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# Analysis of Tall Building by using Different Dimensions Under Wind Load Effects

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***Abstract: The expense of land is increasing day by day because of rapid increase in the population whereas vegetation is diminishing, due to diminished vegetation contamination is expanded. In this Research paper, we analyze the various types of the dimensions of the building considering them side ratios too and the effect of windward forces on the building in mainly X and Z direction. This paper is about the study of four-building models as Dimensions (30m*30m), (40m*25m), (55m*20m), (80m*15m) having their horizontal Aspect ratios viz. 1, 1.6, 2.75 & 5.33 at an angle of 0 degrees. The height of the building is 90m. Therefore, the research is proceeding to balance out the structure from an increasingly affordable perspective. To find out the best performance and economical for the lateral wind-force resisting system of different models of 25 storey buildings are modelled in STAAD-PRO, assuming the site location as AGRA (Uttar Pradesh), India. For the different structural systems that are compared for minimum and maximum storey displacement, storey drift. The structural system used is prototype. The axial force, shear force, moment, and reactions at various windward sides are used to compare the best performance of the structure. Above all, wind forces in x- direction shows the adequate displacement and drift values when compared to z- direction but from the economic point of view Model-2 gives the satisfactory result from all the above.***
***Keywords: Aspect Ratio, Wind Load, Tall Building, Storey Drift, STAAD Pro***

## I. INTRODUCTION

The shortage of land and space, resulting in the construction of tall buildings for both commercial and residential purposes. High Rise Buildings are cantilever structures that are susceptible to both static and dynamic loadings. Multi-story buildings are preferred in metro cities due to limited space. High-rise structures face structural challenges such as lateral load effects and displacement. Tall buildings are defined as those that are subjected to lateral loads like wind loads, in addition to gravity loads. Highrise building have a few benefits as well as a few drawbacks too. High-rise buildings are quite popular among young generation working professionals. Privacy concerns of the higher_floors are lucrative too. Apart from these, less pollution is another most demanding benefit of high rises. In Aerodynamics Optimization, shape of buildings is extensively known concept that greatly determines the response of the high structures under wind loading. Optimizing the geometry of supertall structures for aerodynamics during the design stage is an excellent technique to reduce wind response.

### A. *High-rise buildings: Benefits*

A high-rise building can provide you with the best place for a noise-free environment. Good quality air, proper ventilation, etc., are the major benefits of a high-rise building. The serene beauty of high- rise building is mind blowing. Wind excitation becomes a precarious force on the structure as the building goes higher, especially if the plan geometry is super high.

## II. OBJECTIVE AND SCOPE

1) Rectangular Plan building (30m*30m) with side ratio 1
2) Rectangular Plan building (40m*25m) with side ratio 1.6
3) Rectangular Plan building (55m*20m) with side ratio 2.75
4) Rectangular Plan building (80m*15m) with side ratio 5.33

- To find the effect of wind load under the different dimensions with having ratios on models with same plan area and height.
- Comparing various parameters such as Storey Drift (X and Z), Maximum Shear Force (Fy), Axial Force (FX), Reaction of Forces, Deflections of storey in X and Z for all the models under the action of wind load.
- To calculate the values of (Cpe and Cpi) for the assumed dimensions on the basis of Wind Load.

## III. LITERATURE REVIEW

*1) (Effects of Side Ratio on Wind-Induced Pressure Distribution on Rectangular Buildings)*
by J. A. Amin et al.
The findings of wind tunnel testing on 1:300 scaled-down models of rectangular buildings with the same plan area and height but side ratios ranging from 0.25 to 4 are presented in this paper.
Because wind pressures vary, pressure coefficient mean, maximum, lowest, and RMS values are obtained at pressure sites on all models 'surfaces.
The usefulness of side ratios of models in changing the surface pressure distribution is investigated at a wind incidence angle of 0 to 90 at a 15-degree interval.
They discovered that model side ratio has a large impact on the amount and distribution of wind pressure on leeward and sidewalls, but only a little impact on windward walls when the wind incidence angle is zero.

*2) (Wind tunnel study of wind effects on a high-rise building at a scale of 1:300)*
by R. Sheng et al.
The goal of this research is to use wind-tunnel testing on a high-rise building with a well-defined atmospheric boundary layer at a 1:300 scale to investigate the unstable features of global and local wind loads, as well as their relationships with the atmospheric boundary layer.
For global and local wind loads, complete information on wind is analyzed, including mean velocity profile, turbulence strength, and power spectrum of the fluctuation. The findings of this study reveal that, depending on the location, upstream flow or shear layers that form at the building's upstream corners, or both, influence wall-pressure pressures on the tower.

*3) M. GU, Y. Quan (2004)*
In this paper, 15typical tall building models of basic cross-sections and aspect ratios from 4 to 9 are tested with high-frequency force balance technique in a wind tunnel to obtain their first-mode generalized across-wind dynamic forces. The effects of terrain condition, aspect ratio and side ratio of cross section and modified corner of the building models on the across-wind forces are investigated in detail.

*4) Vikram et al. (2014)*
Effect of wind is obtained from analysis and compared with gravity loading. Variation of axial force with storey height in all the models for gravity and wind loads at bottom storey column for different aspect ratio and different storey height. It is observed that when the aspect ratio is 0.25, the axial force is increased by 10% in dynamic analysis compared to static analysis.

## IV. METHODOLOGY

The method of analysis of the tall building of various dimensions are: We have done extensive literature surveys by referring to the published papers, technical papers or research papers carried out to understand basic concepts of the topic then identification of the need for research is done.
Formulation of process in analytical work which is to be carried out, then all the data collection is done, then we prepare models in STAAD PRO.
Loads such as self-weight, imposed loads, snow loads, and horizontal loads from both wind and seismic loads must all be considered while designing a building. Wind load, however are considered to be constantly acting force compared to seismic that is instantaneous in nature.
A structure is required to be analyzed for safety against all the different load combinations acting on it.

Loads are classified as:
*1)* Static load
*2)* Dynamic load

## V. STRUCTURE DESCRIPTION

| | |
|---|---|
| No of Stories | 30 |
| Floor to Floor Height | 3m |
| Location | Agra |
| Building Type | Commercial |
| Dead Load | Self-wight is automatically considered in STAAD-PRO |
| Floor Finish | 1.5kN/ |
| Live Load | 6.5kN/m2 |
| Wind Load | IS 875 Part 3-2015 |
| Displacement check | H/500 mm |
| Drift check | <0.004 |

Table 4.1 Dimension of Model

| Model Shape | Prototype Dimension(m) | Side Ratio | Height of Model (m) | Aspect Ratio |
|---|---|---|---|---|
| Square | 30*30 | 1 | | |
| Rectangle – 1 | 40*25 | 1.6 | 90m | 3m |
| Rectangle – 2 | 55*20 | 2.75 | | |
| Rectangle – 3 | 80*15 | 5.33 | | |

## VI. LOAD AND LOAD COMBINATIONS

The following load combinations are considered as per IS 875 (Part 3):

*1)* Load Case 1 = 1.5 [D.L + L.L]
*2)* Load Case 2 = 1.2 [D.L + L.L + W.L]
*3)* Load Case 3 = 1.5 [ D.L + L.L - W.L]
*4)* Load Case 4 = 1.5 [D.L + W.L]
*5)* Load Case 5 = 1.5 [D.L - W.L]

## VII. MODELLING ANALYSIS

In this study, rectangular-plan shaped buildings with different side ratios are analyzed by using STAAD Prov8i. All the models investigated have the same planarea of 900 m2 and a height of 90 m. The prototype building model was designed as G+25, with eachstorey height of 3 m. It was designed as an RCCbuilding with consideration of beam size of 500 mm x500 mm and column size of 600 mm x 600 mm. The thickness of the floor slab is considered to be 150mm

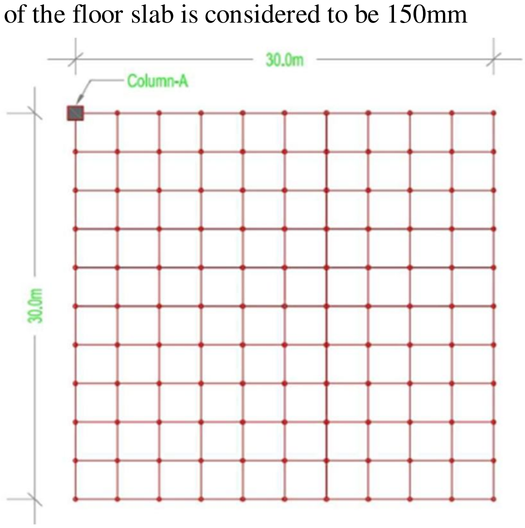


Fig.7.1 position of column A in square model

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## VIII. WIND LOAD ANALYSIS AS PER IS-875

Part-3 (2015)
(Vz) = Vb*K1*K2*K3*K4

Where,
Vz = Design wind velocity
Vb=Basic Wind velocity
K1= Probability Factor/Risk Coefficient
K2=Terrain and Height Factor
K3=Topography Factor
K4=Importance factor for the cyclonic region
The wind pressure at height z is calculated as follows:
$Pz=0.6 [Vz]^2$

## IX. DETAILS OF MODELS

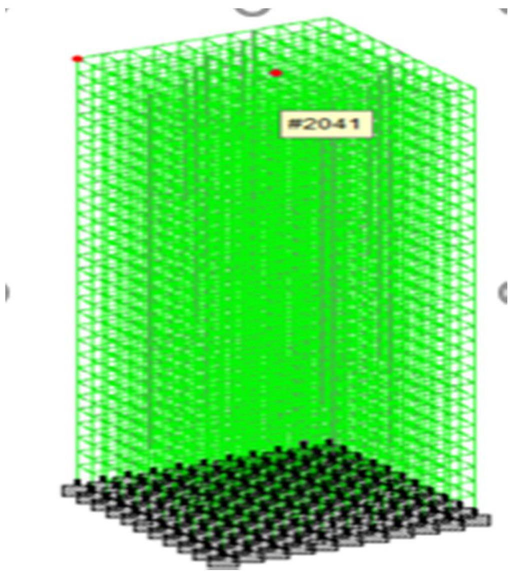


Fig.8.1 Node Element View of MODEL M1 (30m x 30m)

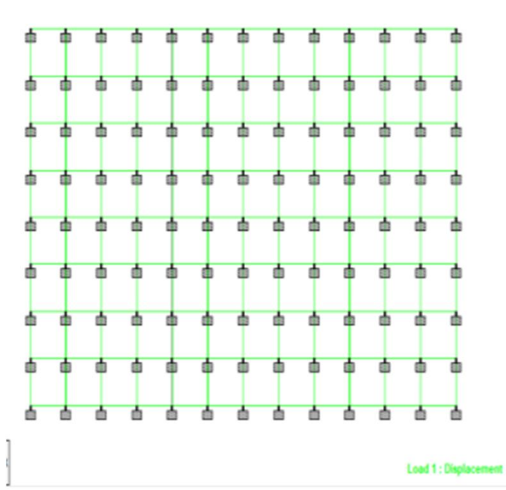


Fig. 8.2 PLAN VIEW OF MODEL 2

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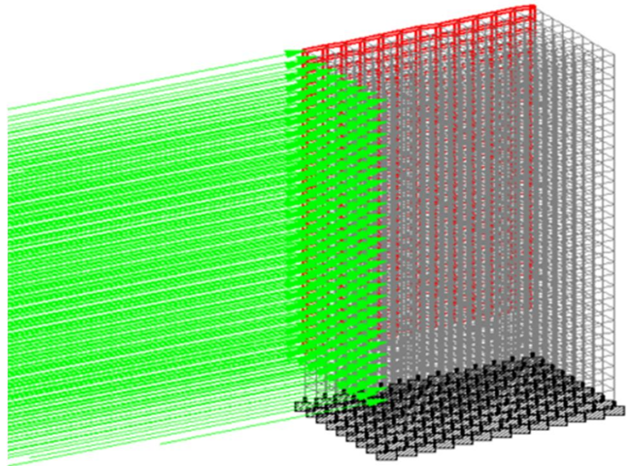

Fig.8.3 Wind Effect In X Dir. Of Model 2

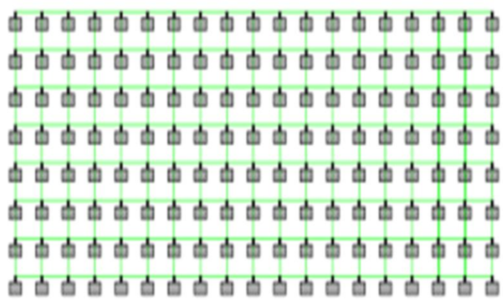

Fig 8.4 PLAN VIEW OF MODEL 3

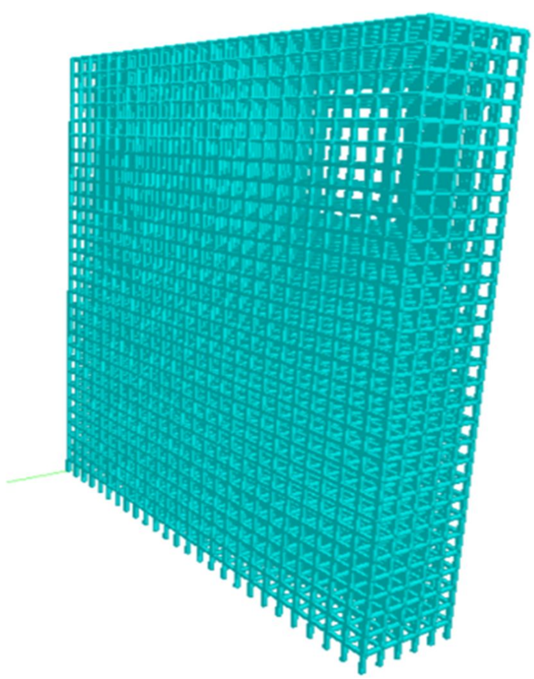

Fig 8.5 3D RENDERING VIEW OF MODEL 4

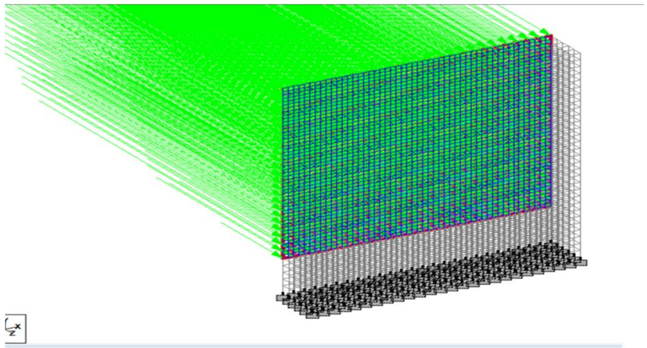

Fig 8.6 WIND LOAD IN Z DIRECTION OF MODEL 4

## X. RESULTS AND DISCUSSION

Deflection through wind load is obtained during the analysis, deflection of column is obtained at every floor level in the "X" direction and the "Z" direction at wind incidence angle 0 degree are obtained during the analysis. The results are plotted as bar graphs, as shown in Fig. Maximum deflection in Column is approximately 25.26 mm at the top of the building at a wind incidence angle of 0degree in the X-direction it is approximately 27.67 mm at the top of the building.

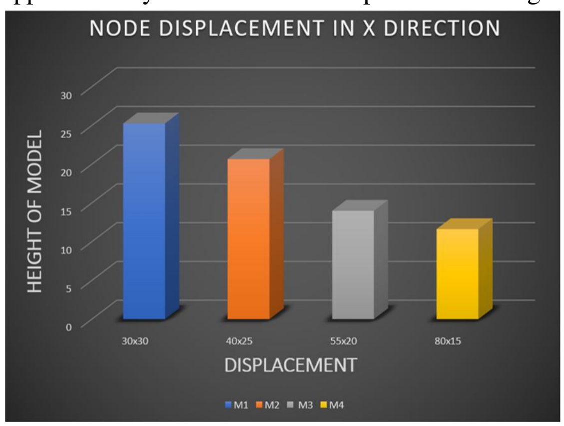


Fig 9.1 Max Displacement

This research study is performed into STAAD Pro and the Graph results are presented in the form of deflection with respect to the height and displacement of four dimensions of a building.

## XI. MAXIMUM STOREY DRIFT

The graph showing here is a maximum storey drift on each building due to wind load. The comparison of results are shown as a comparison of all the models starting from different plan ratios of the structure located in a high wind zone.

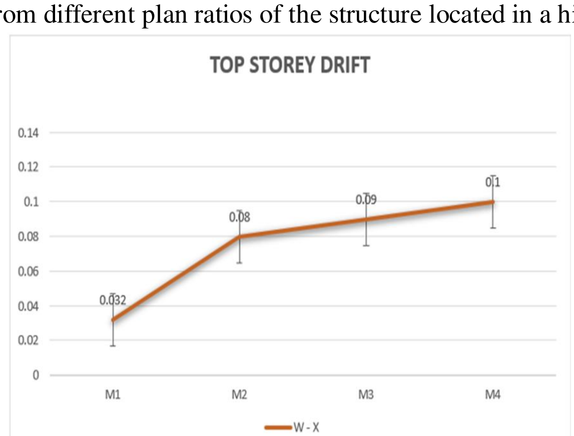


Fig. 10.1 Max Storey Drift

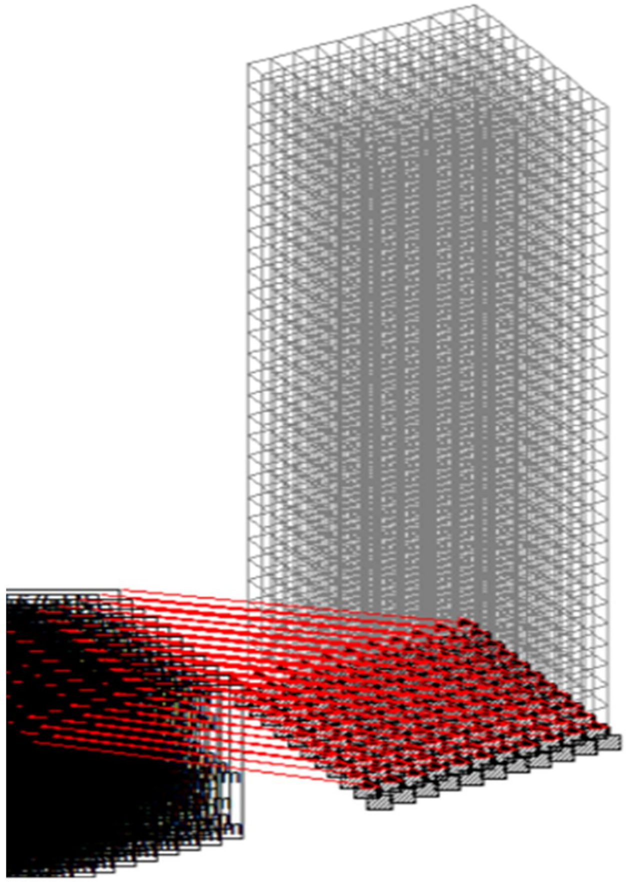

Fig. 10.2 Reaction Force of Model
(30m X 30m)

## XII. SHEAR FORCE

Wind pressures that flow upwards towards the roof.

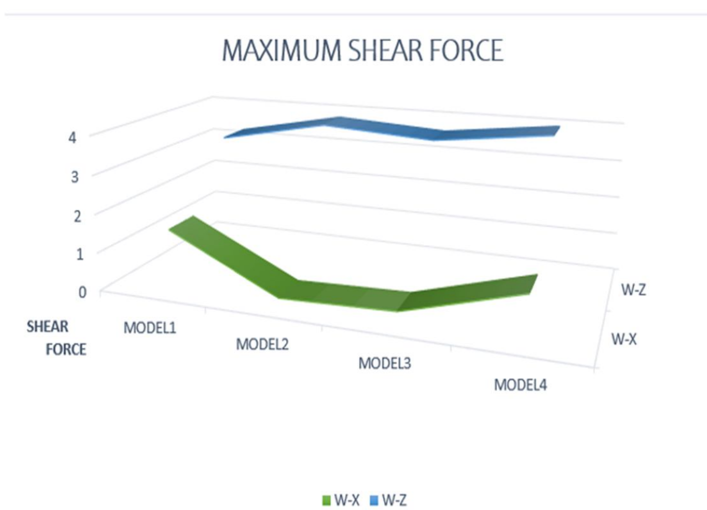


Fig. 11.1 Max. Shear Force

## XIII. AXIAL FORCE

The summation of all the axial forces exist on one side of the section. Here Axial force is considered for the four different buildings whereas the axial force is considered with the highest axial loading due to wind effect.

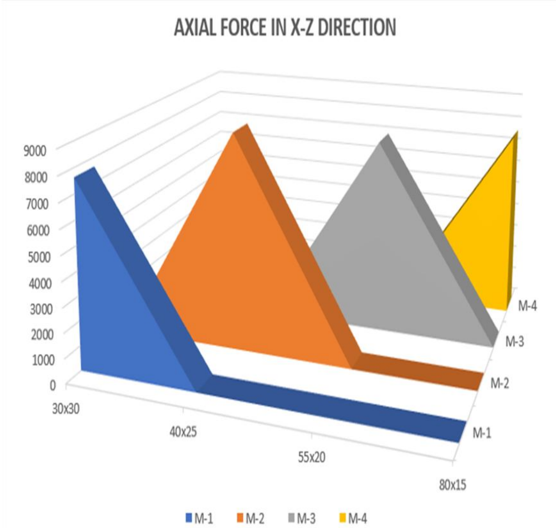


Fig 12.1 AXIAL LOAD ON MODELS

## XIV. CONCLUSION

1) From the graphs obtained, it is clearly depicted that Deflection of columns increases with height and as the side ratio changes it influence on deflection which have been compared for models.
2) Horizontal deflection at column A and B at every floor level in ‘X’ and ‘Z’ direction and in different wind incidence angle are obtained during the analysis. Deflection in X translational is found to be minimum when the angle of wind is 0-degree and as the angle of attack of wind changes the deflections also get reduced in Xtranslational, However, deflection in Z translational is minimum for 0- degree angle of attack and increases as the angle of attack increases further.
3) Max deflection in Z translational is noticed when the wind angle changes to Z direction. Maximum deflection in X direction for Column 4 is around 108mm at top of the building at 00 wind incidence angle for Model 1 whereas Maximum deflection in Z direction is ranging high for Model 4.
4) Axial force shows similar nature of curves in all cases being maximum at ground and decreases with increase in height. Axial force on windward side corner column i.e. Column A increase nearly from top to bottom and small variation is observed with the change in wind incidence angle.

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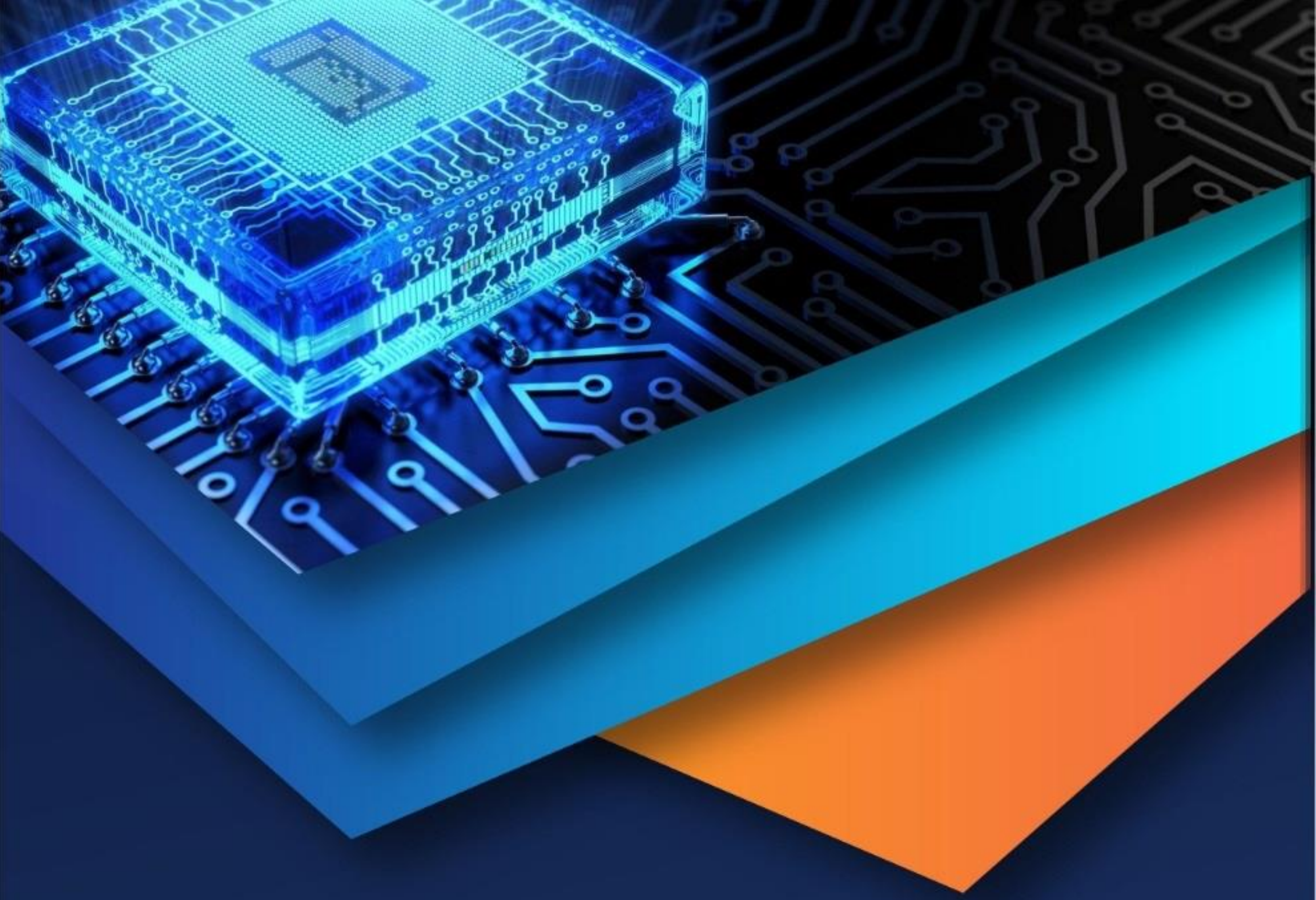


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