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Analysis of Load Deformation Behaviour ofCSFRC Arc Corbel Using ANSYS

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Abstract: ***Corbels are the structural members that transfer the horizontal and vertical load from beams to wall or column element. Corbels projecting from the faces of reinforced concrete columns are extensively used in precast concrete construction to support the primary beam and girders. Corbels are structural members characterized by a shear span-to-depth ratio (a/d), generally lower than unity. Arc corbel has better stress performance than other shaped corbel and also bear the crane loads. It is provided to support rails and support the end spans of the double cantilever balanced reinforced concrete bridges. Corrugated Steel Fiber Reinforced Concrete(CSFRC) is a concrete with short, discrete lengths of steel fibers which are randomly dispersed. This paper illustrates the effect of shear span-to-depth ratio on load deformation behavior of Corrugated Steel Fiber Reinforced Concrete arc corbel. The structure thatgenerates comparatively small deformation within the applied load can be considered as relatively safe. Corrugated Steel Fiber Reinforced Concrete with 1% steel fiber is used in the current study. The shear span-to-depth ratios adopted for the study are 0.1, 0.15, 0.2. The analysis of the structure has been carried out using ANSYS Software.***
Keywords: ***Corrugated Steel Fiber Reinforced Concrete (CSFRC), Arc Corbel, Load deformation behavior, Shear span-to-depth ratio,ANSYS***

I. INTRODUCTION

Corbels may be described as short cantilevers that project from the inner face of concrete columns or walls to support heavy concentrated loads of cranes and beams.

The corbel is generally built monolithically with the column or wall. Corbels projecting from the faces of reinforced concrete columns are extensively used in precast concrete construction to support the primary beam and girders. Corbels are structural members characterized by a shear span-to-depth ratio (a/d), generally lower than unity.

As the shear span-to-depth ratio of corrugated steel fiber reinforced concrete arc corbel increased, there is a decrease in the ultimate load carrying capacity and shear strength. i.e., decreasing the shear span-to-depth ratio leads to increase in shear strength.

The concrete is considered to be a relatively brittle material and has low ductility. In this investigation, the main goal was using corrugated steel fibers to convert the brittle characteristic to a ductile one, increases the shear strength of corbels and improves the ductility. The amount of secondary reinforcement should be increased to increase the strength of corbel, but it cause honeycombing, overcrowding, voids etc. So to increase the strength secondary reinforcement in the corbel is replaced by 1% of corrugated steel fiber to increase the shear strength. Corrugated steel fiber of length 30mm and diameter 0.5mm is used.

It increases the tensile strength, bond strength between fiber and concrete, reduces the crack formation.

By many experimental evidence it is clear that use of steel fibers improves the shear strength of reinforced concrete structures.

It is also observed that corrugated steel fibers used in reinforced concrete corbels improves the energy absorption of fiber reinforced concrete structuresand also act as a arrestors of cracks in the concrete and addition of steel fibers is also known to improve the bond between steel and concrete, and the compressive, impact, flexural, tensile, and toughness properties of the concrete.

Also, the addition of steel fibers provided effective reinforcement against shear failure.

A. Objective of the Study

In the current study, the load deformation behavior of Corrugated Steel Fiber Reinforced Concrete (CSFRC) arc corbel has been carried out.

The structure that generates comparatively small deformation within the applied load can be considered as relatively safe.

Load deformation behavior of CSFRC arc corbel with shear-to-span ratio by varying the value as 0.1, 0.15 and 0.2 is analyzed using ANSYS software.

II. FINITE ELEMENT MODELLING

The model of the Corrugated Steel Fiber Reinforced Arc Corbel for the analysis is created in the ANSYS workbench 16.0. Finite element modelling consist of three models of corrugated steel fiber reinforced concrete arc corbel with dimension 1360mm thickness at face of column and 680mm thickness at free end is modelled. The size of bearing plate provided is 162.5mm X 250mm.There are six numbers of 16mm diameter main reinforcement is provided. The percentage of corrugated steel fiber added is one percentage. The meshing is done after the modelling to get accurate result on analysis by breakup the
whole body into pieces, which each piece represent an element. The size of the mesh is a factor that determines the accuracy ofthe result. The arc corbel with shear span to depth ratio 0.1, 0.15 and 0.2 is modelled in this paper.

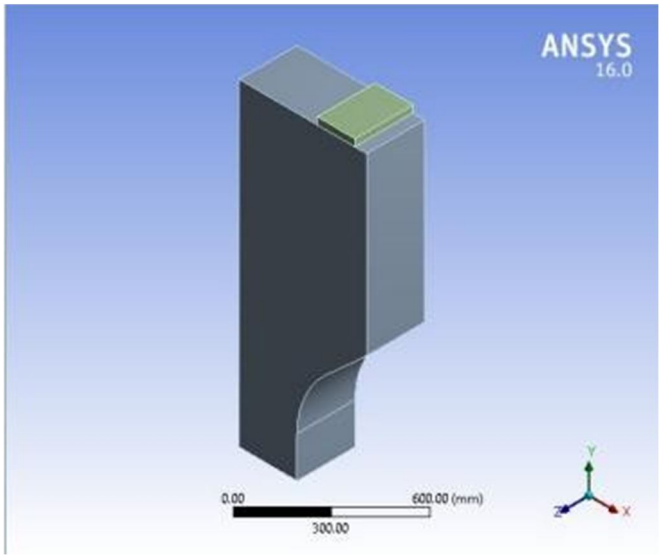

Fig.1 Model for a/d = 0.1

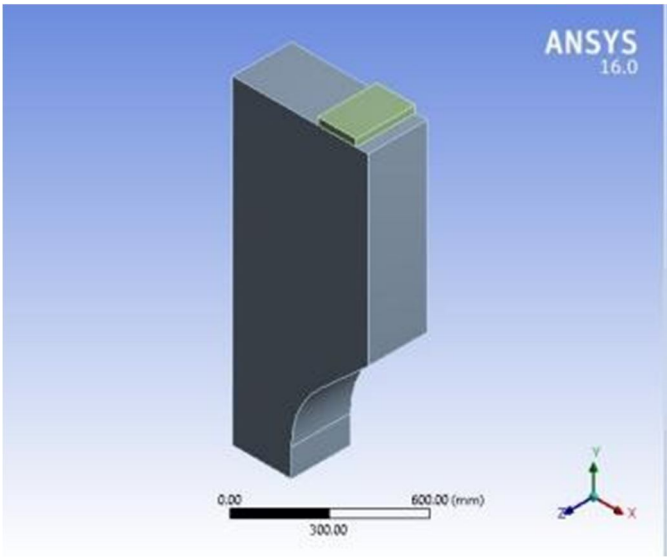

Fig.2 Model for a/d= 0.15

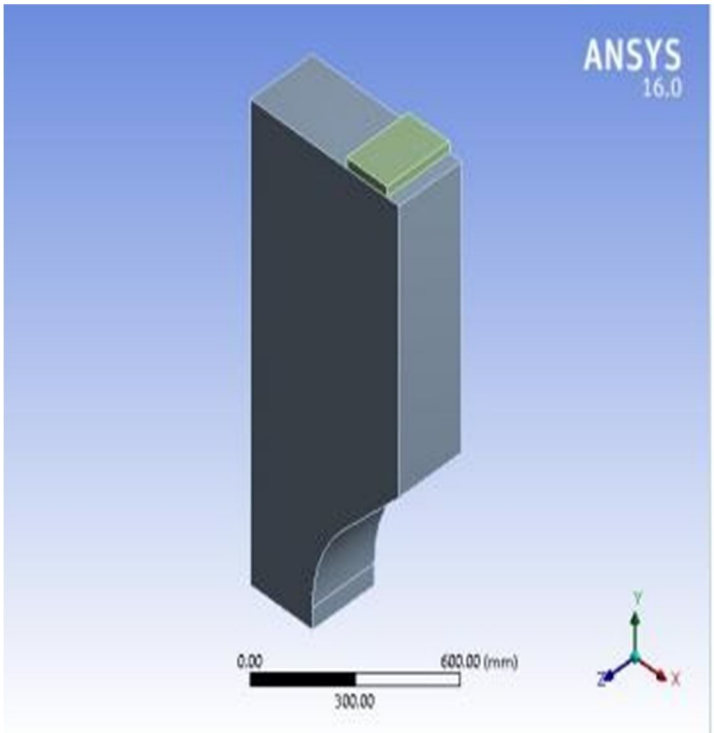

Fig.3 Model for a/d= 0.2

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III. FINITE ELEMENT ANALYSIS

The Finite Element Analysis is performed using the ANSYS workbench 16.0. Three models are considered for the finite element analysis. Finite Element Method is a general numerical method for solving partial differential equations in two or three space variables (i.e., some boundary value problems). To solve a problem, the FEM subdivides a large system into smaller, simpler parts that are called finite elements. ANSYS is a finite element modelling which helps in solving the complex problems by discretizing them into small elements to make the analysis easier.

A. Material Properties

The material properties for the corrugated steel fiber steel and concrete are listed in the table I and II. Corrugated steel fiber of30 mm length and 0.5 mm diameter is used for the analysis. The compressive strength of the concrete is 36 N/mm^2 and the modulus of elasticity is 32.5 GPa.

TABLE I
PROPERTIES OF CORRUGATED STEEL FIBER

Geometry	Corrugated
Length	30 mm
Diameter	0.5 mm
Density	7850 Kg/m^2
Aspect ratio	60
Volume fraction	1%

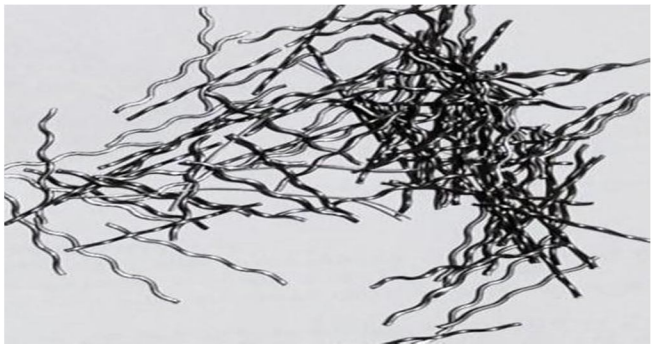

Fig.4 Corrugated Steel FiberTABLE II

MATERIAL PROPERTIES

Mechanical properties	**Results**
Compressive strength	36 N/mm^2
Split Tensile strength	4.56 N/mm^2
Flexural strength	4.71 N/mm^2
Modulus of Elasticity	32.5 GPa
Poisson's ratio	0.199

B. Boundary Condition

For analysis, using ANSYS software various models of arc corbel is evaluated under the vertical force. Here displacement controlled loading is provided. So the arc corbel is treated like one end fixed and other end free. Fig.5 shows the arc corbel having boundary condition. The bottom portion of arc corbel is taken as fixed as shown in the figure and denoted as 'A'. The loading is provided in the top of the arc corbel above the bearing plate in Y direction as force and is denoted as 'B'.

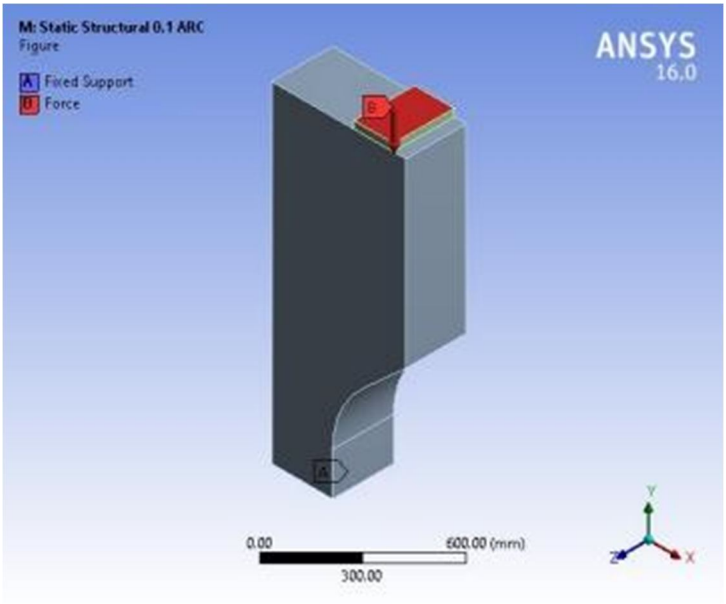

Fig.5 Boundary Condition of Arc corbel with a/d = 0.1

C. Non Linear Analysis-Total deformation

A nonlinear analysis is needed when there is a nonlinear relationship between the forces and the subsequent displacements of a product or structure. The total load applied to a finite element model is divided into series of load members called load steps. The boundary condition applied is the fixed end at bottom and force at the top. A chart is plotted with force reaction on Y axis and corresponding deformation on X axis. Ultimate load value corresponding to each arc corbel is noted. After applying load steps by changing analysis setting, non-linear analysis has been carried out. The force reaction and total deformation were inserted from the solution. The total deformation is given in the figure below:

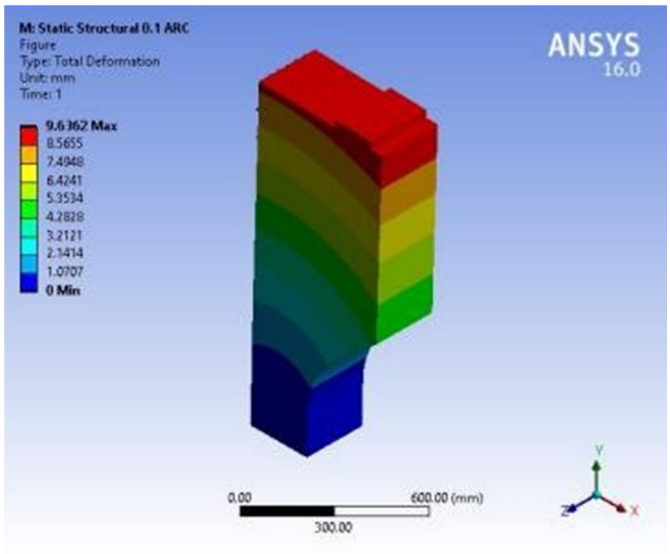

Fig.6 Total Deformation for a/d = 0.1

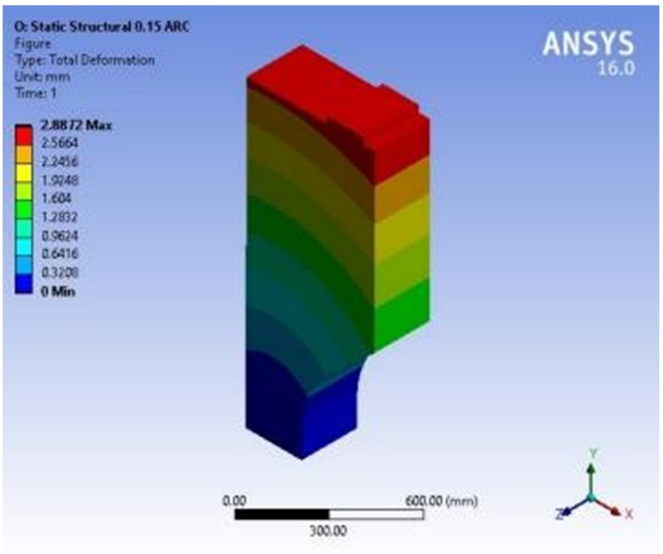

Fig.7 Total Deformation for a/d= 0.15

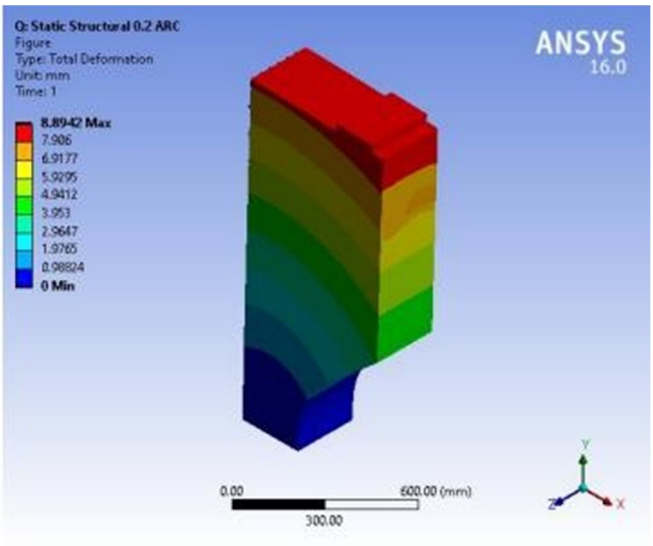

Fig.8 Total Deformation for a/d= 0.12

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 clearly see that as the shear span-to-depth ratio decreases the deformation also decreases and the load carrying capacity increases. That is the arc corbel with shear span-to-depth equal to 0.15 has highest shear strength and low deformation than other shear span-to-depth ratio (0.1 and 0.2).

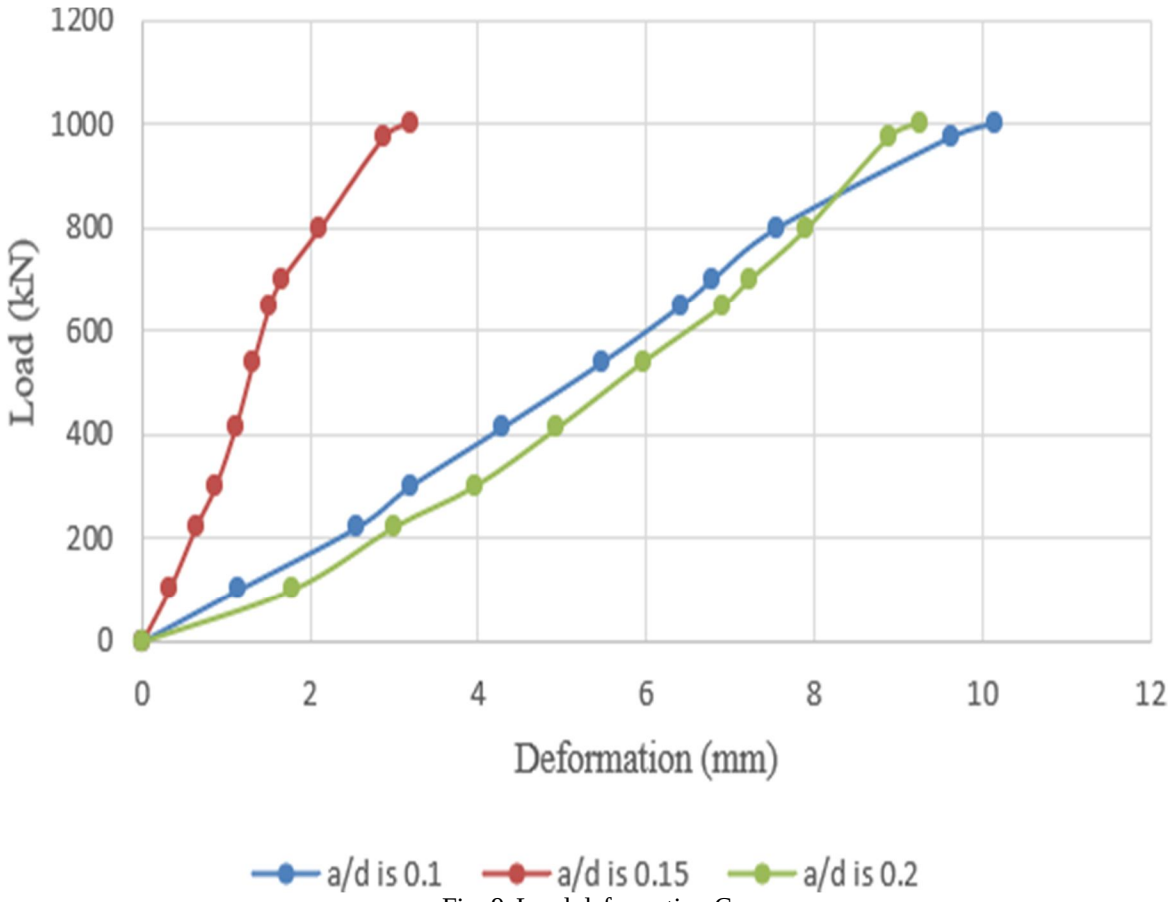

Fig. 9 Load deformation Curve

IV. CONCLUSIONS

Corbel is a structural member that transfers the horizontal and vertical load from the beam to column or wall element. The corbel constructed with the concrete added with 1% of corrugated steel fiber has high strength than the reinforced concrete corbel. The corrugated steel fiber provides best reinforcement effect due to its surface shape and it increase the interface bonding force between fiber and concrete. The corrugated steel fiber reinforced concrete has greater mechanical properties than the conventional concrete. Corrugated Steel Fiber Reinforced Concrete Arc corbel takes more load than the reinforced concrete corbel. The shear span-to-depth ratio is one of the important factors that affect the load carrying capacity and shear strength of the arc corbel. As the shear span-to-depth ratio of corrugated steel fiber reinforced concrete arc corbel increased, there is a decrease in the ultimate load carrying capacity and shear strength. i.e., decreasing the shear span-to-depth ratio leads to increase in shear strength. The arc corbel with shear span-to-depth equal to 0.15 have maximum shear strength, load carrying capacity and low total deformation. Total deformation is maximum at the point of application of load and minimumat the fixed supports.

V. ACKNOWLEDGMENT

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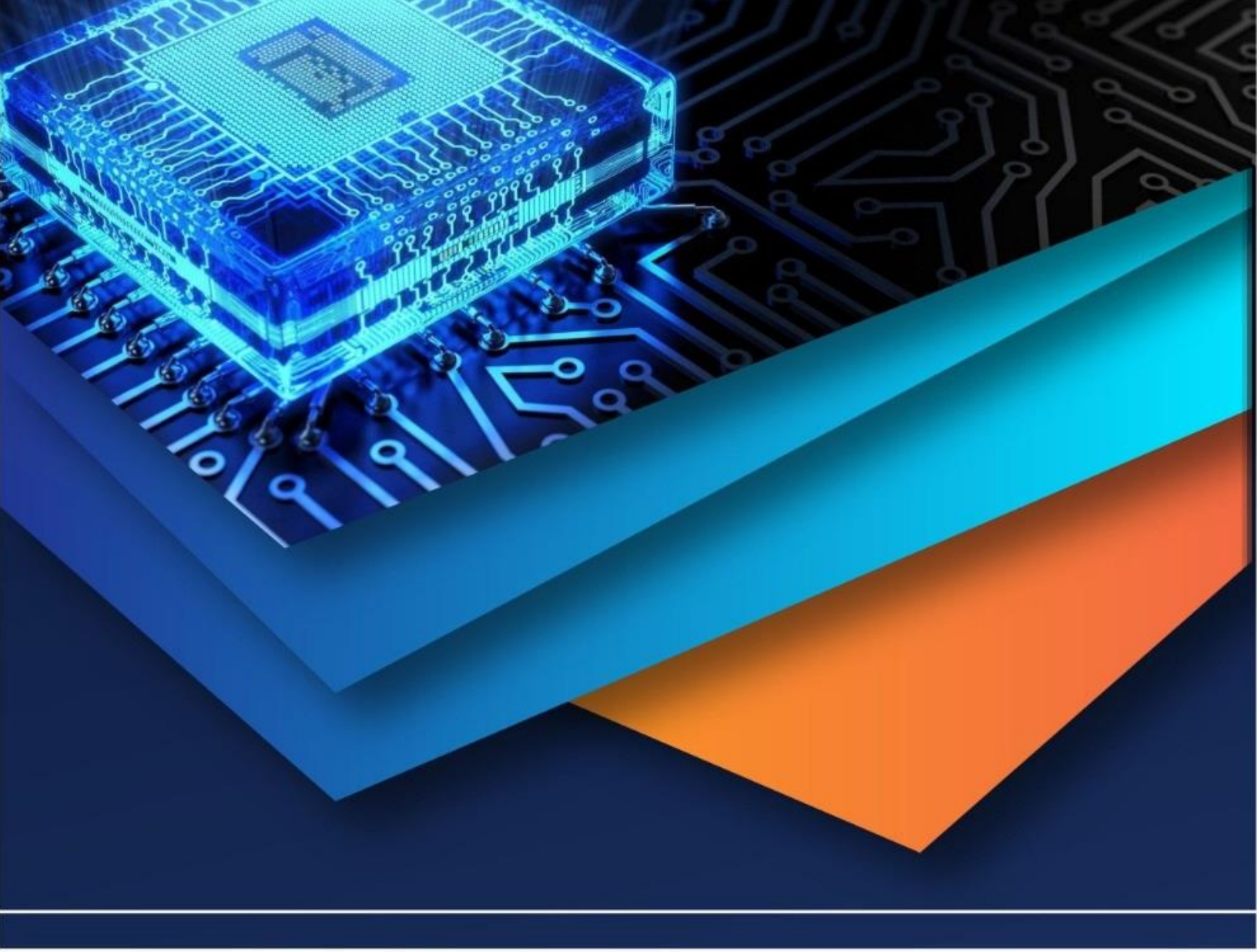

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