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Non-Linear Static Analysis of Hollow and Solid SIFCON column under Axial Loading

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Abstract: ***Concrete is a crucial material for creating various structures. The use of steel fiber reinforcement in concrete improves the ability of structural elements to withstand high stresses. SIFCON (Slurry Infiltrated Fiber Concrete) is a relatively new composite material using steel fibers in a cement-based matrix.SIFCON column is an innovation in the field of civil engineering that enhances the constructability.This paper aims to the Non-linear static analysis of hollow and solid SIFCON hexagonal columns under axial loading. For this study, three finite element models of Hexagonal SIFCON column with Hooked end steel fibers were analyzed using Ansys 2016 R1. Different hollow ratios is evaluated under axial loading to understand the total deformation and equivalent stress.The Study shows that hexagonal solid column shows maximum load carrying capacity than hexagonal hollow columns.***

Keywords: SIFCON, Cement-based matrix, Hooked Steel fibers, Hollow ratios, Equivalent stress.

I. INTRODUCTION

SIFCON means Slurry infiltrated fiber concrete is a special type of fiber reinforced composite.The manufacturing technique and content of fibers of SIFCON are different from that of normal fiber reinforced concrete and the fiber content of SIFCON is differ from that of FRC. In FRC the fiber content varies from 1 to 3% by volume whereas in SIFCON the fiber content varies from 4 to 20% by volume [12]. The method of preparation of SIFCON is different from that of fiber reinforced concrete due to the high volume of fibers. SIFCON is cast by preplacing technique wherein fibers are positioned within the mould or on a substratum and infiltrated with cement-based slurry. The fibers can be sprinkled with the aid of hand or fiber-dispensing units.The amount of fiber depends on fiber aspect ratio , geometry and placement technique [6]. SIFCON has been successfully utilized in structures subjected to blast and dynamic loading. It possesses high strength and great ductility and has excellent potential to resist high impact force. SIFCON also reduces the construction cost. SIFCON has been used successfully for refractory applications, pavement overlays, and structures subjected to blast and dynamic loading [8]. SIFCON has no coarse aggregate but high cementitious content. SIFCON column possess high strength and Deflection of SIFCON column will be very less compared to the conventional columns. The limitation of SFRC is the balling problem due to the increasing amount of steel fibers it can be overcome by SIFCON, because of its fiber alignment. Due to the unique features of SIFCON concrete, the significance of this study lies in the possibility of reducing the size of the column, where small cross-section hollow columns were chosen for this purpose, this offers interesting opportunities to achieve high-performance columns with fulfilling architectural demands such as increasing spans, service requirements like pipes for plumbing and electricity wires through the hole of hollow columns and minimize the dead load of concrete members, this dead load decrease leads to reduced material and foundation costs [2].

A. Objective of the study

In this study, the Non-linear static analysis of solid and hollow hexagonal SIFCON columns are analysed by varying hollow ratios and also find the total deformation and equivalent stress. The total deformation behaviour and equivalent stress of hexagonal SIFCON column are analyzed using ANSYS software.

II. FINITE ELEMENT MODELLING

In this paper, the model of finite elements is implemented by using the ANSYS program. ANSYS is a finite element modelling package which helps in solving even complex problems. The element used in this analysis is SOLID 185. This software creates simulated computer models of structures, electronics, or machine components. Finite element modelling consists of three models having SIFCON hexagonal columns with different percentages of hollow ratios is modelled. The column may be named SHS-0% ,SHS-25% and SHS-33%. Model of Hexagonal SIFCON column for the analysis is created in ANSYS Workbench 16.

After the modelling, meshing has been done to get an accurate result of the analysis. It breaks up a whole body into pieces, where each piece represents an element. The mesh was set up such that square or rectangular elements were created. A Hexagonal column of 115 mm side and 1000 mm height is used. Different hollow ratios of the hexagonal column are modelled and analyzed.

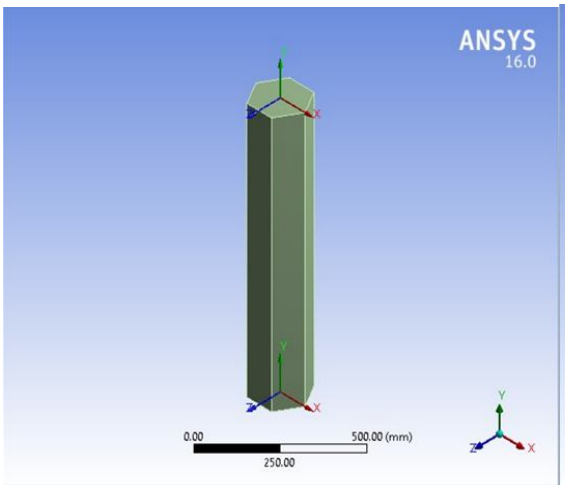

Fig. 1. SHS-0%

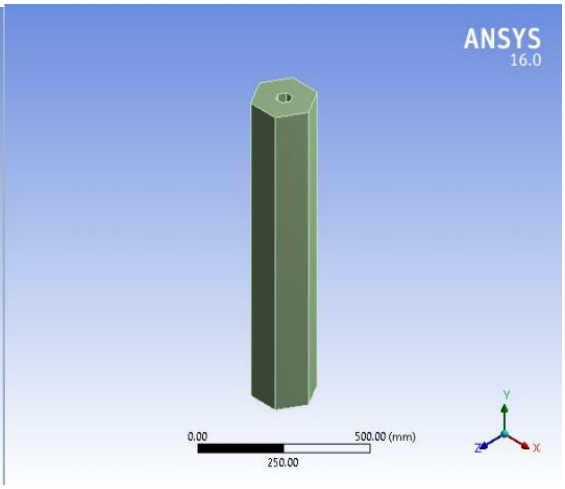

Fig. 2. SHS- 25%

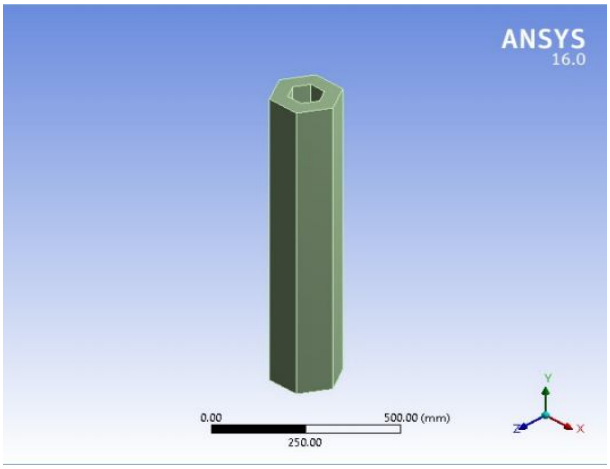

Fig. 3. SHS- 33%

III. FINITE ELEMENT ANALYSIS

In nonlinear analysis, the total load applied to a finite element model is divided into a series of load increments called load steps.. Force reaction was inserted from the probe menu to obtain the load deformation details. A Chart is plotted with the Force Reaction on Y-axis and corresponding deformation on X-axis. For FE analysis, Ansys software is used. Three models were considered for the finite element analysis.

A. Material Properties

The material properties for the Hooked end steel fiber and SIFCON is listed in the table I and II

TABLE I
PROPERTIES OF HOOKED END STEEL FIBER

Geometry	Hooked End
Length	30mm
Diameter	0.5mm
Density	7850 Kg/m^2
Aspect ratio	60

Fig.4.Hooked End Steel Fiber

TABLE II
MATERIAL PROPERTIES

Mechanical Properties	Results
Compressive strength	47.28
Split Tensile strength	4.50
Flexural strength	5.3
Modulus of Elasticity	30 Gpa
Poisson's ratio	0.27

B. Boundary Conditions

Displacement-controlled loading is adopted. About the boundary condition, one end is fixed and the other is free. So the bottom portion of the wall is provided as fixed and remote displacement is provided at the top of the column.

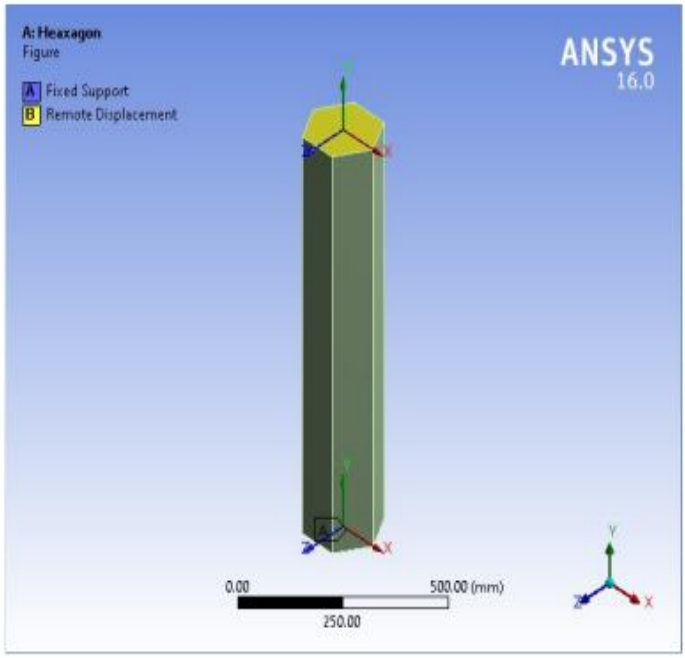

Fig. 5. Boundary condition of SHS-0%

C. Total deformation of the column

After applying load steps by changing analysis settings, a non-linear analysis has been carried out. From solutions, force reaction and total deformation were inserted. The deformed shape of Hexagonal columns obtained after the analysis is given below

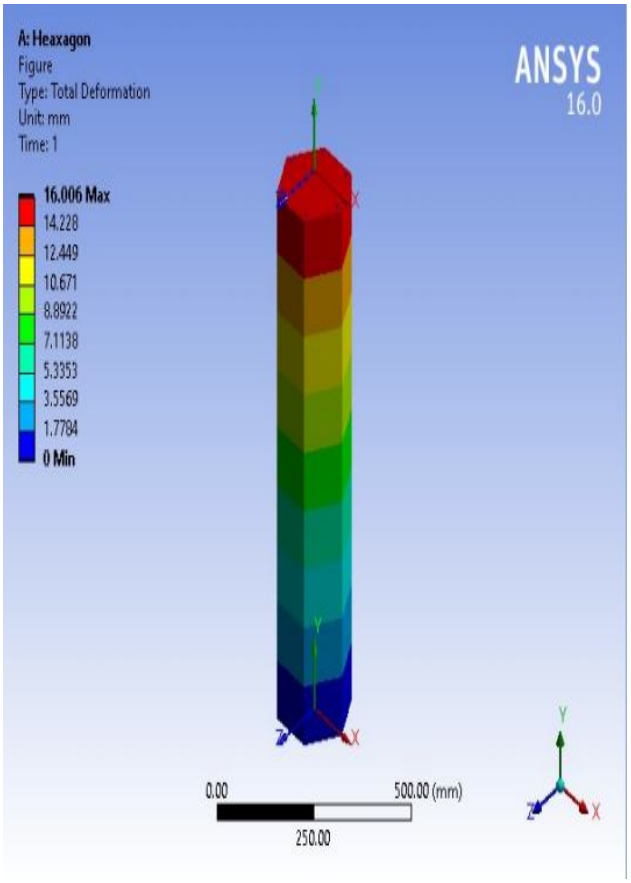

Fig. 6. Total deformation of SHS-0%

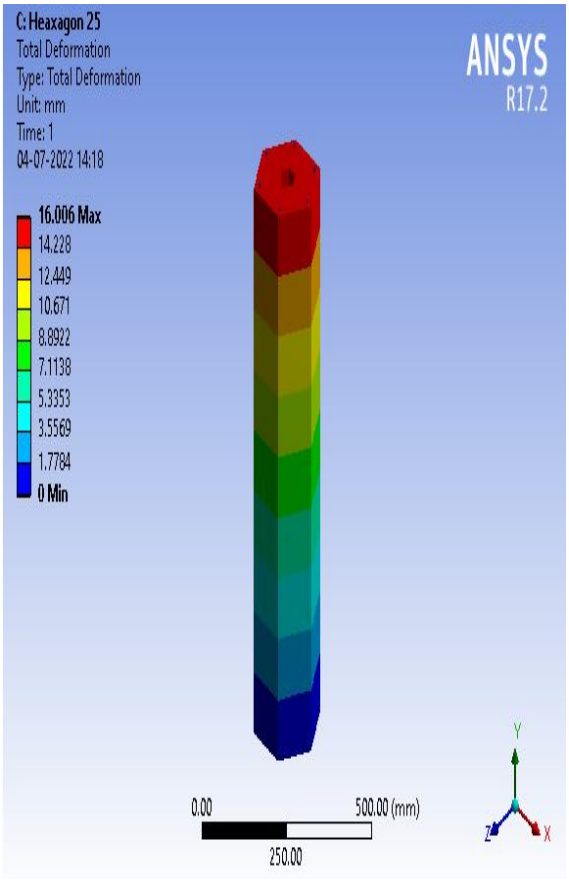

Fig. 7. Total deformation of SHS-25%

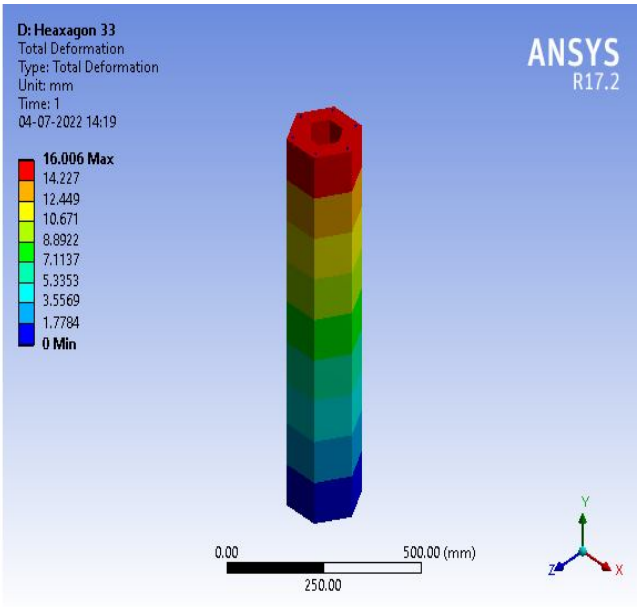

Fig. 8. Total deformation of SHS-33%

D. Load Deformation Curve

The load is taken on Y axis and total deformation is taken on X- axis respectively. From the total deformation, we can see that the load carrying capacity increases with the decrease in hollow ratios.

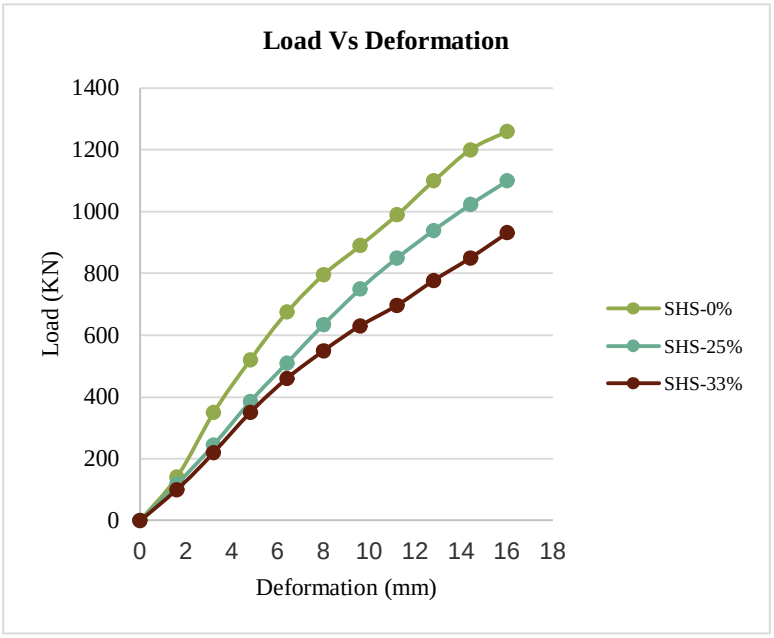

Fig. 9. Load Deformation Graph -Comparison

E. Equivalent stress in Hexagonal Column

From equivalent stresses /Von mises stress, it is a value used to determine if the material will yield or fracture. The concept of Von mises' stress theory arises from the distortion energy fraction theory. According to the theory, failure occurs when the distortion energy in the actual case is greater than the distortion energy in a simple tension case at the time of failure. The equivalent stress in hexagonal column with SHS-0% ,SHS-25% and SHS-33% is shown in the figure below.

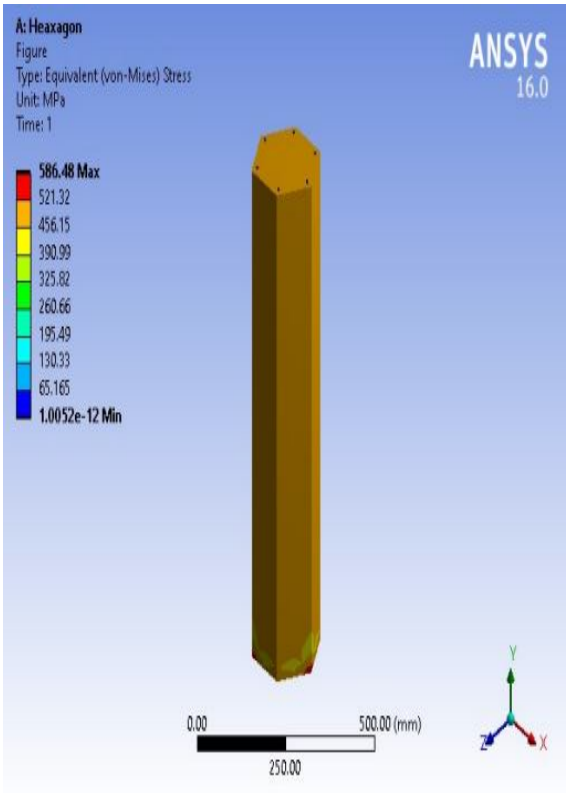

Fig. 10.Equivalent stress of SHS-0%

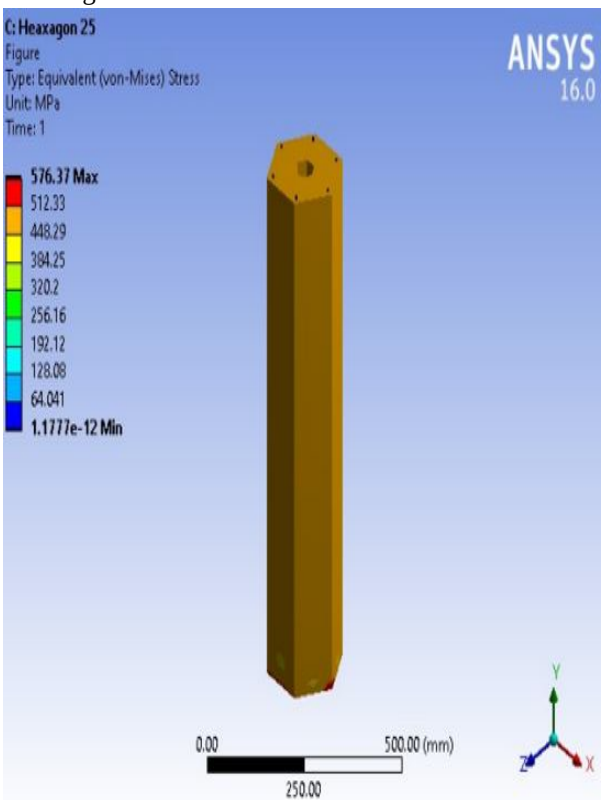

Fig. 11. Equivalent stress of SHS-25%

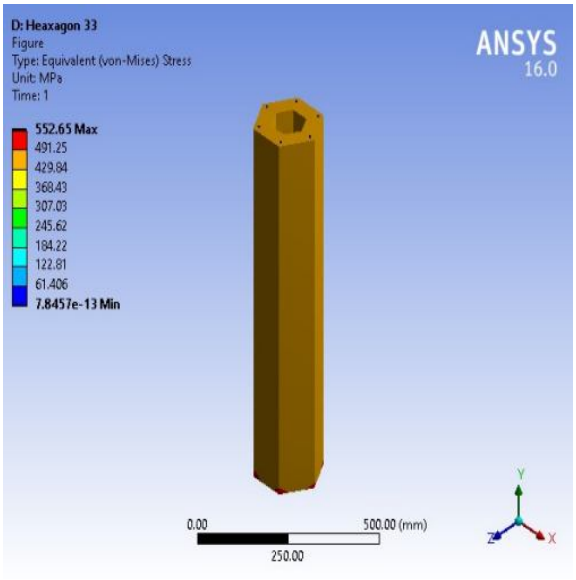

Fig. 12. Equivalent stress of SHS-33%

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IV. CONCLUSIONS

In this paper hexagonal SIFCON columns with different percentages of hollow ratios are evaluated under axial loading. From the analysis, it is clear that the hollow ratio decreases, the load carrying capacity increases that is the model SHS-0% shows better performance. The behaviour of hollow columns is distinct from that of solid columns due to the presence of a hole.The hole has a major effect on load carrying capacity of column. The solid column resists more load carrying capacity that of hollow column.The decrease in the load carrying capacity of column specimens with the increase in hole size. Solid Hexagon shaped column shows more load carrying capacity than different percentages of hollow columns.

V. ACKNOWLEDGMENT

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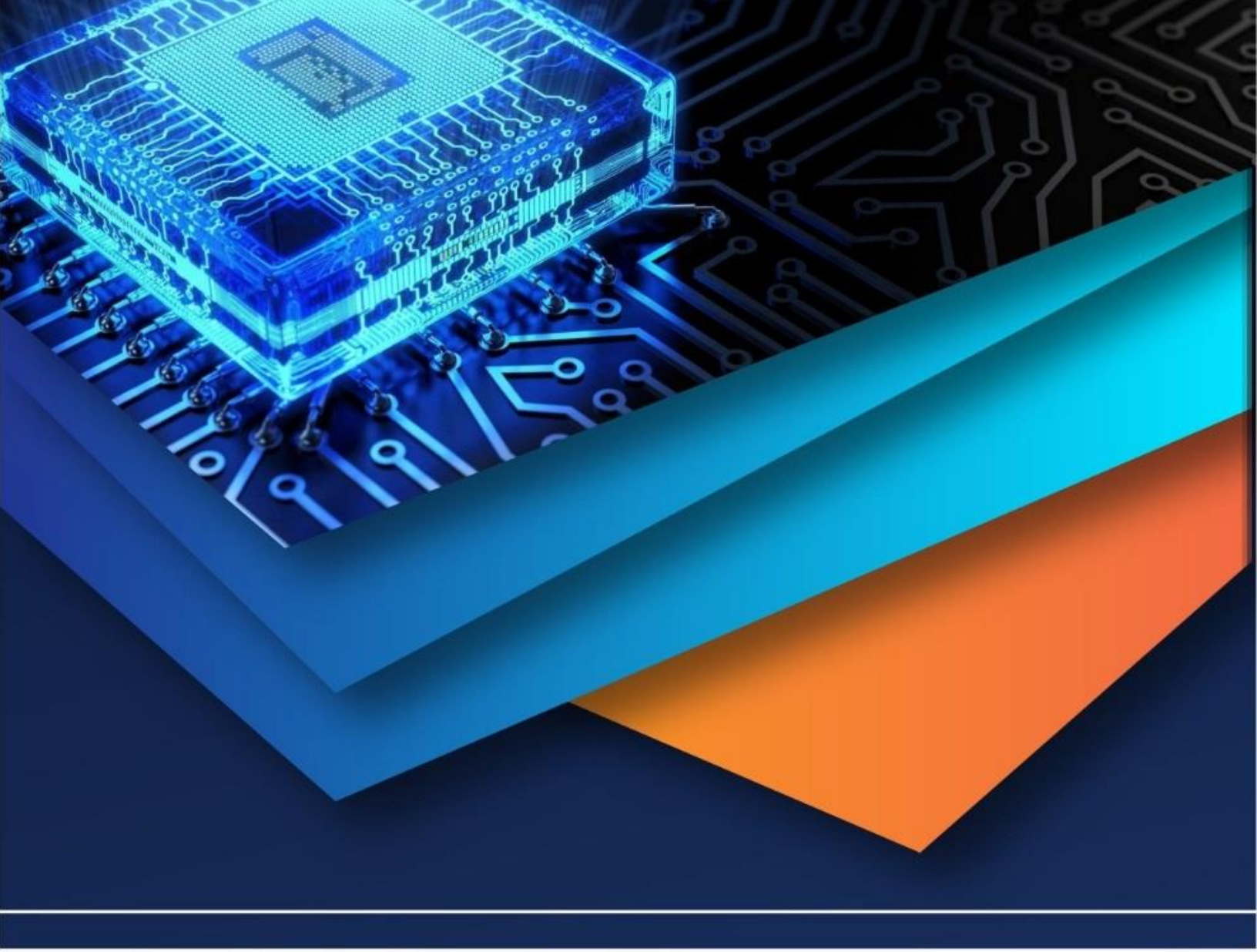

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