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Seismic Response of Large span slab in Horizontal Setback Building: A Review

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Abstract: ***The demand of multistory Building is increases day by day. The residential plus commercial building predominantly used for the need of large span. The large span is needed for Flat slab, Waffle slabs & ribbed slab stands as an excellent option for architects when larger spans in a building has to be covered with the least possible number of columns. The use of different types slabs are evolving as a new trend and are becoming a big challenge for structural engineers. Therefore it is necessary to study about its structural behavior. The paper is review the behavior of different types slab for large span type of building. Final aim to gets the suitable type of slab for large span for effective manner. It is found that very less work is taken setback building with large span, it is required to analysis on the setback building with large span.***
Keywords: Flat slab, Waffle slabs, ribbed slab, multistory Building, large span.

I. INTRODUCTION

Slabs are the structural elements that carry the additional dead and live loads in different structures. They are used in buildings, paths and bridges. Usually, they can be classified to one way and two ways systems. One way slabs with beams in one direction are commonly used for small spans up to six meters. Two-way slabs with beams and without beams are used for larger spans. Two- way slab systems are mainly used to resist high loads or they are used when there are large spans to minimize the slab thickness and to decrease the internal forces in the slab and to limit the slab deflection. It is common to have two-way slabs in parking floors as the spans are long and they may reach about nine meters or more. Drop beams of depth that is larger than slab depth is very common especially in parking floors and industrial structures as the existence of these beams does not affect the shape or the use of the structure. Drop beams can be used in buildings that have false ceilings and decorations. In residential buildings, it is not common to have false ceilings, so the existence of drop beams in these buildings is not recommended architecturally, so hidden beams must be used. Two way ribbed slabs are slabs with concrete blocks while waffle slabs are slabs with removable forms. Two-way ribbed slabs are commonly used in residential and office buildings. Waffle slabs can be used in halls, industrial buildings and parking floors. There are major three slab are used other than normal slab. These slabs are as follows:

1) *Waffle Slab:* A waffle slab is made of reinforced concrete with concrete joists spanning in mutually perpendicular directions on its bottom. Due to the grid arrangement generated by the R.C. ribs is termed as waffle. It is also known as two-way joist slab. It is mainly used when span is greater than 12 m. It is stronger than other type slab. The slab has two parts. The part one is in top side which is flat surface and second part at bottom consist of joists create a grid like structure. The grid is appeared when moulds are removed in it. It is also used when heavy loads are acting n the structure. Under the effect of rigidity this type of Slab is used when buildings require minimal vibration, such as used for laboratory, manufacturing facilities.

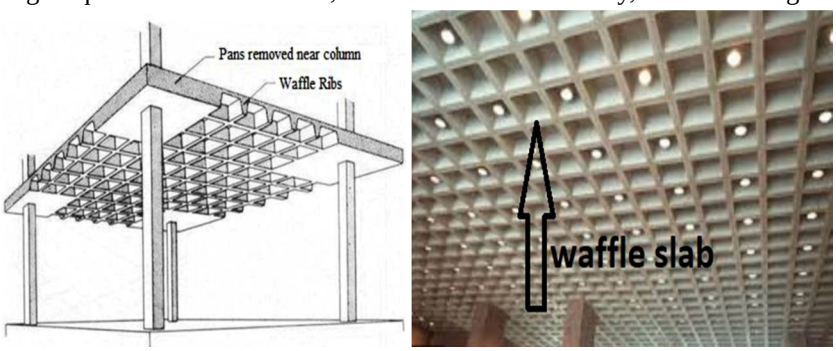

Fig. 1: Typical examples of waffle slab

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2) *Ribbed Slab:* These types of slabs are slabs cast completely with a series of closely spaced joist which in turn are supported by a set of beams. The main benefit of ribbed floors is the lowering in weight achieved by removing part of concrete below the neutral axis. This creates this type of floor economical for buildings with a long span with light or moderate loads. Ribbed slabs are slabs cast integrally with a series of closely spaced joist which in turn are supported by a set of beams. The main advantage of ribbed floors is the reduction in weight achieved by removing part of concrete below the neutral axis. This makes this type of floor economical for buildings with a long span with light or moderate loads.

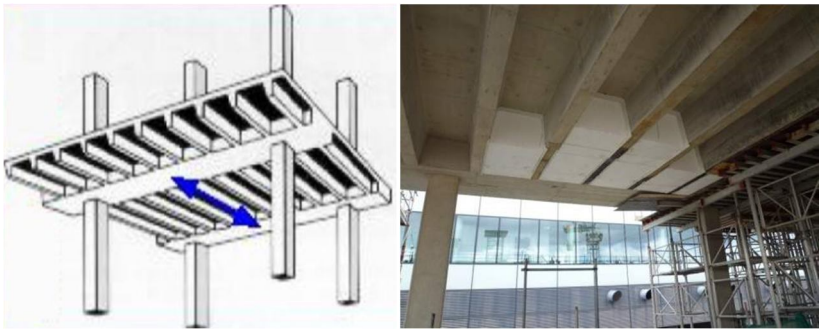

Fig. 2: Typical examples of ribbed slab

3) *Flat Slab:* A reinforced concrete slab supported directly by concrete columns without the use of beams. This types consist different system of elements such drops, column head, perimeter beam etc along with flat slab. These types of structures use column heads and column strips as a replacement of beams to provide large spans of columns. Whole slab rests on these column heads and column strips and acts as a diaphragm. These structures are vulnerable to dynamic earthquake forces so analysis regarding dynamic earthquake behavior of the structure must be done before designing these structures in earthquake prone areas

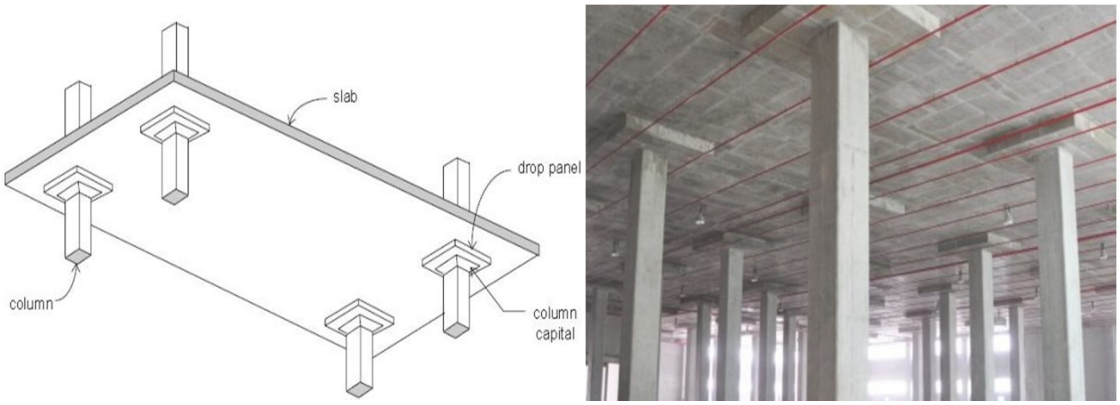

Fig. 3: Typical examples of flat slab

II. LITERATURE REVIEW

The following research papers are studied under the study of analysis of a Structure containing the different slabs such as Flat Slab, Waffle Slab, and Ribbed slab. The summarized reports of different researchers are as follows:

A. Imran S. M., Kumar R. R. & et. al. (2020)

In this study, the optimal design of a reinforced concrete (RCC) ribbon plate called waffle plate in accordance with the Indian RCC Code (IS 456: 2000) is proposed. The objective function is the aggregate value of the reinforcement, concrete and uniform products that sum up the cost of the tape plate. The structure is directly analyzed by design method. The objective function is developed after a detailed study of the ribbon plate. The optimization process is carried out for different concrete levels. Comparative results for different levels of concrete are counted and tabulated. Optimization for reinforced concrete (RCC) ribbon slab is performed and the optimal design and conventional design results are compared. The problem of optimization is NLPP. The mathematical model is analyzed using mathematical software. The study found that optimizing the reinforced concrete slab can save up to 25%.

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B. Joshi R., Patidar G., & et. al. (2020)

In this research are analyzing the feasibility of G+3 building with a single column, alternatively applying the flat and waffle slab in place of the conventional one at a time to check the difference in the characteristics of a building like bending moment, end moments, deflection, shear force, etc. The interpretative study between both the slabs along with the G+3 single column building with varying floor span, slab span, slab thickness, column thickness, adding dome like structure on bottom has been carried out under the influence of loading via a software specially used for the analysis of the multi-storied building named as ETABS. The course of Single Column Multi-Storied Building is nothing different from the journey of any structural design when it comes to the point it was first developed and till now when it is near the edge of being completely adopted in the daily chores. Single Column Multi-Storied Building demonstrates how contrasting structural members could also be assimilated into the traditional multi-storied building design to get the design of showing different properties having great impact in terms of environmental, structural, construction management aspect. Flat Slab and Waffle Slab in one form (with or without outer column) have had noticeable effect in the properties of the multi-storied building design, enabling its utilization for different purposes of the building.

C. Gagankrishna R.R & Nethravathi S.M (2015)

The analysis method adopted for the current study is a nonlinear static or pushover analysis. The Pushover investigation is usually subject to a shift control and is carried out in accordance with the instructions of the ATC-40 and FEMA documents. Analytical parameters are considered that affect the operation of the devices and the flat plate of the RC frames and the comparative research. Pushover analysis has been found to be a simpler way to study the nonlinear behavior of structures. As a result, it was found that the shear was very high compared to a flat plate without a shear wall, with all the structural systems with a beam edge and shear wall. Due to the increase in the lateral strength of the structures. Also, for a flat plate and a flat plate, accept the shear wall and edge beam, and see the slope decrease as the side strength increases.

D. Shaga A., Polisetty S. (2016)

The present work envisages the IS:1893 (Part1)-2002 rules for comparative study and loading of earthquakes in a 6-storey building located in the RCC flat plate structure and conventional slab structures in the earthquake zone. Three-dimensional modelling and structure analysis is carried out with the help of E-tabs software. Linear static analysis method and response spectrum analysis method are used to analyze flat plate structure and conventional plate structure. Each structure analyzes the developed forces and all relative displacements, layer shear, and moments of overthrow. The results of the analysis are discussed. In addition, these results were used to understand the performance of a flat plate structure and a conventional plate structure under the influence of side loads and earthquakes. The results were compared and it was found that the flat tile structure performed better in the event of an earthquake than the conventional tile structure.

E. Bansal A., Patidar A. (2016)

The purpose of the present study is to compare behavioural analysis, the porous structure of flat-panel multi-storey buildings with porous structures, and then to identify the main shear, shear displacement, and impact. three phenomena of multi-storey buildings with seismic forces are considered for the purpose of relocating a particular part or for maximum relocation. For this rehabilitation on request. area 20 m x 20 m, 4 floors, 8 floors and 3.6 m height 12 floors. All three cases are considered flat and porous, and are analyzed by SAP2000 software. The observation shows that the Pushower analysis is a simple way to study the nonlinear motion of a building. The analysis is an approximate method based on static loading. “The seismic performance of various RC boards cannot accurately reflect dynamic phenomena. The production points for a flat plate are larger than the grid plate models. Tall construction systems ”, areas for flat tile, obtained as a model, as well as the main shear of two types of tiles are larger than the porous tile plates and perform a variety of analytical similarities. The concluding conclusion is that multi-storey buildings provide a good source of information about the parameters of the pusher analysis.

F. Utane S. N., Dahake H. B. (2016)

The current purpose of this work is to compare various parameters such as flat shear and main shear movement in the wafer plate system, story shifting, and story shifting. The expansion joint between the existing building and the industrial structure in the earthquake-stricken area is also being investigated. The analysis of large industrial facilities constructed using square and rectangular flat tiles and wafer tiles will be carried out with the help of Etab software using IS 456-2000, the change of industrial structure with flat tiles system is non-welded rectangular and rectangular. The replacement of a rectangular layout of an industrial structure with a flat plate and a wafer plate is higher than that of a rectangular layout.

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As the height of the structure increases, the slope also increases. The story structure of an industrial structure built using a flat slab system is more than a waffle slab system for a square and rectangular layout.

G. Sharma A. & Pushpa. C. J. (2015)

In this paper, an attempt was made to study the seismic effect in a multi-storey building G + 9, 14 & 19 with waffle slab and flat slab using ETABS 2013 software. Spectral analysis of IS 1893 (2002) is performed by response to seismic evolution. Waffle tiles are recommended for structures less than 40 meters high, and for tiles higher than 40 meters it is recommended to go with a flat plate. From the results obtained above, it is recommended to use a wafer plate other than a flat plate for a device less than 40 meters high, and a flat plate for structures higher than 40 meters.

H. S. Mohana , M. R. Kavan (2015)

The G + 5 commercial, a flat-plate and conventional slab in the design work, includes a multi-storey building, which has been analyzed for parameters such as main shear, floor sliding, axial force and sliding. The performance and behavior of the two facilities have been studied in all seismic zones of India. In the current study, the shear shear of the flat plate is 5% larger than the normal shear structure, the axial forces in the apartment laboratory building are about 6% greater than the normal shear, and the difference in the shear displacement of the flat and conventional building is about 4mm. floor The present work provides relevant information on the suitability of a flat plate for various seismic zones without compromising the operation of conventional slab structures. The shear shear of the flat plate is 6% higher than that of the conventional shear structure, the shear shear is the highest and the highest at the top. The design axial forces on the flat plate are about 5.5% the difference in forces compared to the conventional structure. The solid-state displacement is higher than that of the building, and the flat-plate structure has a larger-than-normal displacement, with an average of 4mm displacement in each seismic zone for the two structures.

I. Moldovana I., Mathe A. (2015)

This paper shows the aspects of calculating a square-shaped waffle plate, supports it in a timely manner, and has a parabolic double-strand fastening. The waffle slab system, characteristics, preliminary design of the constituent elements, technological aspects related to the production of spherical panels, details related to the materials used, the order of fastening and the calculation of prestige strength are described. The work demonstrates the design, calculation, and location of the fixation (TBP9 tendons) to be placed on the ribs of the wafer-shaped plate. The sequence of the tendons, the geometric features of their location, and the maximum force applied to the TBP9 tendons and the calculated force on the initial force at time t = to are shown. It should be noted that the change in the angle of the tendon profile creates a negative force on the member that “balances” the structurally dead loads.

J. Midhun M. S. (2017)

This paper studies the effect of wafer plates on openings and the behavior of the plates when the distance between the beams I changes. The effect of discoveries of different sizes is studied. the opening is marked in the center of the plate. The distances between the rays are also varied and the effect of such a change on the wafer plate is studied. It has been concluded that the provision of open spaces has a significant effect on the strength of wafer plates and can reduce power by 38%. Adjusting the magnitude of the distance between the I rays has less effect than the effect of openness. It will reduce its capacity by only about 20%. Special considerations should be taken when providing holes in the waffle plate. Proper recycling methods should be used to avoid immediate failure due to the concentration of stress near the pit. From the comparison table, it can be explained that the hole wafer plate size of 1400mm will be reduced by only 38.62%. If higher loads are moving, the hole size can be limited to 1000mm. this high carrying capacity is achieved mainly due to the presence of I rays that add considerable strength to the wafer plate structure. Changing the distance of the beams I does not have a significant effect on the strength of the wafer plate compared to the effect of the holes. By increasing the distance, you can achieve a higher economy without much damage to the load-carrying capacity of the waffle plate.

K. Idrizi Z. & Idrizi I. (2017)

This paper conducts a comparative study between the “hard” and “waffle” plate systems. An example of this is the construction of a 14-storey RC building as an example. The first part of this study is aimed at finding the most suitable solution for the solid and wafer slab system, which is considered to be the compiler of all the stories of the 14-story building. In the second section, the impact of the two-story system on the 14-story construction model is described in detail.

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This study aims to emphasize the advantages of medium-rise buildings formed from the waffle slab system from those characterized by solid-type slabs in terms of economy, structural safety and productivity.

L. Uzodimma U.O. (2016)

On this paper, a 12m x 20m hall with no inner columns was decorated using ocevrocod2. The floor system of the hall was supported by the effects of primary and secondary rays. Complete steps were taken by hand for the load analysis, the transfer from the second beam to the main beam, the structural analysis and the complete design of the structure. After analysis and design, a 0.9m x 0.4m section and a 1,786% reinforcement ratio were found to meet the final and service limits of the main beams. As a result, if adequate analysis, design, and detailing of the members is carried out, the interaction of the primary and secondary beams can be used as an alternative to large-distance construction.

M. More R.S., V. S. Sawant & et. al. (2013)

More R.S., V. S. Sawant was performed by comparing his behavior with that of a conventional beam column. The grid slab system is selected for this purpose. A flat plate system is also analyzed to study the effect of the opening panels on the behavior of the flat plate during lateral loads. The zonal factor and soil conditions also include two other important parameters that influence the behavior of the structure. ETABS software is used for this purpose. In this study, the connection between the number of stories, the zone and the state of the soil is developed.

N. Hassaballa A. E., Ismaeil M. A. & et. al.(2014)

The project involved a four-storey residential-reinforced concrete building in Khartoum-Sudan, which is facing seismic hazards. Plastic hooks are used to indicate fault mode in rays and columns when member is assembled. The Pushover analysis was performed in a building using SAP2000 and similar static methods according to UBC97. Performance-based seismic engineering principles are integrated with the seismic risk analysis to calculate the expected seismic performance of the structure. The tip of the so-called “pushover curve” is an important result of the push-pull curve with the sliding curve. Pushover analysis is performed in polo positive and negative x and y directions. The default hook properties available in some programs based on FEMA-356 and ATC instructions are used for each member. An example was chosen for this purpose. The assessment proved that the four-story apartment building was not seismically safe.

O. Arman I. M. (2014)

In this study, the ACI is used directly as a design method by hand or as a hand-counting method, and the solution will be compared to the analysis results of a three-dimensional structural model performed by the Sap2000 computer program. The rays, the pillar column area, and the moments in the middle zone of the plate will be determined. On the double-sided tiles with hidden rays, it will be shown that the distribution of moments is preferable to the distribution of moments without rays because of the low intensity of the hidden rays. It is recommended that three-dimensional modelling by computer software be the best solution for determining and distributing the moment.

P. K. S. Priya, Durgabhavani T. & et. al. (2012)

The researcher analyzes the flat plates using the most commonly used SAP2000 software on this paper. Most of the existing flat-plate buildings may not have been designed for seismic forces. It is therefore important to study their responses in seismic conditions and to evaluate seismic retrofit schemes. But flat plates are more popular and important because they are economical compared to beam column connections. Under the pressure of recent events, seismic codes, along with the amount of energy absorbed, have begun to explicitly demand the identification of sources of flexibility in the structural response. Most of the existing buildings were not built for seismic forces. It is important to strengthen research, strengthen existing structures, and evaluate them. Pushover curves and demand curves can be obtained by conducting pushover analysis on flat plates. It is then decided whether to rehabilitate or recycle, depending on the seismic area of the existing facilities.

Q. Shuraim A. B. (2002)

The relevant investigation method for the two-sided plate systems supported by the behavior and the panel of the primary and secondary rays are not fully understood. The general purpose of the two-part study is to study the use of ACI code methods to evaluate the design of moments for such slab systems. This section analyzes five beam systems with different configurations through code and finite element procedures.

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One slab system has a second beam that does not have a second beam, the other four have beams ranging from 2.6 to 5 be the primary and secondary rays are not fully understood. The general purpose of the two-part study is to study the use of ACI code methods to evaluate the design of moments for such slab systems. This section analyzes five beam systems with different configurations through code and finite element procedures.

One slab system has a second beam that does not have a second beam, the other four have beams ranging from 2.6 to 5 beams, and the second beam reduces the floor weight by 30% when the beam has five beams.ams, and the second beam reduces the floor weight by 30% when the beam has five beams. Strengthened their systems equally. However, access to equal-strength slab systems is not straightforward and cannot be judged only from the features of the section. It has been found that the same strength of the slab system based on section characteristics alone led to a 38% error in the calculated deflation. In the beam plate system, the projection of the beam rib creates the problem of modelling. There are two options: a physical offset with a tight connection option, or an enlarged beam type to compensate for the rib closure. This section discusses the advantages and disadvantages of the two modelling approaches.

III. CONCLUSIONS

The following conclusion is made based on the study and surmised report on review of literatures. The conclusions are as follows:

1) It is found that very less work is taken under setback building with large span, it is required to analysis on the setback building with large span.
2) The different researchers used different slabs in the structure as per the needs, therefore multistory buildings flat slab is predominant and with high rise the waffle and ribbed can be adopted for large span structure.
3) The analysis is carried out with rigid frame structure and seismic response mainly with single slab or compare with conventional slab.
4) The building with flat slab is adopted in commercial buildings and to effective architect purpose the waffle and ribbed can be adopted in the buildings.
5) The scaffolding is easy in flat with somehow more required and tuff task in waffle and ribbed slab and more aesthetic view to the building.
6) Ribbed slab is more effective in moment resisting by optimizing the effective depth and the percentage of reinforcement. It is used for larger span of slab and floor with less number of columns.
7) The structure of the wafer plate shows its carrying capacity, it is larger than other types of plate in terms of weight and material savings. Vibration control capability. It also affects fast and rapid construction.
8) The secondary beam is adopted when large span is required with the main beam.

IV. FUTURE SCOPE

The following work should be taken in future for research purpose.

1) Analysis of Setback building with large span under irregularity concept.
2) Optimized structure analysis with various slabs for longer span.
3) Design the large span structure in place of pre exiting building.
4) Use of different seismic methods such RSA & THA and compare between them.
5) Assessment of dynamic wind analysis as per CFD & Wind Tunnel data.
6) Study based on Slabs with dampers.
7) Study with Slabs with composite structures.

V. ACKNOWLEDGMENT

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A. Abbreviation Used

1) NLPP: Problem of limited linear programming
2) ATC: Applied Technology Council
3) RCC: Reinforced Cement Concrete

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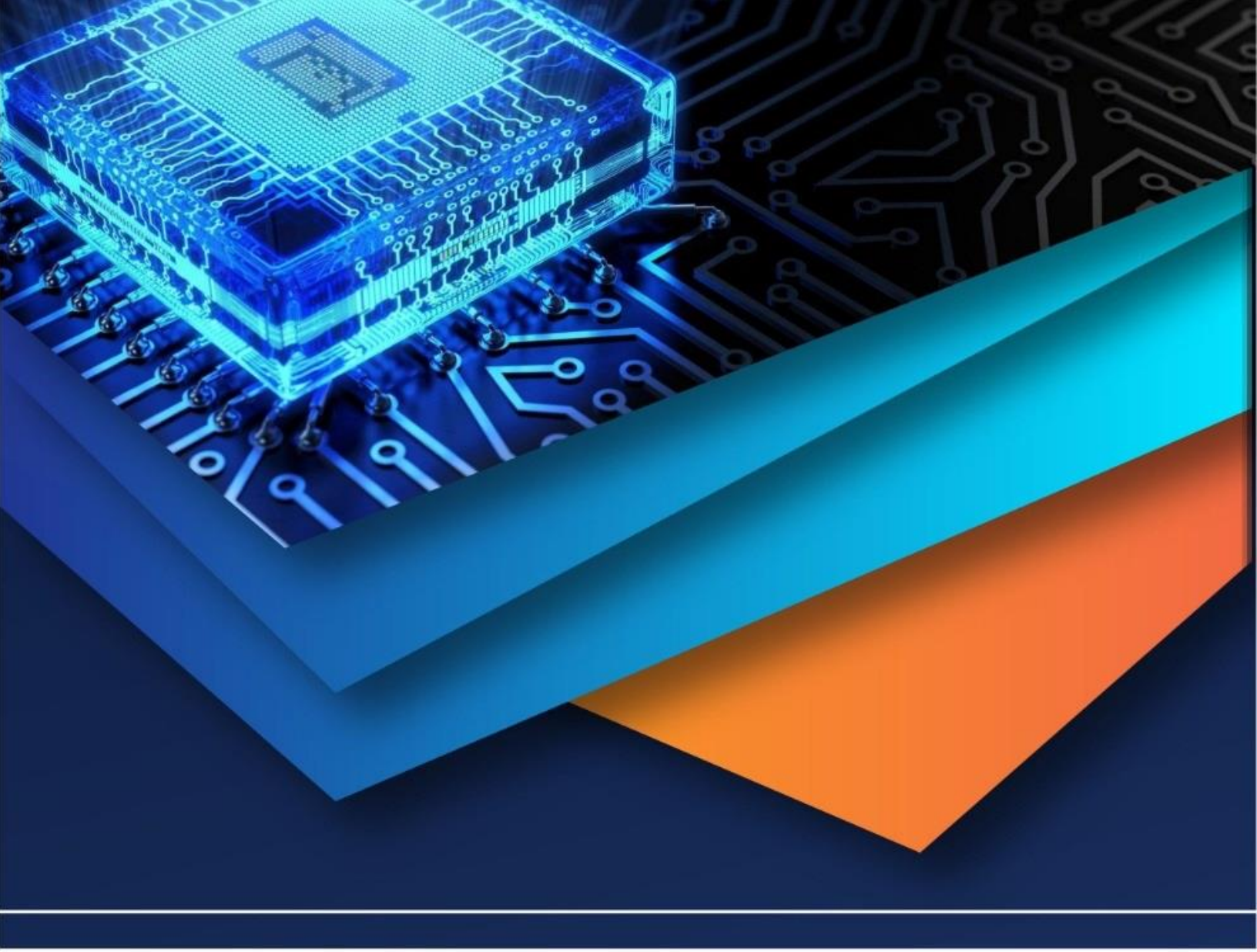

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