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"Analysis of different shaped footing under soft soil condition"

Manawer Ali[1], Pratiksha Malviya[2]
P.G.Scholar[1], Asst. Prof.[2], Department of civil engineering, M.I.T.S. Bhopal

Abstract: Soil Structure interaction is very important part of a building-load distribution. As the total load of a building is directly transmitted to the soil beneath footing. Shape of footing plays a vital role in distributing load to the soil, thus shape of footing should be ideal to distribute maximum load to the soil. In this study we are comparing six different shapes of footing to justify the most suitable and responsive shape of footing to distribute structure load evenly to the soil beneath. For this study finite element analysis is done using the Staad Pro analysis tool. In this research work we are comparing different shaped footing for same loading condition and same soil bearing capacity to determine the best suitable and stable type of footing which can transfer load and also we are preparing cost analysis of all to determine the economical section using analysis tool staad.pro.
Keywords: Staad.pro, Footing, Soil Interaction, Structure analysis, seismic load, S.O.R

I. INTRODUCTION

1) The lowest part of a structure which transfers its load to the soil beneath is known as foundation. The stability of a structure mostly depends on the performance of foundation. Its design should be done properly, considering its importance.
2) Depending on the depth of embedment, foundations can be classified as shallow or deep. The ultimate load which can be sustained by the soil is identified as bearing capacity.
3) Bearing capacity and settlement are two parameter requirement for the design of shallow foundation. It is essential for engineers to estimate the foundation's bearing capacity subjected to vertical loads.
4) Settlement of foundation under load due to the movement of soil particle horizontally and vertically below the footing. Settlement of the footing caused by eccentric loading which results to non-uniform stress distribution and unequal settlement below the footing.

A. Finite Element Analysis

The Finite Element Analysis (FEA) is the simulation of any given physical phenomenon using the numerical technique called Finite Element Method (FEM). Engineers use it to reduce the number of physical prototypes and experiments and optimize components in their design phase to develop better products, faster.

It is necessary to use mathematics to comprehensively understand and quantify any physical phenomena such as structural or fluid behavior, thermal transport, wave propagation, the growth of biological cells, etc. Most of these processes are described using Partial Differential Equations (PDEs). However, for a computer to solve these PDEs, numerical techniques have been developed over the last few decades and one of the prominent ones, today, is the Finite Element Analysis.

B. Footing

Foundations provide support for structures, transferring their load to layers of soil or rock that have sufficient bearing capacity and suitable settlement characteristics. The term footing or footings is an ambiguous one that can be interpreted in a number of ways. In some cases 'footings' is used as a synonym for shallow foundations. Shallow foundations are typically used where the loads imposed by a structure are low relative to the bearing capacity of the surface soils. Here, the most commonly used term is strip footing (or footings), referring to a strip foundations, used to provide a continuous strip of support to a linear structure such as a wall. Approved Document A of building regulations defines minimum widths for strip footings based on the load of load-bearing walling they support.

Footings are structural elements, which transfer loads to the soil from columns, walls or lateral loads from earth retaining structures. In order to transfer these loads properly to the soil, footings must be design to

1) Prevent excessive settlement
2) Minimize differential settlement,
3) Provide adequate safety against overturning and sliding

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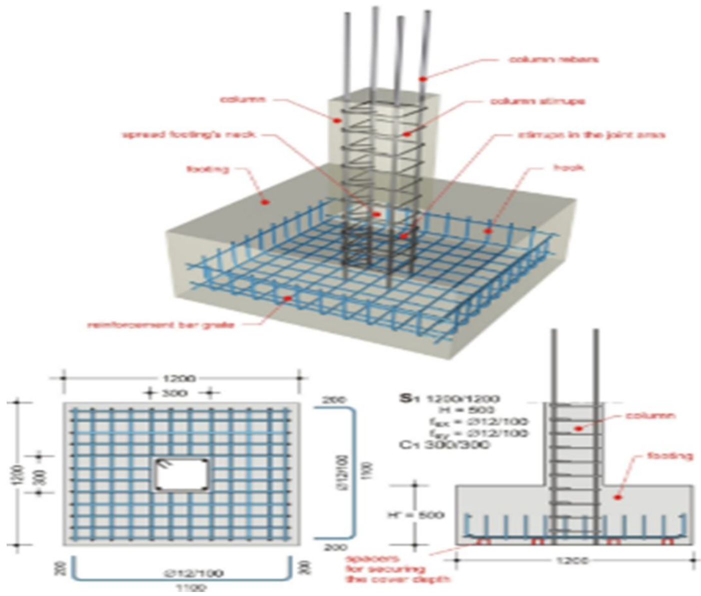

Fig 1: Footing plan

C. Seismic Analysis

Seismic analysis is a subset of structural analysis and is the calculation of the response of a building (or non-building) structure to earthquakes. It is part of the process of structural design, earthquake engineering or structural assessment and retrofit in regions where earthquakes are prevalent.

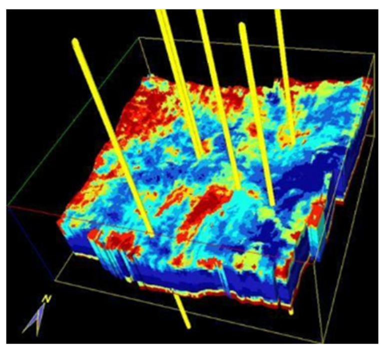

Fig 2: Seismic analysis

D. Soil Interaction Ratio

Foundation structures undergo soil-structure interaction. Therefore, the behaviour of foundation structures depends on the properties of structural materials and soil. Determination of properties of soil of different types itself is a specialized topic of geotechnical engineering. Understanding the interacting behaviour is also difficult.

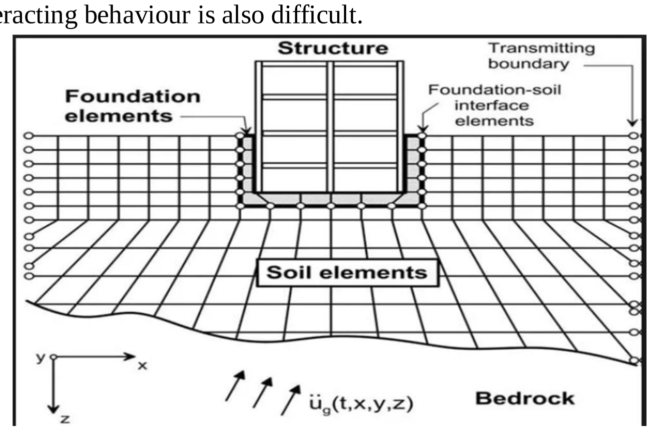

Fig 3: Soil interaction

II. LITERATURE REVIEW

Dewaikar et al. (2011) (Principle and numerical method of finite element method) observed on the model circular footing with reinforced soil to study the load settlement behaviour. The study showed that provision of a single layer reinforcement, ultimate bearing capacity increases and settlement decreases. Further, in case of BCR and SRF rubber grid performed better than the Geo-grid.

Elsaied et al. (2014) (soil-structure dynamic interaction." Englewood Cliffs: Prentice-Hall) three dimensional physical laboratory models were examined to investigate the influence of soil confinement on circular footing behavior resting on granular soil. Observed that on increasing the number of geogrid layers more than one layer had a small significant effect on the footing behavior. Moreover, placing geogrid layers underneath the cylinders improves the bearing capacity up to 7.5 times that of the non-confined case. The load-settlement behavior depends on the diameter and height of the confinement cylinder relative to the footing diameter.

Gupta et al. (2014) (Comparative Analysis of RCC and Steel-Concrete-Composite (B+G+ 11 Storey) Building) investigation has been done on the influence of three dimensional confinement of dense sand on the behavior of a model circular footing resting over dense sand. The load bearing capacity was studied for a circular footing supported on a three-dimensional confined sand bed. The results indicate that, by confining soil the bearing capacity of circular footing can be increased appreciably. As compared to the unconfined case the bearing capacity was found to increase by a factor of 36.18

Joao T. et. al. (2015) (Comparative Study on Dynamic Analysis of Composite, RCC & Steel Structure) Illustrated that Isolated footings are reinforced concrete elements whose flexural and punching shear strengths are usually governing for their design. In this work, both failure modes and their interaction are investigated by means of the kinematical theorem of limit analysis. Previous works in this domain have traditionally considered failure mechanisms based on a vertical penetration of a punching cone. In this work, two enhanced failure mechanisms are investigated considering not only a vertical penetration of the punching cone, but also a rotation of the outer part of the footing, allowing to consider the role of both bottom and top reinforcements on the failure load. A rigid-plastic behavior with a Mohr–Coulomb yield criterion is considered for the concrete and a uniaxial rigid-plastic behavior is assumed for the reinforcement bars. The analysis shows that a smooth transition between flexural and punching shear failure occurs, corresponding to a flexural-shear regime. With respect to the punching shear failure regime, it is shown that the top reinforcement might play an important role (a fact usually neglected by previous investigations). Simplified formulations, allowing easy calculation of the load carrying capacity of footings, are derived and compared to the solutions according to limit analysis. Both theoretical and approximated solutions are finally compared with experimental results, showing consistent agreement

Jaroslaw et. al. (2016) (Comparative Study of RCC and Composite Multi-storeyed Building) studied the analysis of the behavior of the foundations of historic buildings. Some basic aspects of foundation engineering are discussed, with an emphasis placed on its development, applied techniques, and materials. Several different approaches and methods for the analysis of foundations of historical buildings are presented. A particular analysis has been focused on an example of a typical stone foundation from the sixteenth century. First, the calculations have been performed using the finite element method, then the bearing capacity and the settlement analysis has been determined according to EC-7. Next, the bearing capacity has been evaluated using simplified analysis. A settlement of the foundation has been also estimated using Kerisel's proposal. The information should allow for a better understanding of the behaviour of foundations discussed in this research, and especially of methods of their analysis. A comparison analysis has been performed and possible directions for further research in this field have been indicated.

A. *Problem Identification*

No detailed study on suitability of footing shape has been done in past researches were conducted on different soil types and loading including soil interaction however information on techno-economic feasibility of different shaped footing is to be used in future aspects.

B. Objectives

Objective of this research is to study the effect of different types of footing geometries for same building with same loading conditions in unsymmetrical shape (irregular) building considering dynamic analysis using response spectrum method as per 1893-I 2016, modelling of RCC frame building and different footing is analysed using STAAD. Pro and STAAD foundation software.

1) To study the soil interaction ratio using Staad Pro.
2) Analysis of different footing type and shape for same soil bearing capacity.
3) To determine the best suitable footing type and Shape for a considered soil property.

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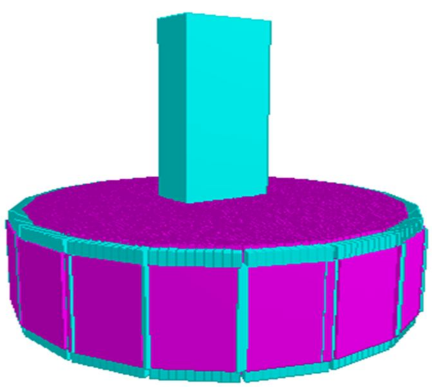
III. METHODOLOGY

1) Firstly sample soil collected as soil influences the motion of the structure and the motion of the structure influences the response of the soil
2) The finite element model shall be developed using the Staad pro.
3) Analyzing the same soil bearing capacity on various footing shapes.
4) Prepare a comparative study using M. S. Excel
5) Conclude the study research.

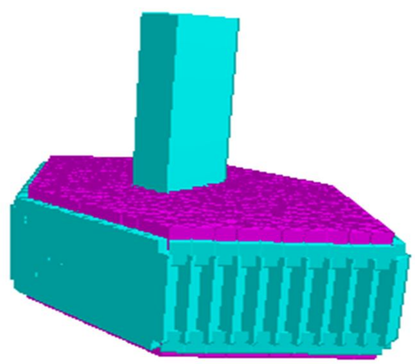
Table 1: building description

S.NO	Building Description	
1	Plane Area	15.8m X 13.8m
2	Storey Height	3.2 m
3	Number Of Storey	G+1
4	Beam Dimension	200 X 300 mm
5	Column Dimension	200 X 400 mm
6	Slab Thickness	0.15 m
7	Thickness Of Wall	0.1m
8	Bottom Support Condition	Fixed Support
9	Seismic Zone	3rd
10	Zone Factore	0.16
11	Soil Type	medium
12	Importance Factore	1
13	Response Reduction Factor	5

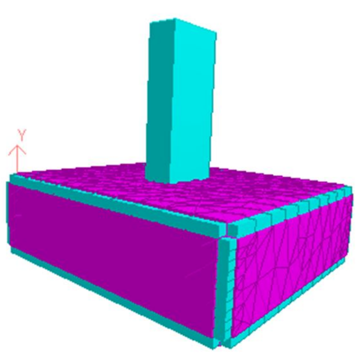
A. *Shape of Footing*



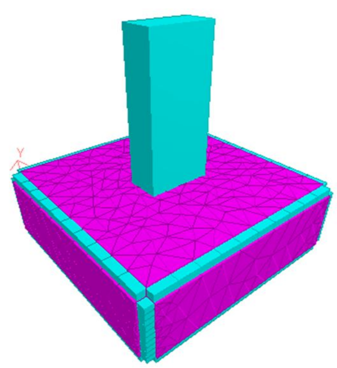
a. Circular footing



b. Hexagonal footing



c. Rectangular footing.



d. Square footing

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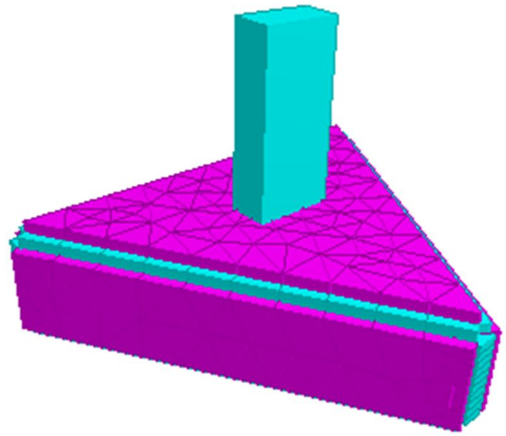

e. Triangular footing
Fig 5: Footing geometry

Table 2: Loading description

S.No.	Load Type	As per I.S.
1	Dead Load	I.S. 875-PART-1
2	Superimposed Load	I.S. 875-PART-2
3	Seismic (dynamic) response reduction	I.S. 1893-PART-1
4	Load Combinations	I.S. 875-PART-5

B. Result Analysis

1) Max. Bending Moment

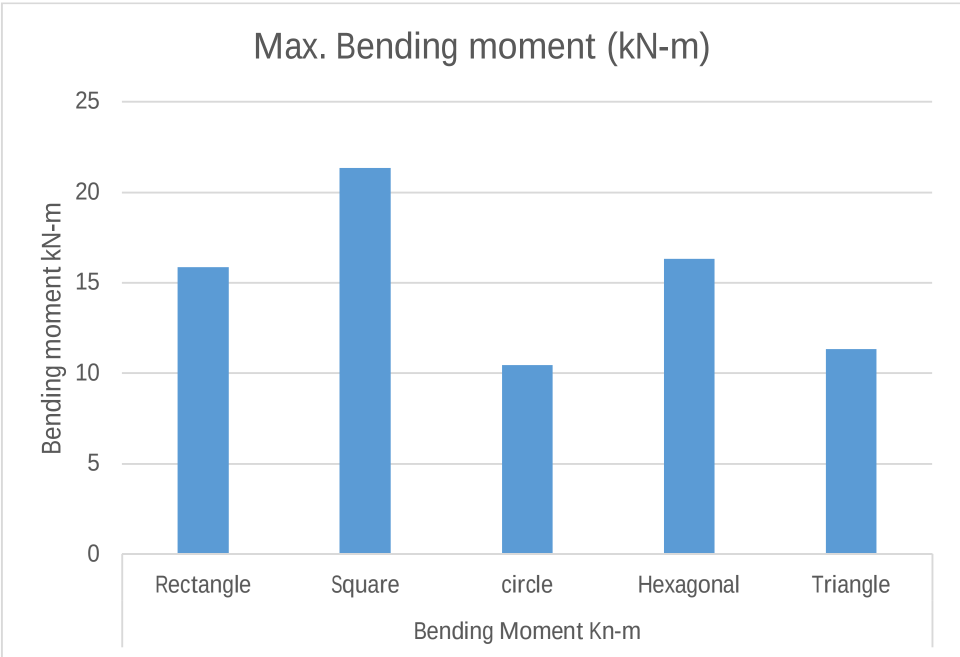

Fig 6: Bending moment

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2) Shear force

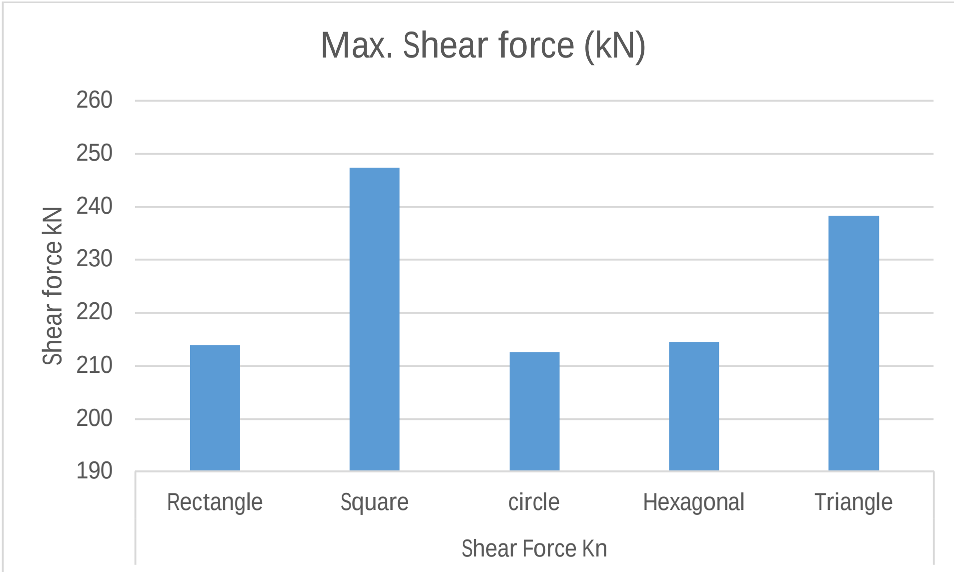

Fig 7: Shear force

3) Cost Analysis

Table 3: Cost analysis

S.No	Type of footing	Qty. of concrete	Qty. of reinforcement	Concrete rate/cu. M	Reinforcement rate/kg	Cost of concrete	Cost of reinforcement
1	Triangular	0.672	107.54	4500	48	3,024	5161.92
2	Rectangular	0.672	99.87	4500	48	3,024	4793.76
3	Hexagonal	0.672	109.76	4500	48	3,024	5268.48
4	Square	0.672	94.76	4500	48	3,024	4548.48
5	Circular	0.672	87.76	4500	48	3,024	4212.42

IV. CONCLUSION

The dynamic analysis of RCC building shows that dynamic analysis not only gives better understanding of the structural behavior but also following conclusion remarks can be made:

1) Circular footing shows 52% less unbalanced forces comparing to Hexagonal shape footing case.
2) In comparison of five different type of footings it is observed that Circular type of footing in economical and best suitable where as Square & rectangular are second and third best whereas hexagonal is least suitable type of footing.
3) Bending moment is observed minimum in Circular shape which results in minimum reinforcement requirement.

A. Summary

In this study is can be concluded that circular footing is comparatively more suitable and best in comparison with other cases whereas Square footing is second best and hexagonal footing is showing worst result.

B. Future Scope

In future study further following conditions can be implement are as follows:

1) In this study dynamic seismic analysis is considered, in future wind and temperature effect can beconsider.
2) In future matt footing and pile can be consider for study.
3) In future different soil conditions can be taken into account

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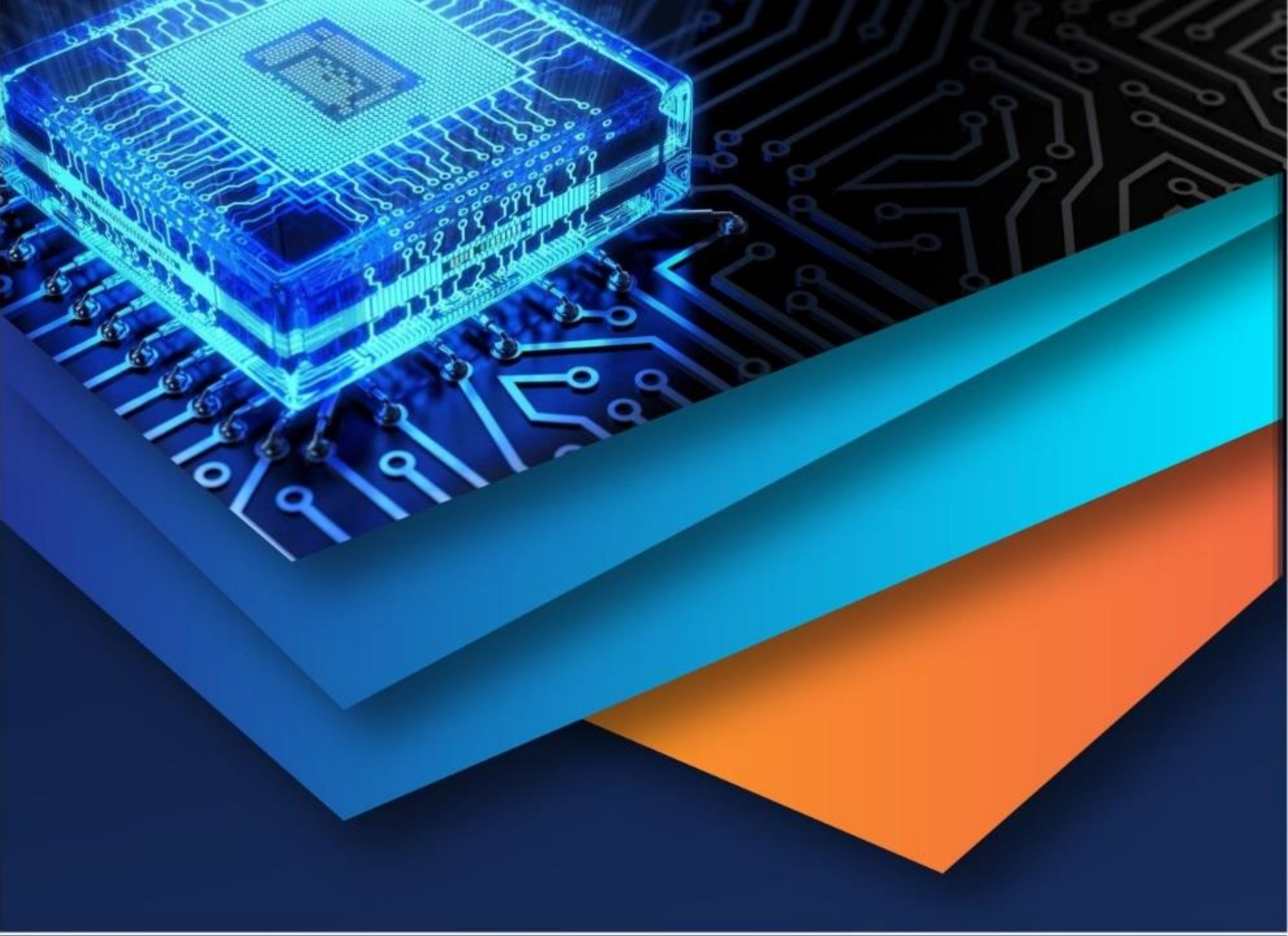

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