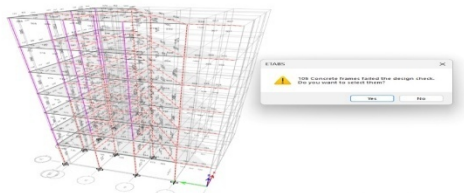
Problem Statement

The asymmetric building showed very highstorey drift, and displacement because of its irregular shape and uneven distribution of earthquake forces. Due to these effects some structural members failed during the earthquake analysis.



Solution

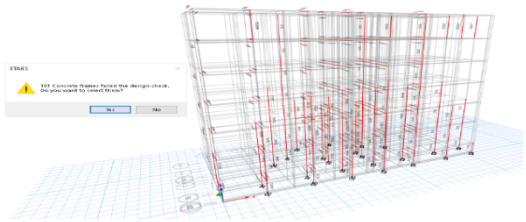
We increased the column sizes and used stronger concrete to make the structure stronger and more durable. Some columns were also shifted slightly to improve the buildings balance and stability. This helped reduce twisting during and earthquake and improved the buildings overall earthquake resistance.



4) MODEL 4 – ASYMMETRIC BUILDING

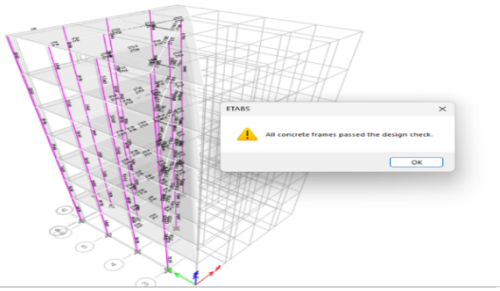
Problem Statement

The building shape uneven, earthquake forces were not distributed evenly. This caused excessive stress in certain areas and made the building twist during shaking, which led to damage and failure of some structural members.



Solution

The beam and column sizes were increased, and stronger materials like the M40 concrete and Fe 500 steel were used to make the structure stronger. Some part of the building layout was also adjusted to improve balance and symmetry. These changes helped reduce building movement during earthquake and made the structure safer overall.



VI. ADVANTAGES AND DISADVANTAGES

A. Advantages of SymmetricStructure

1) Better earthquake resistance:Symmetric buildings distribute earthquake forces more evenly, which help the structure perform better and remain safer during seismic activity.

2) Reduce twisting during earthquakes:Because the building is balanced properly, it experiences very little twisting or torsion during an earthquake, leading to more stable behavior.

3) Less building movement and drift:Symmetric structures show lower sideways movement and floor to floor drift, which helps reduce damage to both structural and non- structural elements.

4) Even load distribution: Loads are shared more uniformly among beams and columns, reducing stress on specific members and improving thebuildings' strength and durability.

5) Simpler design and analysis: The regular shape of symmetric buildings make them easier to analyze and design using structural software like ETABS.

6) Improve stability and safety: Due to their balanced shape and uniform response, symmetric structures provide better overall stability and safety during earthquakes.

B. Disadvantages of SymmetricStructure

1) Limited design flexibility: Symmetric structures usually follow simple and regular shapes, so architects have less freedom to create unique or innovative designs.

2) Not ideal for complicated layouts: These structures are difficult to use in buildings that need uneven room arrangements, different shapes, or complex planning.

3) Less effective for irregular land or modern styles: Symmetric buildings may not fit well or irregularly shaped plots and can look less modern or attractive compared to asymmetric design.

C. Advantages of Asymmetric Structures

1) More freedom in design: Asymmetric structures give architects more flexibility to design modern and creative buildings with different shapes like L-shaped, T-shaped or setback designs.
2) Good for ComplexBuilding Layouts: These structures work well for irregular plots and complicated layouts, making them suitable for buildings like hospitals, malls, hotels, and commercial complexes.
3) Better use of Space: Asymmetric buildings help make best use of available land and floor space by allowing different areas to be planned according to their purpose.
4) More attractive appearance: These structures usually have modern and unique looks, which make the building more visually appealing and distinctive.

D. Disadvantages of Asymmetric Structures

1) More twisting during earthquakes: Asymmetric buildings can twist during earthquakes because their weight and strength are not evenly balanced, which makes them less stable.
2) Uneven load distribution: The structure does not distribute weight and stiffness equally, so some parts of the building carry more force than others.
3) Lager movements during earthquakes: These buildings can move more from side to side during earthquakes, which may damage both structural and non-structural parts.
4) Higher stress in some parts: Certain beams, columns and joints face more stress especially in irregular areas, which can cause cracks and weakness.
5) Greater chance of earthquake damage: Due to twisting and uneven force distribution, asymmetric buildings are more likely to suffer damage or even fail during strong earthquakes.
6) Needs advanced analysis:The complex behaviour of asymmetric structures requires detailed analysis using software like ETABS to properly study their performance.
7) Higher design and construction cost: Extra reinforcement, shear walls, and detailed planning are often needed to make these buildings safe, which increases cost and design complexity.

VII. CONCLUSION

From the detailed analysis done using ETABS, shape and arrangement of a building greatly affect its behavior during earthquakes. Symmetric structures perform better during earthquakes because their mass and stiffness are evenly distributed. This reduces the twisting effect and helps the buildings respond more safely and evenly to seismic forces as result, symmetric buildings show lower displacement, less story drift and better overall stability.

On the other hand, asymmetric structures have irregular shapes and uneven stiffness distribution, which causes more twisting during earthquakes. This leads to higher displacement, uneven stress in structural members, and a greater chance of damage.

Therefore,symmetricstructures are generally preferred in earthquake-prone areas because they provide better safety and performance. However, if asymmetric designs are required for architectural or functional reasons, special measures such as shared walls, bracing systems, and proper structural detailing should be used to improve earthquake resistance. Advanced analysis using software like ETABS is also important to accurately study the building's behavior and ensure a safe and reliable design.

VIII. FUTURE SCOPE

This study can be improving future by using more advanced Methodes to better understand how structures behave during earthquakes. In future studies, advanced analysis techniques such as time history analysis and pushover analysis can be used to study the actual response of buildings during earthquakes accurately.

The study can also be extended to taller buildings and more complex structural shapes, where irregularities have a greater effect on seismic performance. Additional structural elements like shear walls, bracing systems, and dampers can be included to improve earthquake resistance and reduce displacements and drift.

Furthermore, using a performance-based design approach can help engineers evaluate how buildings performance under different earthquake intensities, leading to safer and more reliable structures.

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Advanced software tools beyond ETABS, along with the study soil-structure interaction and modern construction materials, can provide more practical and accurate results.

These improvements will help in developing safer, stronger and more economical earthquake resistant buildings in the future.

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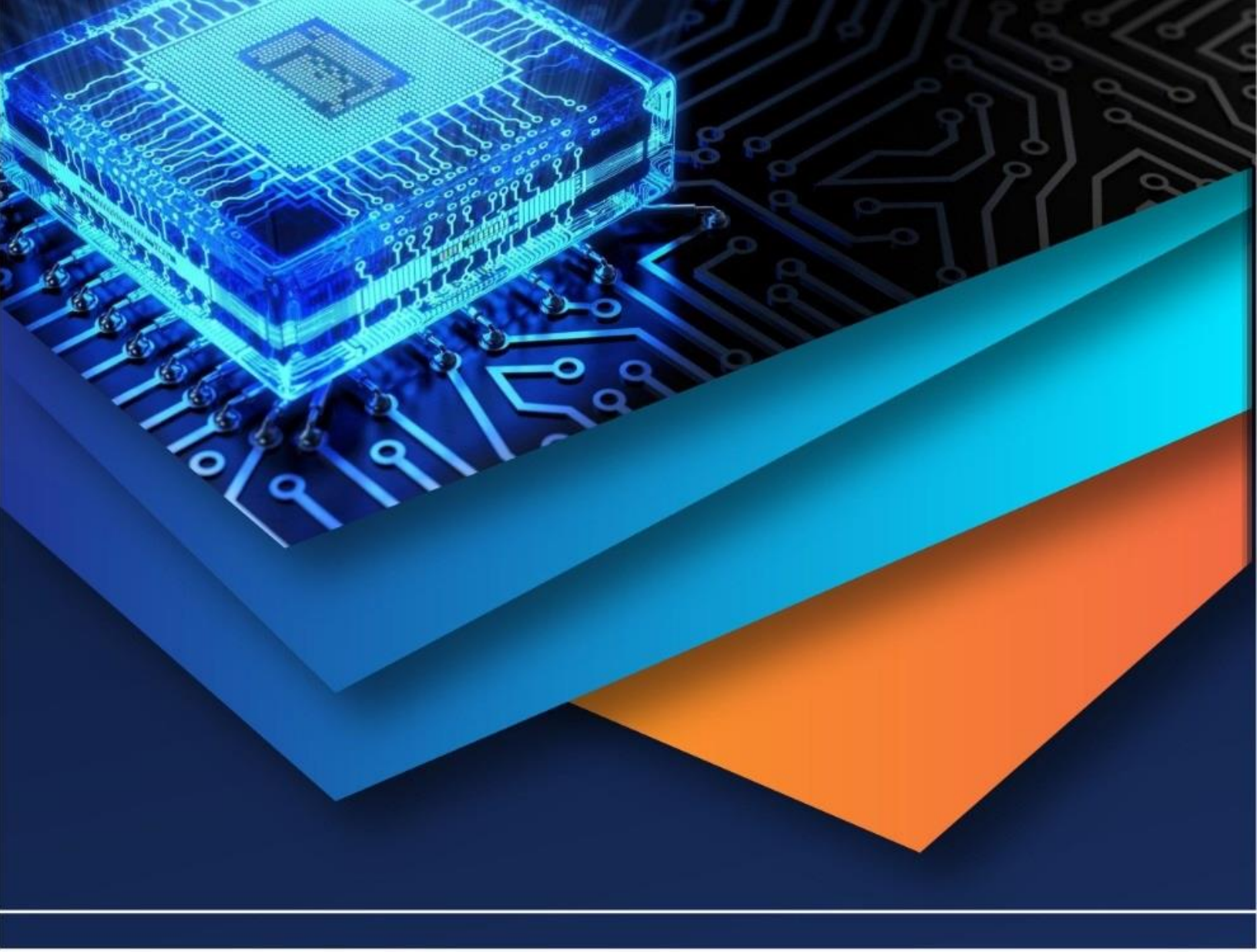
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