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Analysis of Mono Column Multi-Storey Structural System Subjected to Different Wind Intensities

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Abstract: ***The design and analysis of mono column multi-storey structural system subjected to different wind intensities are analysed using STAAD Pro V8i. Mono column provides maximum serviceability due to maximum space utilization. In this study planning, structural analysis and design aspects of a G+8 mono column building using steel has been compared with similar RCC building. Various steps involved in the designing of mono column structure are geometric modelling, providing material properties and sectional properties, fixing supports and boundary conditions, providing loads & load combinations, special commands, analysis, specification and design command. The acting loads considered in this analysis were self-weight, floor load, wind load and earthquake load under the seismic zone II subjected to different wind intensities were compared. Comparison of RCC mono column and steel mono column is done.***

Keywords: Mono column building, Static and dynamic loading, Multi-storey building, STAAD Pro V8i, Earthquake loads, Wind loads

I. INTRODUCTION

Structure supported on a mono column provides better architectural view compared to structure supported on many columns. Satisfying the requirement of stability conditions for a mono column structure will be a complicated one, compare with the structures supporting in all the sides depends upon their configuration. Mono column structure is a critical one when it is being to a symmetrical and eccentric loading condition. Eccentric loading will cause the structure to twist in any direction and may cause failure of structure is very critical condition. Since single column is supporting whole structure, all other members will act as cantilevers. To reduce the cantilever span for the structural beams converting two-third of the length as simply supported by providing the two ring beams and inclined beams. The structure is analysed and designed using Staad pro (structural analysis package), which is based on stiffness matrix method.

Fig. 1 Finnlandhaus in Germany

Fig. 2 L & T Head Quarters in Chennai

II. NEED FOR THE STUDY

Due to the scarceness of land multi-storey structures has been constructed using modern construction technology. Stability of a structural system depends upon the boundary conditions and loading of the structure. Mono column structural system has been gained popularity due to the requirement of large serviceable spaces. The structural system will be more stable when all the components are balanced. Fulfilling the criteria of stability conditions for a mono column will be a complicated one. Mono column structure has supported on a single column provides more serviceable area as compare to conventional RCC frame building. These types of structures provides more spaces for offices and parking areas. Mono column structure provides maximum serviceability due to maximum space utilization. In this study planning, structural analysis and design aspects of mono column building using steel has been compared with similar RCC building.

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III. SCOPE AND OBJECTIVES

The scope of the study is to perform the analysis of the mono column multi storey building using RCC and Steel subjected to different wind velocities using STAAD Pro V8i. The main objectives are:

A. To develop, planning and analysis model of the High rise structure in STAAD Pro V8i.
B. To study the seismic load applied on the structure as per IS 1893-2002.
C. To compare the results of seismic load applied on the structure by STAAD Pro V8i.
D. To verify displacement for a mono column building with steel and RCC.
E. To study the effect of different wind velocity on structure as per IS 875 Part-III.

IV. METHODOLOGY

A G+8 Mono column structural system of RCC and steel located in seismic Zone II subjected to three different wind intensities (i.e. 39m/s, 47m/s and 55m/s) are considered for the analysis. The analysis is conducted on 3D frame models using STAAD-Pro V8i. This study deals with the study of wind behaviour of mono column structure with steel and RCC as per IS875 (Part-III):1987 under different wind intensities. A comparative study has been carried out which resulted in terms of storey displacements. Typical bay width is taken 5m in both X and Z direction. Number of bays in both directions are 4 and 3m storey height were considered. All the joints of beam, column and inclined beams are rigid. The complete detail of the structure including modelling concepts is given in Table 1. These values are provided as an input to the STAAD-Pro software for drawing, analysis and designing purposes.

Table 1 Details of the Building Parameters used for the Analysis

Building Type		RCC	STEEL
Plan area		20 x 20	20 x 20
Storey height	Floor to floor	3	3
	Floor to ground floor	6	6
Inclined Beam size		0.6m X 0.6m	ISWB 600 H
Beam size		0.50m X 0.50m	ISHB 450
Central Column size		1.8m X 1.8m	1.8m X 1.8m
Column size		0.50m X 0.50m	ISWB 500
Slab thickness		150 mm	150 mm
Wall Thickness		Brick 230 mm	Al Glazed 4 mm
Type of building		OMRF	OMRF
Grade of concrete		M20	M20
Grade of steel		Fe 250	Fe 250
Height of building		30	30
Density of concrete		25 KN/m^3	25 KN/m^3
Earthquake Zone		II	II
Soil type		II (Medium)	II (Medium)
Response reduction factor		3	3
Importance factor		1	1
Damping ratio		5%	5%

A. Load Case Details

The loads assigned in the Analysis will include Dead load (IS875 Part-I 1987), Live load (IS875 Part II 1987), Seismic loads (IS 1893-2002) and Wind loads (IS 875 Part III 1987). The load combinations considered for the analysis and design is as per IS: 1893-2002. The different load cases considered are given below.

1) RCC Frame

a) 1.5 (DL + LL)

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b) 1.2 (DL + LL ± EL)
c) 1.5 (DL ± EL)
d) 0.9 DL ± 1.5EL
e) 1.2 (DL + LL ± WL)
f) 1.5 (DL ± WL)
g) 0.9 DL ± 1.5WL

2) Steel Frame

a) 1.7 (DL + LL)
b) 1.3 (DL + LL ± EL)
c) 1.7 (DL ± EL)
d) 1.7 (DL ± WL)
e) 1.3 (DL + LL ± WL)
f) 1.3 (DL + LL)

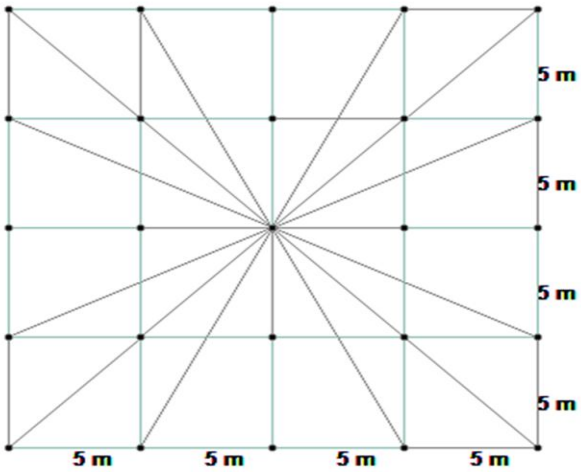

Fig. 3 Common Plan for All Building Model

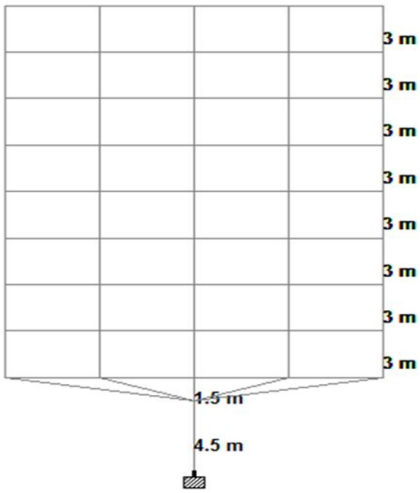

Fig. 4 Elevation of Plan

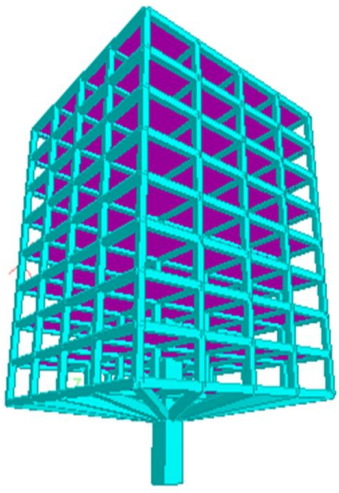

Fig. 5 Three Dimensional Model of RCC Structure

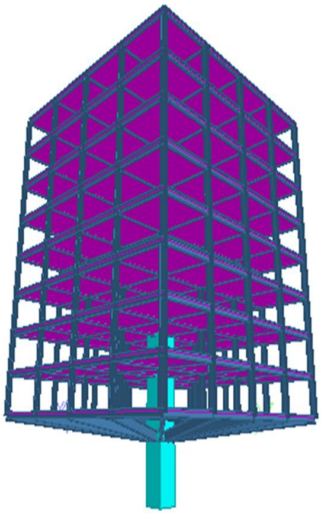

Fig. 6 Three Dimensional Model of Steel Structure

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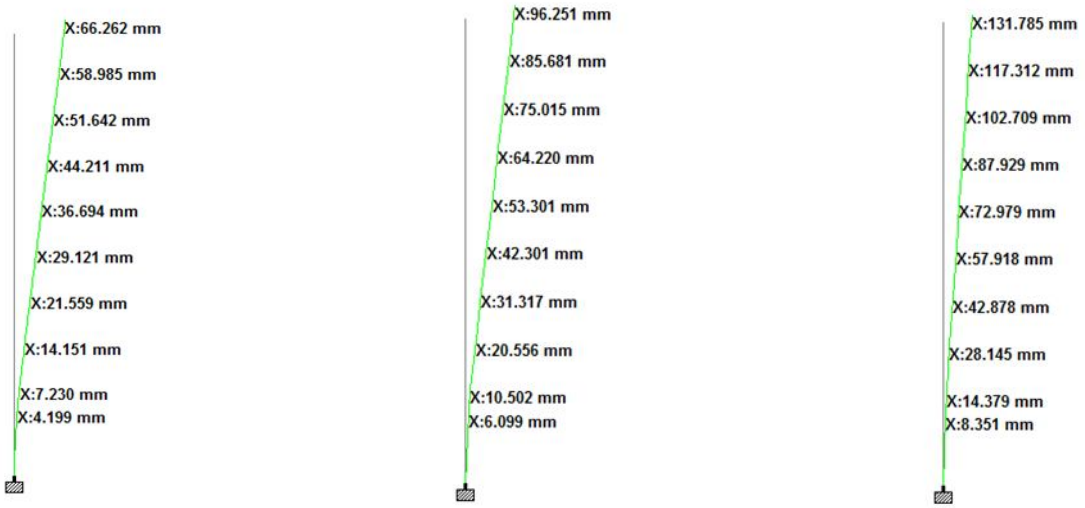
V. RESULT

A. *Storey Displacement*

Storey displacement is the absolute value of displacement of the storey under the action of the lateral forces. The maximum storey displacement values are plotted against number of stories. The storey displacement of RCC and Steel building subjected to wind intensities of three different places (Trivandrum with 39m/s, Agra with 47m/s, Darbhanga with 55m/s) were studied. Consideration of proper wind intensity highly influence the analysis and design of structure.

1) *Comparison of RCC Frame Subjected to Different Wind Intensities:* It is seen that there is an increment in lateral displacement in longitudinal as well as transverse direction with increase in wind intensity. For wind intensity 47m/s increments in lateral displacement is up to 45.260% as compared with wind intensity 39m/s in both longitudinal and transverse direction. For wind intensity 55m/s increments in lateral displacement is up to 98.88% as compared with wind intensity 39m/s in both longitudinal and transverse direction and it is observed that for wind intensity 55m/s increments in lateral displacement is up to 36.92% as compared with wind intensity 47 m/s in both longitudinal and transverse direction. (Fig. 7 & 8)



Wind Intensity 39m/s Wind Intensity 47m/s Wind Intensity 55m/s

Fig. 7 Storey Displacement of RCC Frame Subjected to Different Wind Intensities

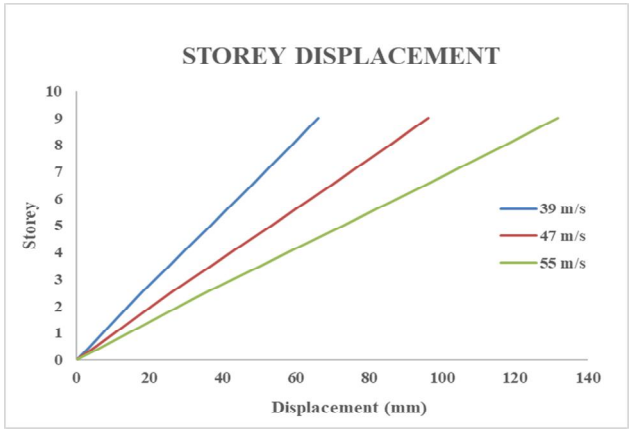


Fig. 8 Comparison of Storey Displacement of RCC Frame

Fig. 9 Comparison of Storey Displacement of Steel Frame

2) *Comparison of Steel Frame Subjected to Different Wind Intensities:* It is seen that there is increment in lateral displacement in longitudinal as well as transverse direction with increase in wind intensity. For wind intensity 47m/s increments in lateral displacement is up to 45.29% as compared with wind intensity 39m/s in both longitudinal and transverse direction. For wind intensity 55m/s increments in lateral displacement is up to 98.94% as compared with wind intensity 39 m/s in both longitudinal and transverse direction and it is observed that for wind intensity 55m/s increments in lateral displacement is up to 36.92% as compared with wind intensity 47 m/s in both the directions. (Fig. 9 &10)

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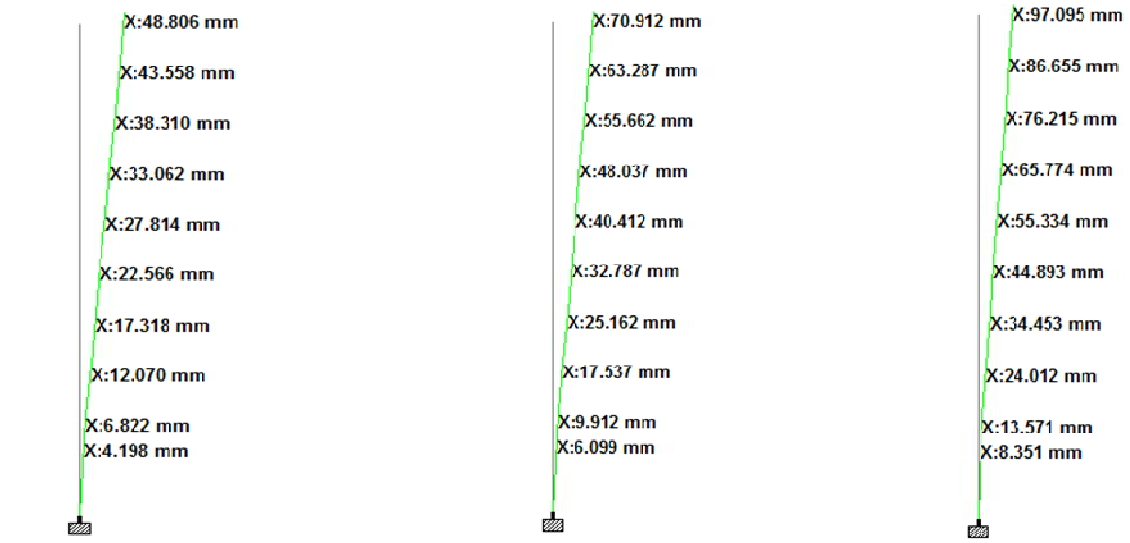

Wind Intensity 39m/s Wind Intensity 47m/s Wind Intensity 55m/s

Fig. 10 Storey Displacement of Steel Frame Subjected to Different Wind Intensities

3) *Comparison of Steel and RCC Frame Subjected to 39m/s Wind Intensity:* Fig. 11 shows the comparison of storey displacement between multi-storey mono column RCC and Steel framed structure with wind intensity 39m/s. It is observed that the storey displacement in RCC framed structure is 26.344% more than steel frame structure.

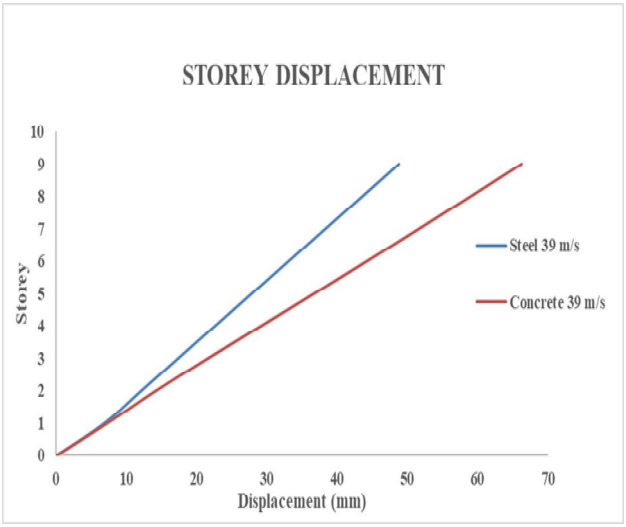

Fig. 11 Comparison of Steel and RCC Frame (39m/s Wind)

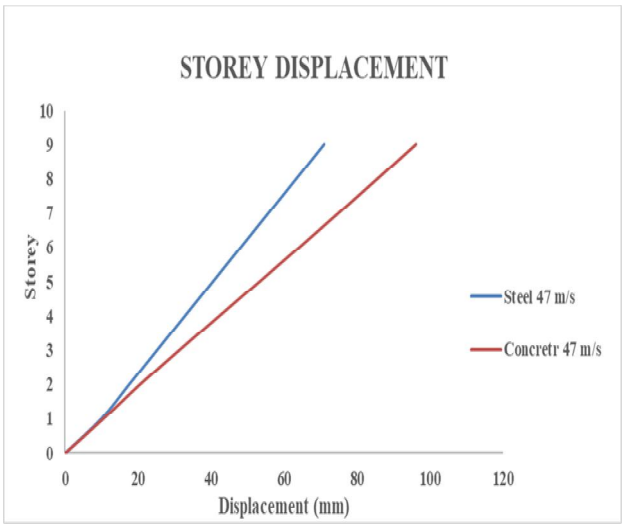

Fig. 12 Comparison of Steel and RCC Frame (47m/s Wind)

4) *Comparison of Steel and RCC Frame Subjected to 47m/s Wind Intensity:* Fig. 12 shows the comparison of storey displacement between multi storey mono column RCC and Steel framed structure with wind intensity 47m/s. It is observed that the storey displacement in RCC framed structure is 26.326% more than steel frame structure.

5) Comparison of Steel and RCC Frame Subjected to 55m/s Wind Intensity: Fig. 13 shows the comparison of storey displacement between multi-storey mono column RCC and Steel framed structure with wind intensity 55m/s. It is observed that the storey displacement in RCC framed structure is 26.323% more than steel frame structure.

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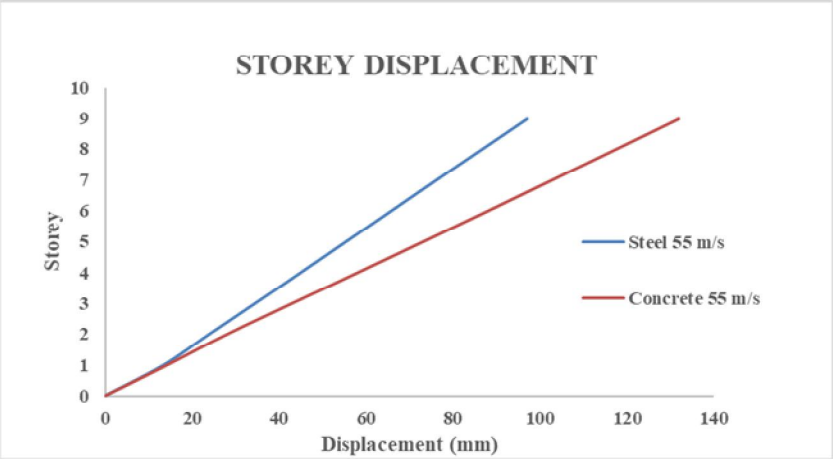

Fig. 13 Comparison of Steel and RCC Frame (55m/s Wind)

VI. CONCLUSIONS

The analysis of mono column RCC and Steel building models are done and the results are compared. The conclusions are as follows:

A. Mono column RCC and Steel structure has been designed successfully to withstand all loads including earthquake and wind load.
B. On comparing the results it is found that mono column structure with steel makes structure more serviceable as compare to RCC mono column structure.
C. Steel structure having less dead weight as compare to RCC structure.
D. The mono column multi storey steel structure is more effective in resisting lateral loads.
E. Deflection controlled by using inclined beam member which support large cantilever span by made it propped cantilever.
F. There is an increment in lateral displacement in longitudinal as well as transverse direction with increase of wind intensity for both RCC and steel structure.
G. Storey displacement in RCC frame structure is 26% more than that of steel frame structure in all wind cases.
H. Consideration of proper wind intensity highly influences the analysis and design of structure.
I. STAAD-Pro V8i is an advanced software which provides us fast, efficient, easy to use and accurate platform for analysing and designing structures.

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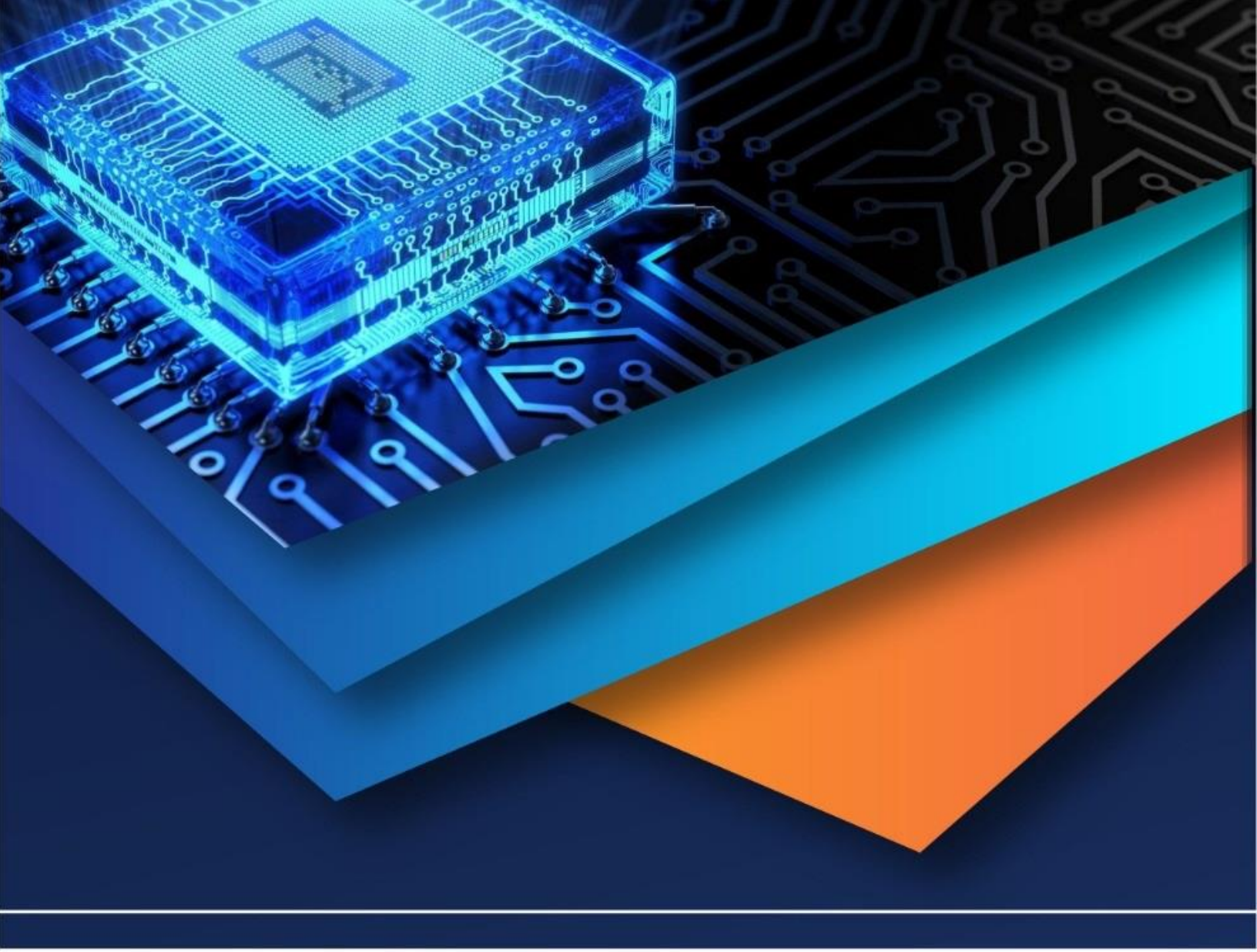

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