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Analysis and Design of Steel Concrete Composite Structure and Its Comparison with RCC Structure

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Abstract: Composite Structure is quickly gaining acceptance in India's non-residential multi-story building sector. The reason for considering composite construction is simple: Steel is best in tension and concrete is best in compression. Combining these two materials strengthens their structural properties, which can be used to create a highly effective and lightweight design. Steel-concrete composite building systems are formed by connecting the steel beams to the profiled deck slab using shear connectors so that they function as a single unit, and for columns steel section is encased in concrete. In this present work, comparative study of G+15 R.C.C and composite multistorey commercial building located in Earthquake zone IV is Considered by Equivalent Static Method of Analysis. ETABS 2018 Software is used for modelling of both the structure. Storey Displacement, Storey Drift, Storey Shear, Self weight, Axial force, Bending moment and Shear force are considered as parameters. When the results are compared, it is observed that the Composite structure is superior in every aspect.

Keywords: Composite Structure, Composite Column, Composite beam, Deck slab, Shear connectors, Equivalent Static Analysis, ETABS 2018

I. INTRODUCTION

A. General

Reinforced concrete members are widely used in framing system because it is the most convenient and cost-effective system for low-rise buildings. However, because of increased dead load, less stiffness, span restriction, and tremendous formwork, this type of structure is no longer economically feasible for medium to high-rise buildings. The steel concrete composite system can provide an efficient and cost-effective solution to the majority of these issues in medium to high-rise buildings. When compared to RCC and steel work, composite structure is considered to be one of the most cost-effective and time-efficient construction method. composite structure is comprised of a column with an I-section encased or embedded in concrete, a steel I-section as a beam, and a deck slab which consists of profile sheets and mortar. Shear Connectors connect the beams to the deck slab.

B. Elements of Composite Construction

Elements of Composite Construction are mentioned below.

1) *Composite Beam:* Composite beams are comprised of a steel beam over which a reinforced concrete slab with shear connectors is cast. The concrete slabs are simply supported by steel beams. These two segments act freely in response to load activity, and there is no correlation between the slabs and steel beams. It is suitable for enduring repeated earthquake loading, which usually requires a high level of resistance and ductility.

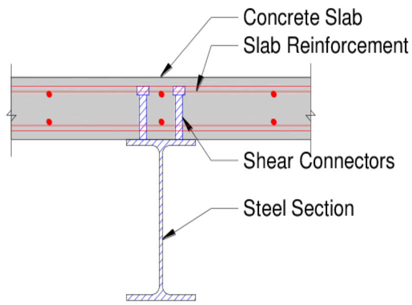

Figure. 1. Composite Beam

2) *Composite Column:* Composite columns are made up of structural steel and concrete to take advantage of the best qualities of both materials. The intelligent and fundamental behaviour of cement and steel components makes the composite section a solid, more malleable, economical, and thus fundamentally effective building component. Concrete Encased, Concrete Filled, and Battered Section are the three types of composite columns used. Below figure shows the composite column.

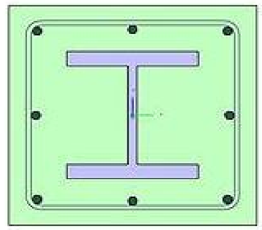

Figure. 2. Composite Column

3) *Composite Slab:* Composite slabs comprise of steel beams, deck sheets and concrete. They are typically built with reinforced concrete cast on top of steel decking, which serves as formwork and a working platform in the course of the construction stage.

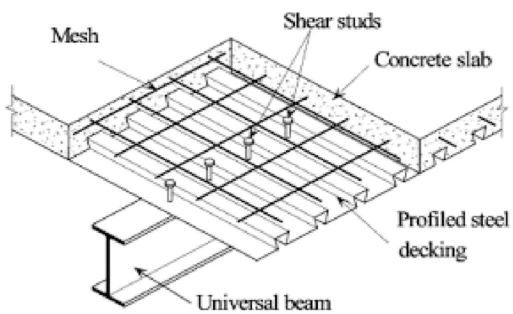

Figure. 3. Composite Slab Components

4) *Shear Connectors:* Shear connectors are important in composite construction because they increase the compression capacity of the supported concrete slab and steel beam while also increasing load carrying capacity. It is installed between the composite slab and the steel beams. Headed studs, Perfobond Ribs and Waveform strips are types of shear connectors.
5) *Deck Profiles:* The composite deck's bottom surface is made of corrugated cold form steel sheets, also known as profile deck. Deck profiles are classified into two types: Trapezoidal profiles and Re-entrant profiles.

II. STRUCTURAL DETAILS

The structure under consideration here is a commercial structure in Seismic Zone IV Located in Pune. The plan size is 20m x 20m. Both R.C.C. and composite construction are studied on the same building plan. Both types of structures have the same basic loading.

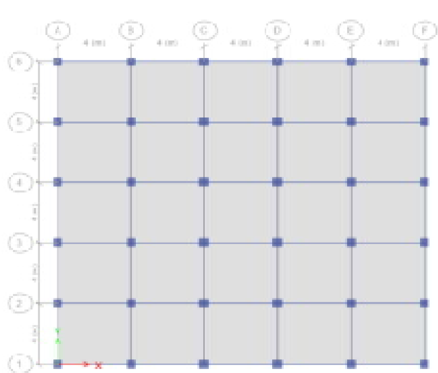

Figure.4. Floor Plan of the Structure

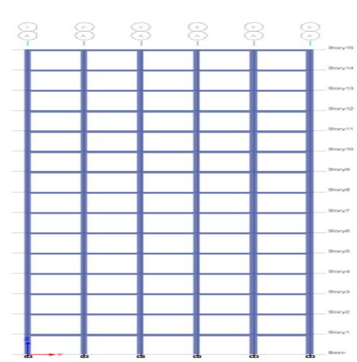

Figure. 5. Elevation of the Structure

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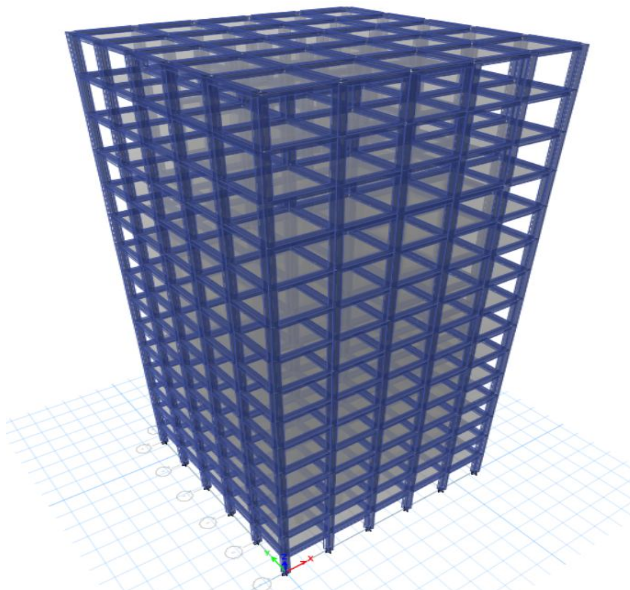

Figure. 6. Structure 3D View

Table. 1. Data for Analysis of RCC and Composite Structure

Particulars	RCC Structure	Composite Structure
Plan Dimension	20m x 20m	20m x 20m
Total height of the building	45 m	45m
Height of each storey	3 m	3 m
Height of Parapet	1 m	1m
Size of Beam	300 x 500 mm	ISMB 450
Size of column	500 x 500 mm	500 x 500 mm Embedded I Section (ISMB450)
Thickness of wall	230 mm	230 mm
Thickness of slab	150 mm	150 mm
Wind Speed	39 m/s	39 m/s
Seismic Zone	III	III
Importance Factor	1	1
Soil Condition	Medium soil	Medium soil
Zone Factor	0.16	0.16
Response Reduction Factor	5	5
Terrain Category	III	III
Structure Class	B	B
Damping Ratio	5 %	5 %
Live Load at all floors	3 KN/m2	3 KN/m2
Floor finish	1 KN/m2	1 KN/m2
Grade of concrete	M30	M30
Grade of Reinforcing steel	Fe415	Fe250
Reinforcing Bars	Fe415	Fe415
Density of brick	20 KN/m3	20 KN/m3

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III. RESULTS AND DISCUSSION

The 3D building model is analyzed and Designed by Equivalent Static method of analysis according to Indian and American Standard Codes with the help of ETABS 2018 software. The results of Maximum Storey Displacement, Storey Drift, Storey Shear, Bending moment and Shear force, Axial force, Self-weight of the Structure, Quantities and overall performance of building model are compared.

A. *Maximum Storey Displacement*

Maximum Storey Displacement of RCC and Composite Structure in EQX direction is given below.

Table. 2. Max Storey Displacement in EQX (mm)

Model	Max Storey Displacement in EQX (mm)
RCC	17.33
Composite	13.56

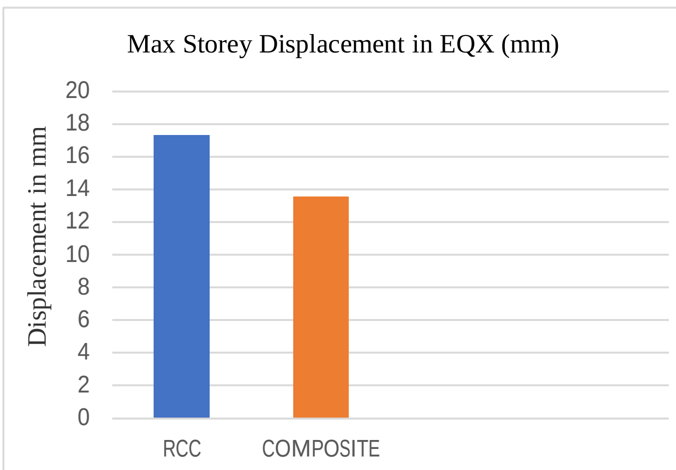

Figure. 7. Storey Displacement

B. *Maximum Storey Drift*

Maximum Storey Drift for RCC and Composite Structure in EQX Direction is given below.

Table 3 : Max Storey Drift

Model	Max Storey Drift in EQX (unitless)
RCC	0.000599
Composite	0.000503

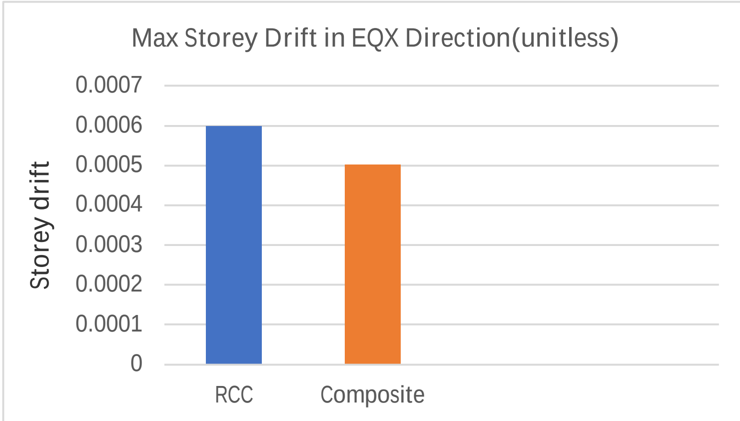

Figure. 8. Storey Drift

C. Storey Shear

Storey Shear for RCC and Composite Structure is given below

Table 4. Storey Shear

Model	Storey Shear (KN)
RCC	564.24
Composite	468.52

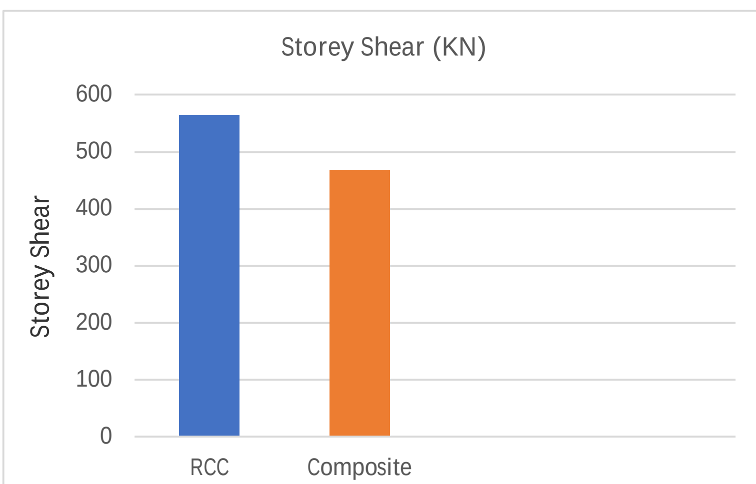

Figure. 9. Storey Shear

D. Bending Moment and Shear Force

Bending Moment and Shear force of RCC and Composite Structure for Beam B31 at Storey 5

Table 5 : Bending Moment and Shear force

Model	Bending Moment (KN)	Shear Force (KN)
RCC	24.43	51.10
Composite	23.40	45.42

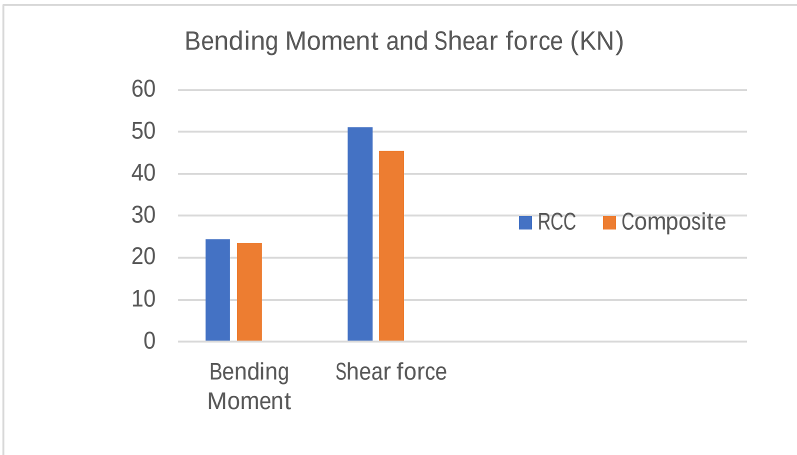

Figure 10. Bending Moment and shear force

E. Axial Force

Axial force of RCC and Composite Structure for Column C1 at Storey 13

Table 6 : Axial Force

Model	Axial Force (KN)
RCC	588.16 KN
Composite	543.42 KN

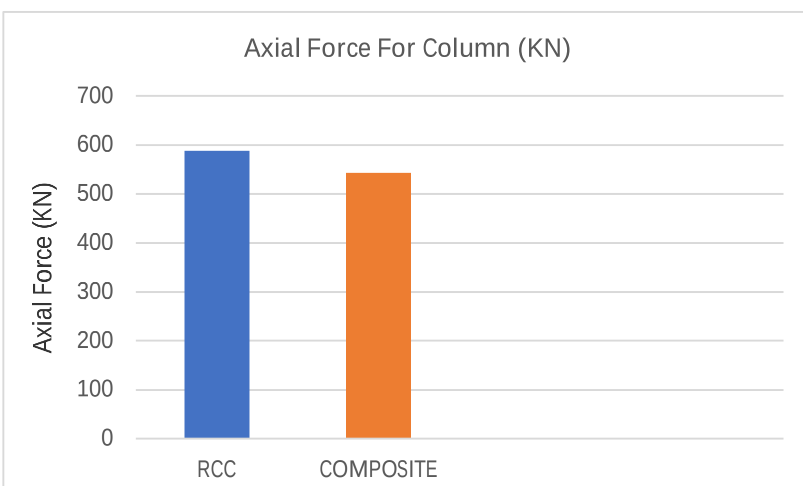

Figure.11. Axial Force

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F. Self- Weight of Structure

Self Weight of RCC and Composite Structure is given below

Table 7 : Self weight of Structure

Model	Self weight (KN)
RCC	44086.97
Composite	30663.06

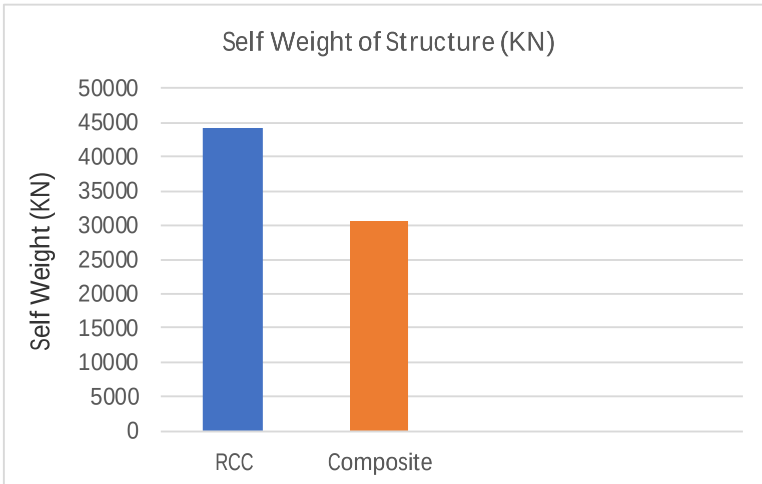

Figure. 12. Self weight of Structure

G. Quantities for Different Models

Quantities of RCC and Composite Structure are given below

Table 8 : Quantities

Structure	Concrete (cu.mt)	Reinforcement (Ton)	Structural Steel (Ton)
RCC	2331	375.93	-
Composite	1305	51.18	412.37

It is seen that, the concrete required for RCC Structure is much higher than composite structure. In Composite Structure, Structural Steel used is absent in RCC Structure.

Based on the Quantities Cost of Construction for both RCC Structure and Composite Structure is found out.
Cost of Construction for RCC Structure = **Rs. 33399490 /-**
Cost of Construction for Composite Structure = **Rs. 31382760 /-**
Difference in Cost = RCC Structure – Composite Structure
= Rs. 33399490 – Rs. 31382760
= **Rs. 20,16,660 /-**

The above results shows that the composite construction is economical.

IV. CONCLUSION

Analysis and Design results of G+15 storied building with comparison of results of Composite Structure and RCC Structure shows that –

1) The Storey Displacement graphs of both RCC and Composite Structure are plotted and comparisons are made. The RCC Structure have Storey displacement 17.33 mm and Composite structure have storey displacement 13.56 mm. it clearly shows that composite structure have more resistant against RCC Structures.
2) Storey drift is compared by using bar graph and results are plotted. RCC Structure have Storey drift of 0.000599 and Composite structure have storey drift of 0.000503. Hence it clearly shows that Composite structure has less storey drift than RCC Structure.
3) Storey shear results shows that RCC has storey shear of 564.24 KN and Composite Structure has Storey shear of 468.52 KN. It shows that RCC structure has more storey shear as compared to composite structure.
4) The bending moment and Shear force of RCC beam and Composite beam is compared. The bending moment and shear force of RCC beam is 24.43 KN-m and 51.10 KN respectively and composite beam bending moment and shear force is 23.507 KN-m and 45.42 KN respectively. It shows that RCC structure has more bending moment and Shear force compared to Composite Structure.
5) Axial Force of RCC Column and Composite Column is compared. Axial force of RCC Column is 588.16 KN and for Composite column is 543.42 KN.
6) The total Self weight of RCC Structure and Composite Structure is 44086.97 KN and 30663.06 KN respectively. From the comparison results it shows that RCC Structure has 35.91 % more Self weight than Composite Structure.
7) The cost comparison results shows that cost of Composite structure is 6.22 % less as compared to RCC Structure.

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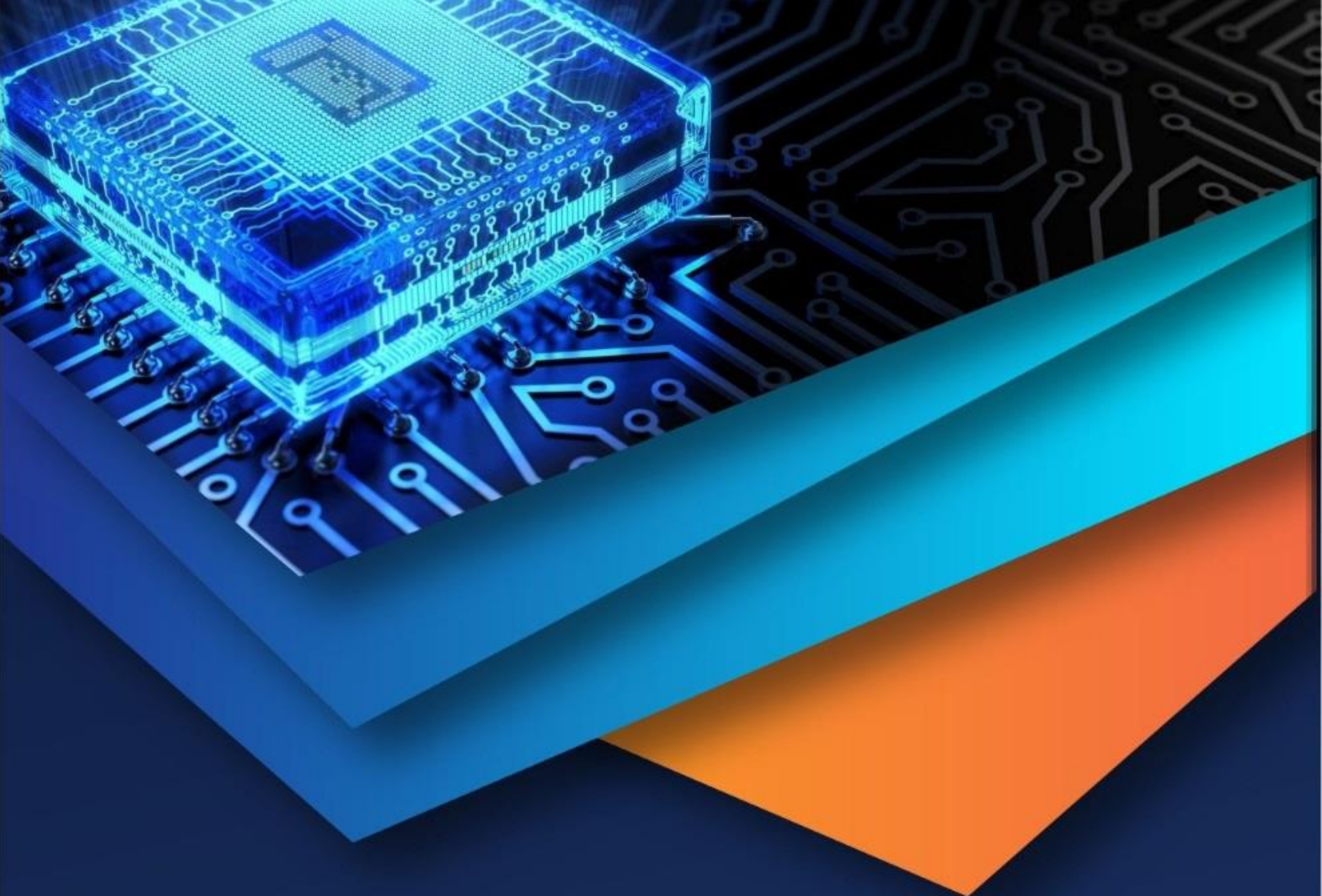

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