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# Scour around Bridge Pier by Providing New Hybrid Collar with Opening Design for Different Pier Particulars

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***Abstract: The scour around bridge piers is a very complex phenomenon. Before the designing of the bridge piers, information of the system of scour around a bridge pier is expected for any designer. For the most part disappointment of the bridge is happened because of the scouring peculiarities. In this proposal work scour around equal compound piers were experimentally studied using recirculating flume. To the satisfaction of the proposition objective, all software modelling and experimental tests run were conducted in clear water scour conditions utilization uniform non-cohesive sand with D50 (Geometric mean size of sand) equal to 1.30 mm was used with different geometry uniform piers. From openFOAM as well as experimental study analysis go for this study to reduced scouring impacts around bridge pier by providing new hybrid collar design with openings for different particulars, in the shape of a collar with openings, to be an improvement over existing FPC. New hybrid collar design with opening combination can reduced scour around 71% to 75% at upstream and 48 to 50% at downstream scour can be minimised from experimental analysis.***

***Keywords*: Openfoam, Scouring; Horseshoe vortex; Opening in pier; Collar design**

## I. INTRODUCTION

Scour in front of and around bridge piers is very hurting to the pressure driven structure itself. Scouring around the lowered or submerged pier and its establishment is one of the main pressing concerns in water power.The worry for public security, as well as to save span foundation, has driven the interest of numerous specialists to find an answer of issues. Implanted upward in an erodible bed, is a complex phenomenon, and the complexity is aggravated with the development of the scour hole. As the pier obstructs a uniform stream, the coming stream speed diminishes from the free surface descending to zero at the bed. Scour specific form of the more general term “Erosion”.

The principal factors affected to the magnitude of scour at piers are as per the following, Bed sediment parameters such as the diameter of particles, cohesiveness of the soil, flow discharge depth, the velocity of flow, Froude number, Reynold number, Pier parameters such as size, shape. With respect bridge structure mainly two sorts of scour are known, general scour and local scour. And furthermore other sub division of scour Clear water scour and Live bed scour. The flow shape around a bridge pier is typically isolated into mainly two sections, (I) The wake vortex, (II)The horseshoe vortex. The downward flow likewise communicates with the arriving river flow and results in a vortex framework as displayed in Figure 1 for wake vortex as well as horseshoe vortex. The vortex flow then, at that point, moves at the edge of the pier downstream. The horseshoe vortex is regularly shaped after a scour opening is created.

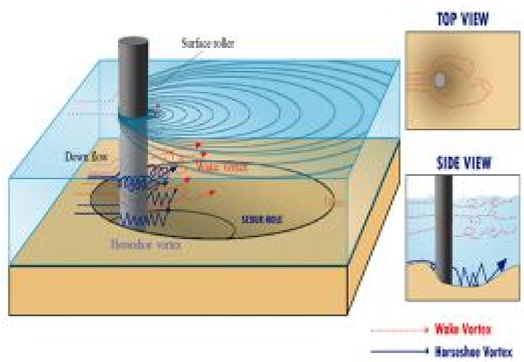


Figure 1. Scour mechanisms (Source:www.guardianretentionsystems.com)

A pier is a raised construction that transcends a waterway and as a rule sticks away from its shore, typically supported by piles or pillars. Superstructure of the extension is laying on piers. In this way, pier is assume a significant part in their security perspective.
Piers can be characterized by numerous way viz, shape, uniformity, size, number of piers, arrangement of piers etc. There are numerous method for arranging the piers however in universally useful, dock is characterized by two different ways. Uniform pier and non-uniform (compound pier) as per figure 2.

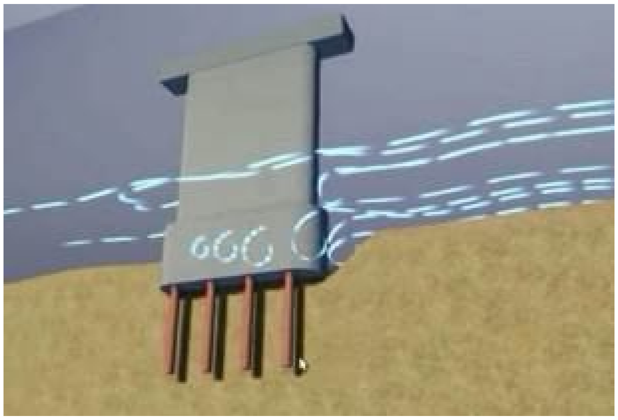

Figure 2. Piers arrangement and types (Source: Flow 3D)

Major bridge failure is due to bed scour in all over world. Then again, various kinds of pier shapes, round, square, and rectangular elongated etc. So decide to examination with parameters. Decide the real flow influence on pier and bed profile. Which shape is generally effective to limit scour influence for various flow condition. The key objectives of this study were to determine the scour depth minimization value by experimental works and validate the software modelling and experimental data.

## II. EXPERIMENTAL SETUP

### A. *Information of flume*

The experimental data is needed to provide for compare with numerical model and to further evaluate the performance of the collars with openings . Experimental tests were conducted in the Civil Engineering Hydraulics Laboratory at the Shantilal Shah engineering college bhavnagar, Gujarat, India. Experiments were performed in a recirculating flume of 6m in length,0.3m wide(0.27m operating width) and 0.75m in depth (see in figure 3).
The corresponding prototype scale sediment size (D50) was 1.30mm, which resembles a gravel bed river. One can notice that the sediment did not scale with the same 1:30 scale as the other laboratory components—this is because the sediment used in the laboratory is small.

Figure 3. Experimental flume (Hydraulics laboratory of SSGEC, Bhavnagar. Gujarat- India)

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Those all parameters like, Determination of slope of flume , Uniform flow establishment, Depth measurement, Measuring velocity of flow, Flow rate must be set during experiments.

### *B. Sieve Analysis And Particle Size Distribution Curve*

For all series of experiments uniform sediment can be used. Sieve analysis carried out and draw particle size distribution curve as shown in figure 4.7.To carry out the experiments uniform sediment having mean particle size of sediment d50 is equal to 1.3 mm can be used.

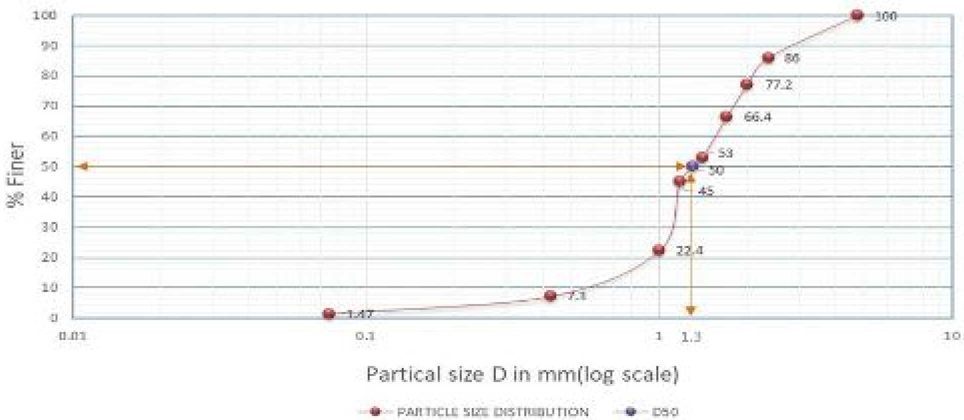


Figure 4. Particle size distribution curve

Follows regular procedure to run the flume and collect data like discharge, velocity, score depth, area of flow. After collecting all data go for the comparison part.

### *C. Experiments Runs*

A total of 6 tests were conducted for different discharges, normal pier and collar with opening design pier. The detail description of the numbers of experiments are as follows:

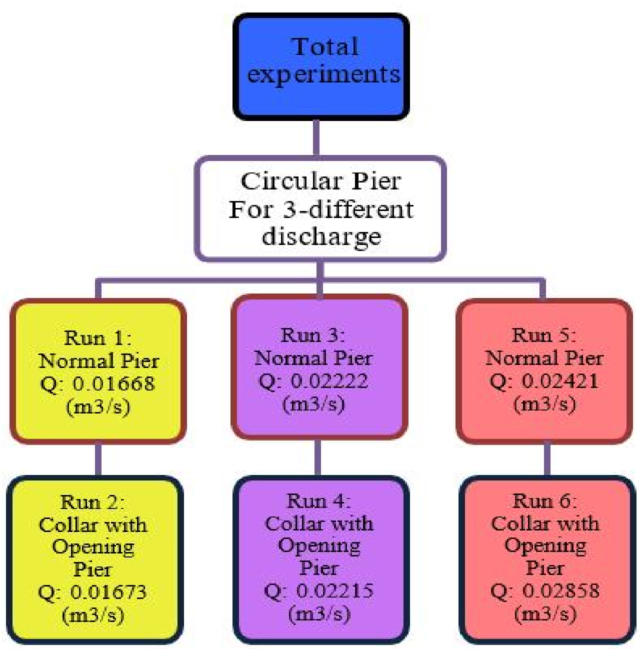


Figure 5. Flow chart of total number of experiment runs

*D. Opening On Pier Body*

Three piers shapes were tested. These shapes are first, rectangular with blunt nose and with dimensions 0.1 m x 0.05 m, a square with side length of 0.05 m , and circular with diameters 0.05 m .An opening arrangement was designed through the piers horizontal plane directions and repeated in the vertical direction.

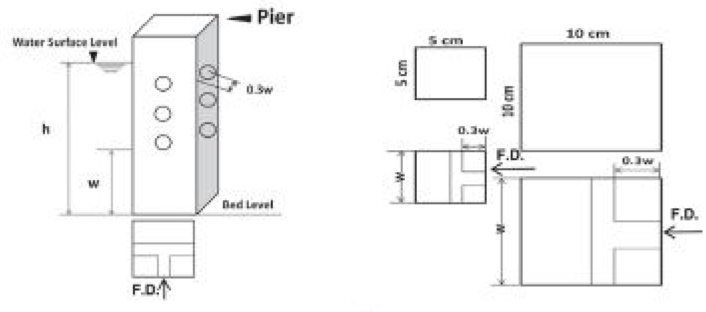


Figure 6. Square pier with opening arrangement (source: National Water Research Centre, Egypt)

The pier was first installed in the flume at the desired location. The different pier shapes as in Fig.6 were tested in sequence. At the completion of each test, the pump was shut down to allow the flume to slowly drain without disturbing the scour topography. which is a scour reduction of 20 to 45% when compared to a normal pier.

*E. Hybrid Collar Design*

In the physical models were to be built and tested experimentally for each plan change, this process would have taken a lot of time, utilized an enormous amount of research facility assets, and been expensive.

Once a satisfactory design was achieved using the CFD tool, a physical replica was developed and tested experimentally for same dimensions as mention in opening design. By joining both CFD and experimental methods, the expectation was to facilitate the design process and reduce costs.

Figure 7. Hybrid collar plat design

From the runs of Hybrid collar plat design some similarities in the scour pattern to that of the FPC were present. Specifically, two separate scour holes formed on either side of the collar, downstream from the pier. which is a scour reduction of 49 to 51% when compared to a normal pier with no scour countermeasure.

*F. Experiment Result*

A total of 6 numbers of experiment is conducted. The varying parameters in these experiments are flow depth, velocity of flow, discharge and pier design. All experiment is done in clear-water scour condition. Results are tabulated as following. Here Circular pier diameter is 0.05m.

Table 1. Scour data and flow parameters of various experimental runs

| Run | Width of channel (cm) | Depth of flow (cm) | Flow velocity (m/s) | Discharge ($m^3/s$) | Maximum scour depth at U/S side (cm) | Maximum scour depth at D/S side (cm) | Run time (min) |
|---|---|---|---|---|---|---|---|
| 1st - Circular pier | 27.00 | 14.20 | 0.435 | 0.01668 | 2.60 | 0.70 | 240 |
| 2nd - Circular pier with opening+collar | 27.00 | 14.25 | 0.435 | 0.01673 | 0.15 | 0.40(away from pier-7.00cm) | 240 |
| 3rd - Circular pier | 27.00 | 15.95 | 0.516 | 0.02222 | 3.95 | 2.10 | 180 |
| 4th - Circular pier with opening+collar | 27.00 | 14.05 | 0.584 | 0.02215 | 0.25 | 3.45(away from pier-13.90cm) | 180 |
| 5th - Circular pier | 27.00 | 14.60 | 0.614 | 0.02421 | 6.45 | 4.45 | 180 |
| 6th - Circular pier with opening+collar | 27.00 | 14.60 | 0.725 | 0.02858 | 1.50 | 3.80(away from pier-20.40cm) | 180 |

### G. *Comparative Analysis*

All Experiments are carried out in a recirculating tilting flume which is located at Shantilal shah engineering college having 6m length, 0.3m width and 1.0m depth under uniform flow and uniform median size of particles (1.3mm). The observed scour depth of normal pier and collar with opening piers was recorded for various experimental runs. Plotted graph between scour depth versus time for normal pier and hybrid collar design with opening.

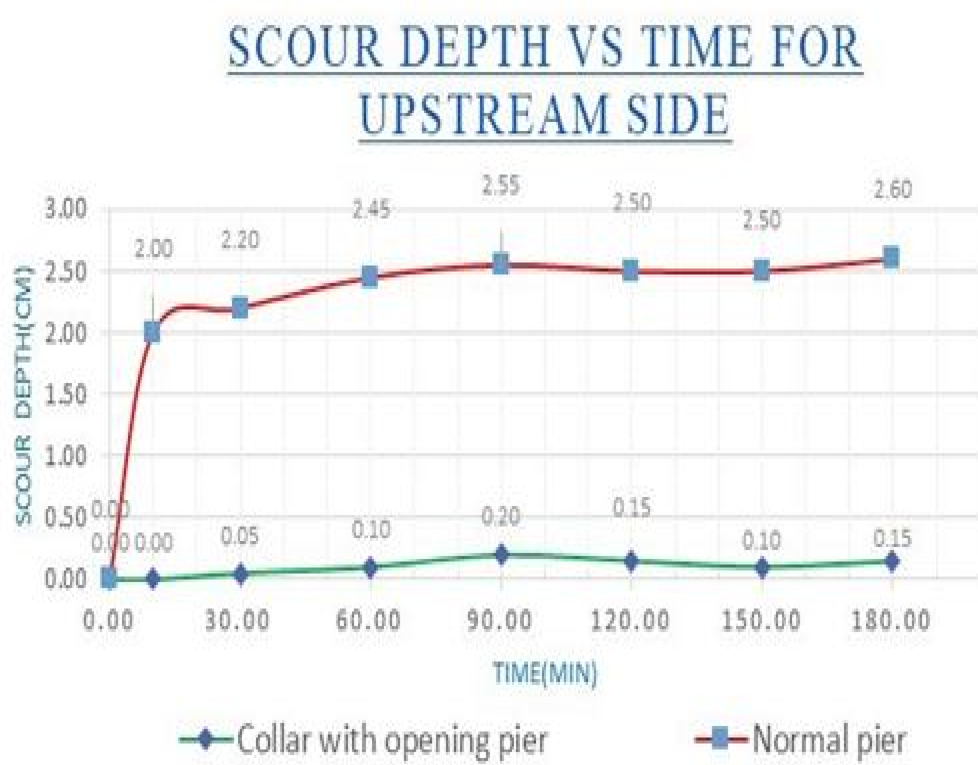


Figure 8. U/S Normal circular pier (Q=0.01668m3/s)V/S Collar with opening type pier (Q=0.01673m3/s)


Figure 9. D/S Normal circular pier (Q=0.01668m3/s)V/S Collar with opening type pier (Q=0.01673m3/s)


Figure 10. Normal circular pier V/S Collar with opening type pier scour effect [Run:1&2]

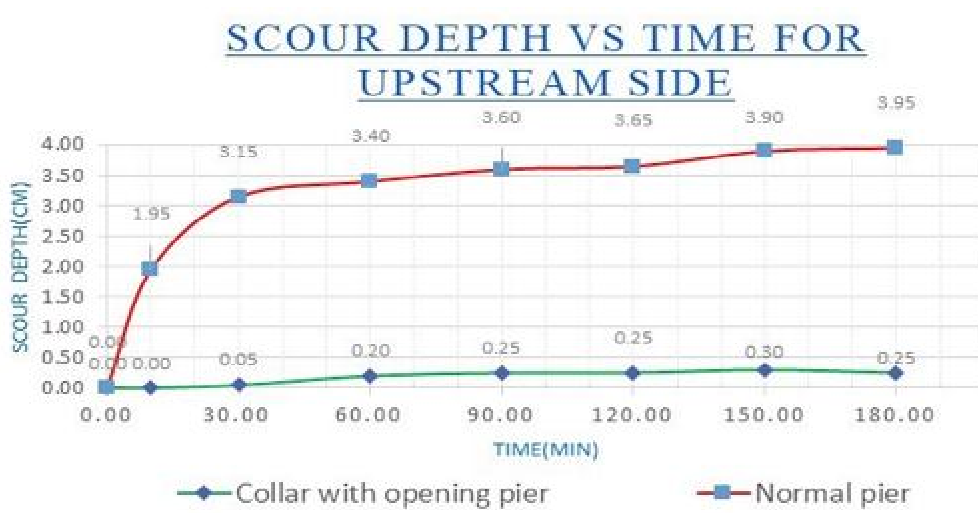


Figure 11.U/S Normal circular pier (Q=0.02222m3/s)V/S Collar with opening type pier(Q=0.02215m3/s)

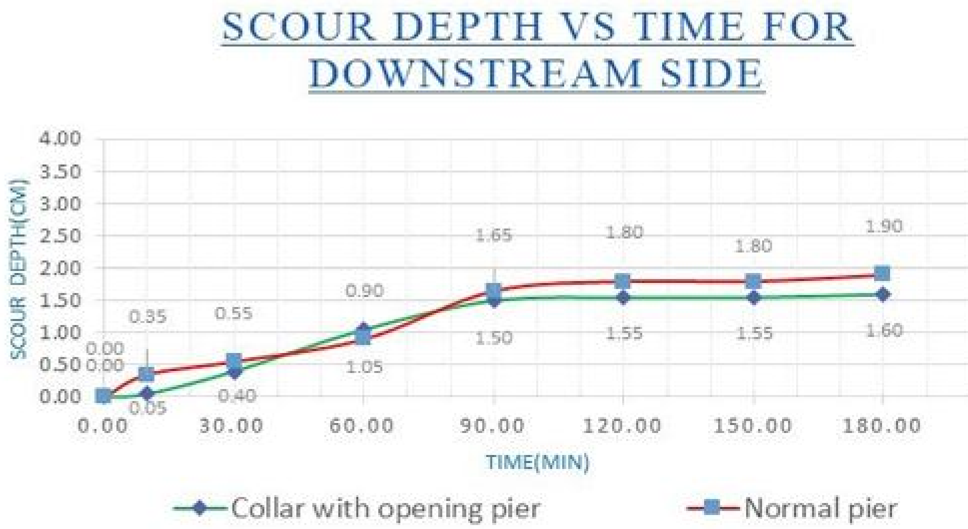


Figure 11.D/S Normal circular pier (Q=0.02222m3/s)V/S Collar with opening type pier(Q=0.02215m3/s)


Figure 12. Normal circular pier V/S Collar with opening type pier scour effect [Run:3&4]

## III. CONCLUSIONS

1) The collar works by containing and guiding the horseshoe vortex with the goal that it doesn't contact the bed close to the pier.
2) Collar plate design was found to be effective at reducing the maximum scour depth such that a 49% to 51% decrease was achieved over a pier. for the only openings arrangement technique reduces the maximum scour depth from 20% to 45 % at upstream side. However new hybrid collar design with opening can minimize scour around 71% to 75% at upstream and 48 to 50% at downstream scour can be minimized from experimental analysis and software calculation.
3) The maximum reduction occurred when using the circular pier and the minimum one occurred with rectangular pier.

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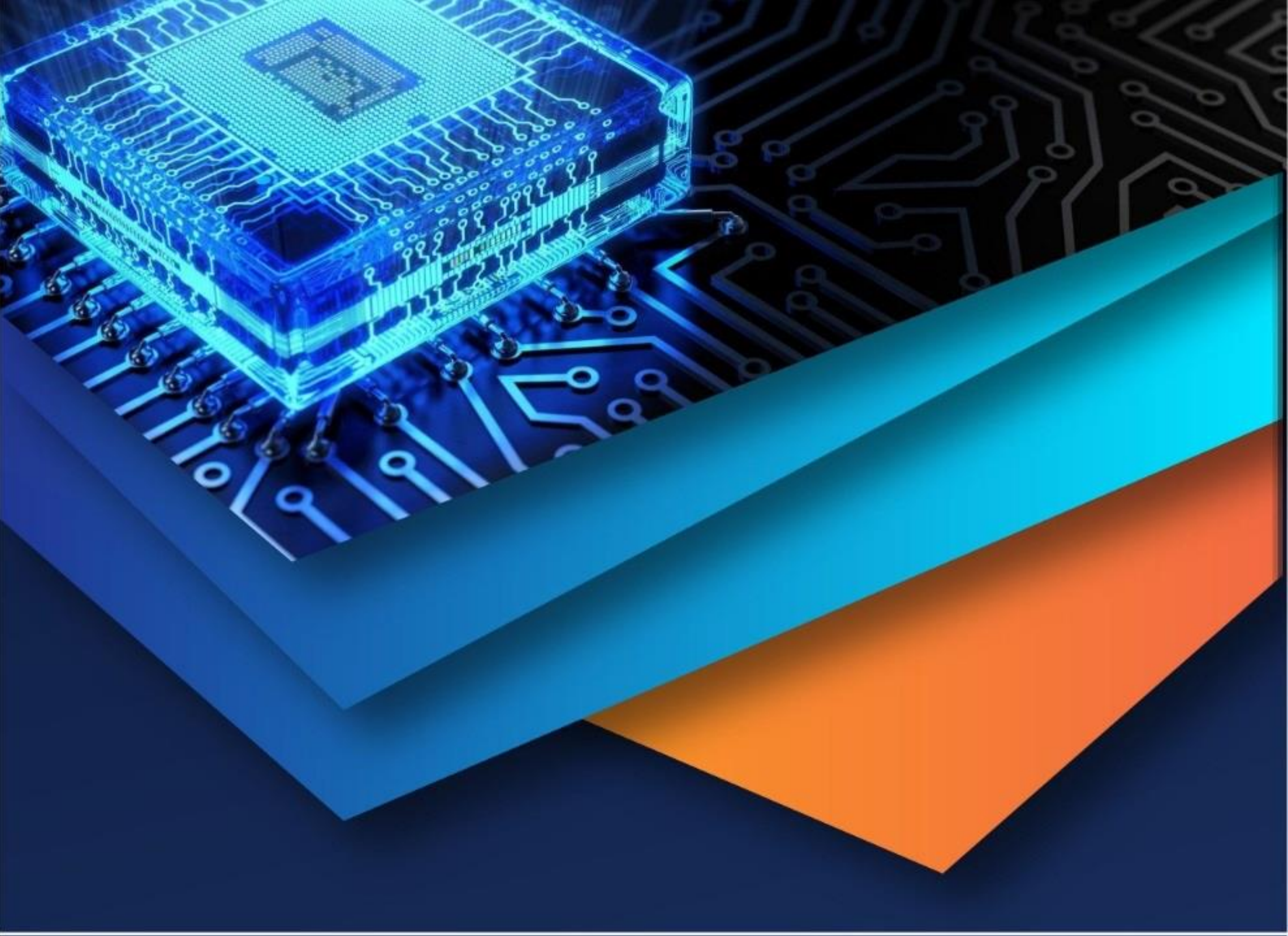


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