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Assessment of a High Rise RC Building with and without Opening of Shear Wall: A Review

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Abstract: ***Shear walls are introduced in modern tall buildings to make the structural system more efficient in resisting the horizontal loads that arises from wind and earthquake. The introduction of shear wall represents structurally efficient solution to stiffen a building structural system. The main function of shear wall is to increase the rigidity of lateral load resistance. It is a structural element which provides stability to structure from lateral loads like wind load and seismic loads. Shear walls are placed parallel to the plane of the wall, thus providing adequate strength and stiffness to control lateral displacements. The stiffness and strength of wall may decreased by the reduction in the concrete area and the discontinuity of the reinforcement due to opening. To know the responses of providing openings and the behaviour of shear wall without openings is the aim of the given study. Hence, it is necessary to demonstrate work on the analysis, design and post effects of shear walls when seismic forces are applied. In this study the study of worked and anysis is carried out based on the different research of different researchers. This includes the study of different earthquake methods analysis in the shear wall structure. The openings of shear wall and without opening of shear wall are carried out in it. The study is also based on the different software and orientation of opening given by different researchers. hence it is important to study on opening of shear wall is the high rise building so that the building is with stand under lateral forces as well comfort of the occupant.***
Keywords: Shear wall, Openings, CSI-ETABS, lateral forces

I. INTRODUCTION

Lateral forces caused by wind, earthquake, etc. causes structures to shake and vibrate and moreover to displace from their original position. These forces need to be well resisted so as to provide comfort to the occupants residing in it. Shear wall is a structural member which is employed to resist the lateral force. Shear walls are placed parallel to the plane of the wall, thus providing adequate strength and stiffness to control lateral displacements. The behaviour of structure during earthquake and wind excitations is governed by the shape of openings and planed position of the shear wall. Speaking theoretically, centre of each half of the building, is the best position for the shear walls. In day-to-day practice, walls are placed at the ends, since it utilizes the lot of space in structure frame work. With respect to these, walls around lift shafts and stairwells are used. there are different types of shear wall are used in the multi story building such as Reinforced concrete, Concrete block, Mid-ply, Plywood & Steel shear wall etc. in it. The reinforced concrete shear wall is important structural elements placed in multi-storey buildings which are situated in seismic zones because they have a high resistance to lateral earthquake loads. Shear walls building structure will be perforated with rows of openings that are required for windows in external walls or doors or corridors in internal walls. Simplified methods for stiffness of shear walls with openings are recommended in several designs. It is necessary to know the effects of openings sizes and configurations in shear wall on stiffness as well as on seismic responses and behaviour of structural system so that a suitable configuration of openings in shear walls can be made. Reinforced concrete multi-storey buildings are adequate for resisting both the vertical and horizontal load.

In the seismic design of buildings, reinforced concrete structural walls or shear walls, act as major earthquake resisting members. Structural walls provide an efficient bracing system and offer great potential for lateral load resistance. The properties of these seismic shear walls dominate the response of the buildings, and therefore, it is important to evaluate the seismic response of the walls appropriately. Shear walls are commonly used in reinforced concrete construction to resist the shear force induced by earthquake. The size and location of opening may play a significant role in the response of shear walls. Though it is a well known fact that size of openings affects the structural response of shear walls significantly, there is no clear consensus on the behaviour of shear walls under different opening locations. Shear walls situated in advantageous positions in the building, they can form an efficient lateral force resisting system. As shown in the Fig. 1(a) and Fig. 1(b), shear walls with and without openings are placed around the periphery of plan of structure.

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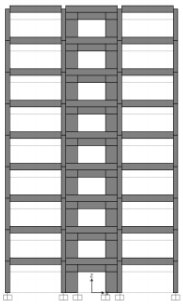

Fig. 1: shear walls with openings

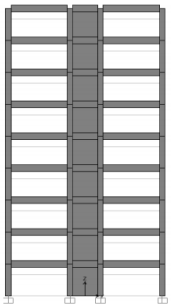

Fig. 2: shear walls without openings

Shear walls with openings are called coupled shear walls which act as cantilevered walls joined by coupling beams. Openings for windows and doors affect the behaviour of the structure and cause to decrease the strength of shear wall. The major opening is taken as rectangular in shape.

II. LITERATURE REVIEW

The following literature papers are studied for the study and knowledge of shear wall with and without opening. The review on the literature is as follows:

Sakurai et. al. (2008) This Paper examines the opening in RCC shear wall by providing with opening under it. In opening of shear wall different no. And layout is taken to get variation result under it. The Specimen is taken as per equivalent perimeter ratio of openings that is 0.4. After the analysis the result is concluded that shear strength, failure mode and deformability of RC shear walls with openings were significantly affected by the difference of the number and layout of openings. The overturning moment value is gets lesser in opening with shear wall with respect to without opening of shear wall due to opening. The searcher also worked on FEM based analysis to simulate the hysteresis loops and failure progress of the shear walls with openings, and good agreement between experimental and analytical results was obtained.

Masood et. al. (2012) The study of this paper compared to shear wall with and without opening by ANSYS based FEM analysis. A set of graphical representation are carried to judge the optimum opening width through it. It concluded that with decrement in the stiffness is lesser in 60% base opening and above this limit of strength and stiffness are excessive. The paper recommended that in high-rise constructions the provision of a base opening up to 50% of the length of the wall may be considered as a feasible option. The increment of deflection is relatively low up to 60% base opening. The shear stress is more adversely affected than flexural stress due to the introduction of base opening in shear wall. In case of single legged shear wall, stress (flexural and shear) ratios increase with the increase of shear wall height, whereas in double legged shear wall these stress ratios decrease with the increase of shear wall height.

Chowdhury et. al .(2012) The study of this paper is carried out on G+6 storey shear wall framed buildings. The analysis used linear elastic analysis with the help of FEM based software. The earthquake analysis carried out by equivalent static method using csi-etabs software. The results concluded that stiffness & seismic responses of structures is affected by the size of the openings as well as their locations in shear wall. It is also explored that top lateral drift of the system can also be reduced thickening the element in the model around the opening of shear wall. Stiffness parameter affected by the size of the openings & locations in shear wall. The opening in shear wall placed in plane of loading is more critical than that of opening in shear wall placed out of plane of loading. Shear wall with different opening sizes and locations considering coupling beam actions may be considered for future research. Also nonlinear dynamic analysis is required to make comprehensive comments.

Khatami et. al. (2012) The researchers analysed the behaviour of opening of shear wall based on earthquake. Under this two near-fault earthquakes were selected from different records of past earthquakes which are Loma Prieta and Taiwan. A G+10 Storey building was modelled with three different types of lateral resisting systems. These Systems are complete shear walls, shear walls with square opening in the centre and right end side. The results showed that a substantial decrease in terms of strength of the wall for shear walls with openings. The model with opening at centre of the wall, maximum lateral displacement was up to 8% less than maximum lateral displacement of the model with opening at the right end side. The effect on opening completed in shear wall that decrease was up to 17% less. Finite element analyses of a panel with opening, showed a dramatic decline in ultimate force up to 54%. This study verified large lateral displacements and ductility for shear walls with openings in comparison with complete shear wall.

Satpute et. al. (2013) In this work the analysis of RC shear walls with openings building was carried out using the SAP2000. The seismic response are examine by the parameters are base shear, storey displacement and storey drift. 5 Models are modelled named as Model 1,2,3,4 & 5. The results vary with the height-wise distribution of top displacement increase by 84.97%, 85.91%, 87.09%, 90.05% in time history analysis and 71.14%, 78.32%, 81.21%, and 82.63% in pushover analysis for model 2, 3, 4, 5, respectively as compared to value of model 1. With increment in % opening increment in displacements is also there. The distribution of the story drift ratio over the frame height becomes non uniform as frame height increases for both the methods. Storey drift ratios for different damage states of class of buildings designed as per IS1893-2002. The capacity spectrum method gives demand curve intersects the capacity curve at event IO (immediate occupation), so plastic hinges occurred in the structure remains stable.

Muthukumar et. al. (2014) The project studied the dynamic behaviour of shear walls using degenerated shell element with assumed strain approach. The assumption taken under study is material nonlinearity considered as per plasticity approach. The yielding/crushing of the concrete with tensile cut off a fie-parameter Willam-Warnke failure criterion is considered. The analysis has been done for different damping ratios. It has been observed that the large number of small openings resulted in better displacement response. It has been concluded that shear walls are penetrated by large number of small openings than small number of large openings. Moreover, the influence of strengthening has been considered essential especially for undammed shear wall. The shear wall with four windows has been considered best for both slender and squat shear walls. The strengthening (ductile detailing) has been considered significant in the case of slender shear wall with staggered openings. However, for higher damping, the strengthening has not been considered essential.

Itware et. al. (2015) The researchers investigate the effects of openings in shear wall on seismic response of structures. The study is based on G+ 6 and G+12 storied 7x3 bays. The buildings having the typical floor plan of 35mx15m and floor height of 3m with different openings size and location in shear walls. The structure is modelled in STAAD pro. The analysis is based on equivalent static method using codal approach as per IS 1893 (part 1): 2002. The results show that for opening area < 20%, the stiffness of the system is more affected by the size of openings than its arrangement. The opening area >20%, the stiffness of the system is significantly affected by openings configuration in shear walls. It concluded that for opening area < 20% of shear wall area, the stiffness of shear wall structure is more affected by the size of openings than their arrangement in the shear walls. However, for opening area>20% of shear wall area, the stiffness of the system is significantly affected by the openings arrangement in shear walls.

Bhruguli et. al. (2015) The paper is based on earthquake analysis of a G+6 Storey building with shear wall. The Staad Pro software are taken for finite element study. The paper is showed that the size of the openings as well as their locations in shear wall. The result is associated for both stiffness & seismic responses of structures. The top lateral drift of the system reduced thickening the element in the model around the opening of shear wall. Through graphical representation % of opening increases deflection increases up to 40% in proportion but after that as % of opening increases deflection increases more rapidly. For 20% opening Eccentric zigzag has lesser deflection and Eccentric Straight has maximum deflection and concentric loading has less deflection than Eccentric Straight. The opening increases bottom stresses also increases proportionally up to 40% then after Stresses increases vastly.

Hosseini et. al. (2015) This paper investigates the seismic behaviour of Building With shear walls.

The location of shear wall provided at the centre core and centre of each side of the external perimeter with openings. The main opening locations are taken at centred. The G+40 Storey buildings (120m) have been modelled using ETABS Software taking a zone V of earthquake in India. It was also found that this model exhibited high stiffness. The concentration of stresses in shear walls increases when openings are provided. It was found that the maximum stress induced increased threefold due to openings. The model with openings in shear walls gave a result with a deviation of approx. 5% with that of shear walls without openings. The displacements, drifts and also the base shear values were within the 5% range. So provision shear wall with openings helps to achieve economy.

Gadling et. al. (2016) The researcher of this paper evaluates the responses of providing openings and the behaviour of shear wall without openings. A review is taken out over the analysis and design of RCC shear walls with and without openings. The aim of review is to study more detail analytical results and conclusions. The result arr such that Base shear is relatively less for shear walls with openings than shear walls without openings. The ductility and shear strength of the shear wall with openings is highly affected by reinforcement provided around openings. Compared with common shear wall, the researches on prefabricated composite shear wall with boundary frames and openings are relatively less.

Kalpana et. al. (2016). This paper analyzed the structural be hiver with shear walls with varying height for different models. Two reinforced concrete framed regular building with different zones locations of shear walls situated in seismic zone III and zone V have been Analyzed. Five-storied buildings were taken with shear-walls and without shear-walls. The result is taken in terms of axial forces, lateral displacement and bending moment. The displacements are reduced in building with shear wall compared to building without shear wall. The building with shear wall has more earthquake resistance compared to building without shear wall. There is no variation on wind effect for with and without shear wall building. There is small variation on bending moment and axial force for with and without shear wall. The node displacements are more for Zone V compared to Zone III for earth quake load. The Axial forces are decreased with increasing structural height for all models. Comparison of Zone III and Zone V for the wind effect, the nodal displacements in the exterior columns with shear wall and without shear wall structure are same.

Kankuntla et. al. (2016) The paper present comparative study for seismic performance of G+15-Storey with openings in shear wall situated in earthquake zone V. The Seismic coefficient method and Response spectrum method are used for seismic analysis. SAP software is used and the results are compared. Position of shear wall by changing the sizes and shape of openings in shear wall for all buildings models is determined. Comparative study concludes that changing the position of shear wall of reinforced concrete structures with various opening sizes in buildings openings is economical. The frames with shear wall are affected by the size of openings than their locations in the shear walls on the stiffness and response of structure with opening area ≤15% of solid shear wall area. However, it is considerably affected by the opening locations in shear walls with opening area >15% of solid wall area.

Hosseini (2017) The researcher examines the behaviour of Shear walls which are located on each level of the structure. The model consist has an effective box structure, equal length shear walls are placed symmetrically on opposite sides of exterior walls of the building. Shear walls are added to the building interior to provide extra strength and stiffness to the building when the exterior walls cannot provide sufficient strength and stiffness or when the allowable span-width ratio for the floor or roof diaphragm is exceeded. Shear walls are analyzed to resist two types of forces: shear forces and uplift forces. Shear forces are created throughout the height of the wall between the top and bottom shear wall connections. The 20 story building with Shear walls are analyzed for two cases with openings and Without openings. With the provision of shear wall the shear force in the columns, decreased. With the provision of shear wall the moment in the columns, increased. No significant difference in shear force and moment provision of 20 % opening in the shear wall. With the provision of the shear walls drift and displacement is decreasing. With the provision of the shear wall the drift and displacement is increasing.

Swetha K S (2017) This paper carried out on a G+7 storey frame shear wall building. The FEM analysis is taken using a method of time history approach with the help of csi etabs software. The shear wall with openings arranged in vertical, horizontal and zigzag manner and by varying percentage of opening in zigzag manner. The result is based time period, displacement, base shear, storey drift and storey acceleration of shear wall with openings. The zigzag arrangement shows comparatively 4% better performance than other arrangement of opening. It is founded that the occurrence of storey shear, storey displacement, storey drift and storey acceleration in structure with shear wall having openings arranged in zigzag manner is approximately 4% lesser as compared to vertical and horizontal arrangement of openings. When the percentage of opening is increased from 4.16 to 22%, the structure with shear wall having openings arranged in zigzag manner having opening area less than 16.67% as compared to shear wall area is founded to be approximately 4% better performance in the base shear, storey displacement, time period, storey drift and storey acceleration than opening area greater than 16.67% as compared to shear wall area.

Mohan et. al. (2017) This paper determined the effectiveness of shear wall with vertical opening and staggered opening in regular and irregular buildings. The lateral load is taken as earthquake loads using ETABS. G+10 regular building with shear wall having different types of opening are taken into the project. The results are obtained in the form of displacement in major axis, storey drift, base shear etc in to it. Different types of shape of the building are also ansysis such as L shape, H shaped and T shaped with regular building. It concluded that regular building with shear wall having staggered opening shows better results in terms of displacement, storey drift and storey shear. In the case of irregular buildings (H shaped and T shaped) buildings with Staggered opening shows better results in terms of displacement, storey drift and storey shear in both X and Y directions. But in case L shaped irregular building, building with shear wall having vertical openings shown good results in terms of displacement and base shear in Y direction.

Vaidya et. al. (2018) The paper consist review of different researchers on the concept of multi-storeyed building with and without she wall. Review points say the maximum utilise building is shear wall structure. The building is vary with style and utility and design. The review consist that shear wall play important role to resist lateral force through it. The analysis is based on the different types of software such as Stadd.pro, Etabs etc. and it can be compared with manual result. Models are generated and shear walls are located at different positions in building to find the least displacement of the structure due to shear walls.

Openings in shear wall are also an issue of concern of study of shear wall buildings. Generally openings provided in shear walls increase displacement in building. some researches stated that change in positions of shear wall effect the attraction of forces. Location of shear wall in any building substantially reduces displacements and reduces impact on the structure.

Gupta et. al. (2018) This study is carried out on a G+15 Story shear wall frame structure. The method adopted in it THMis with the help of ETAB. The study is based on responses of the fifteen storeys RC shear wall building with or without openings. The volume of shear wall reduced in the boundary element. Shear walls are for the most part situated along the edges of structures centre that houses stairs and lifts. The magnitude of strength reduction depends on the size of openings Ear wall without opening proved to be highly advantageous and they were found to provide better lateral resistance than shear walls with openings. The increase of stresses in shear wall without openings is small when compared to shear walls with opening. The displacement and drift shear wall without agreed quite well than that of shear wall with openings. For openings up to 14%, the load carrying capacity and ultimate displacement response were not found to be severely affected by openings. However, for openings beyond 14%, the load carrying capacity of shear wall gets affected due to the presence of openings. Shear walls with different opening sizes and different reinforcing patterns can be further analyzed for future research work, so that the failure mechanism of shear walls with openings can be understood in a better way and a proper design code can be formulated for practice.

Rai et. al. (2018) The researchers Studied the seismic responses of the ten storey RC shear wall building with or without openings. This paper developed mathematical modelling and analyzed the reinforced concrete shear wall building by using different nonlinear methods.

These methods differ in respect to accuracy, simplicity, transparency and clarity of theoretical background. The RC shear walls building with openings multi-storied building was carried out to compare with the different dimension by using ETABS software in multiple areas. All the analysis can be check seismic load in opening shear wall of different shapes and dimension for with or without opening in frame RC shear wall building. Rectangular and square opening shear walls to be proved that they are very advantageous and useful for design purpose.

Husain et. al. (2019) The study of paper developed a 3D high-reliability dynamic nonlinear finite element model. The examination based on ABAQUS theory manual and users' manual, version 6.10. It investigates the behaviour of shear walls with openings strengthened with FRP wraps. The proposed FE model has been validated using previous experimental data in literature. The strengthened specimens dissipated much more energy than the control wall specimen. The ratio of energy dissipation of strengthened specimens to that of the reference specimen was between 1.16 and 1.57. CFRP laminates are not effective on improving the initial lateral stiffness of the retrofitted specimens. Increasing the number of the CFRP laminates increases the ultimate load by about 17% and 23% when increasing the number of the CFRP laminates from two to three layers, respectively. The failure of strengthened RC shear wall with openings was dependent primarily on the thickness of FRP as well as the location and size of openings. In models with a large opening, increasing the CFRP laminate thickness leads to increasing their resistance.

Kolli et. al. (2019) The paper obtained the curve between Load Vs deflection, crack pattern, mode of failure of shear wall without boundary elements. The three specimens of 200mm thick are casted with different reinforcement alignment types. The analysis of shear wall is taken on the STAAD Pro. By adding extra reinforcement in the form of diagonal type, load carrying capacity of walls increasing gradually but along with that stresses are also increasing. For finding the place where stresses are increasing in the specimen, analysis was done by using the software. From that software analysis results, we can clearly say that the stresses were increasing mostly at the supports. For reducing the increase of stresses in walls, reinforcement ratio in walls has to be increased or boundary elements have to be installed in it. In this work, without having boundary elements in the wall specimens, all the three types of walls were ready to resist both lateral and point load, but stresses were developing at the places were boundary elements are not installed for reducing that problem we have to add the boundary elements or special confining reinforcement to that wall specimens

Vishwakarma et. al. (2019) The researcher asset the human comfort behaviour based on peak acceleration calculation. The project consist of two circular perimeter shear wall inner and outer through later support system is increases. The project includes Four different Framed Tubes tall building circular structure having a G+20, G+30, G+40, and G+50 with different condition i.e. Normal Slab, Secondary Beam, Waffle Slab & Ribbed Slab are taken. Typical circular floor is 50 m in diameter and symmetrical in plan in both major directions. Then using ETABS-2013 software maximum displacement is evaluated using dynamic wind analysis of building by applying the gust factor method. By providing two shear wall the story displacement value is reduces and it resist the dynamic wind forces through it.

III. CONCLUSIONS

Based on the above different research papers of the different research following conclusion are made which are as follows:

A. It is found that study of shear wall with and without opening are necessary due to it is common elemental use in high rise and multi-storey buildings.
B. To evaluated earthquake resisting building with shear wall approach the analysis of building or any structure using linear and non linear approach is compulsory.
C. Opening of shear wall are generally taken as rectangular in shape but it may be vary with shape and orientation o building.
D. Comparative study is carried out using multi story building with and without shear wall.
E. Comparative study is taken with shear wall and shear wall with opening.
F. The study is also based on use of different types of software used for analysis such STADD, ANYSIS, FEM, ABACUS, ETABS etc

IV. GAP OF STUDY

Based on the above research papers it is need of a structure to provide shear wall to resist the lateral load such wind and earthquake. Some research is based on earthquake analysis. The analysis based of static and dynamic wind approach with shear wall is very less. The comparative study of shape of opening such as rectangular vs. Square, rectangular vs. Circle etc shapes are remaining. The Study is based on different structural form are quite less to obtain the different phenomena on the analysis**.** It is also seen nobody studied based on different countries codes analysis.

V. FUTURE SCOPE

Based on the research paper the following works are carried out in the future which are follows

A. Analysis of structure with Opening of shear of wall with different phases of wall.
B. Analysis of structure based on varying the opening percentage of shear wall such as 10 %, 15%, 20%, 25% etc from the total area of shear wall.
C. Comparative study of different method of earthquake in structure with opening in shear wall.
D. Comparative study of different method of dynamic wind in structure with opening in shear wall.
E. Data analysis using different country codes.
F. Analysis of opening of shear wall with variation in different structural forms Such as outrigger based, hull core based, bundled tube, tube in tube etc.

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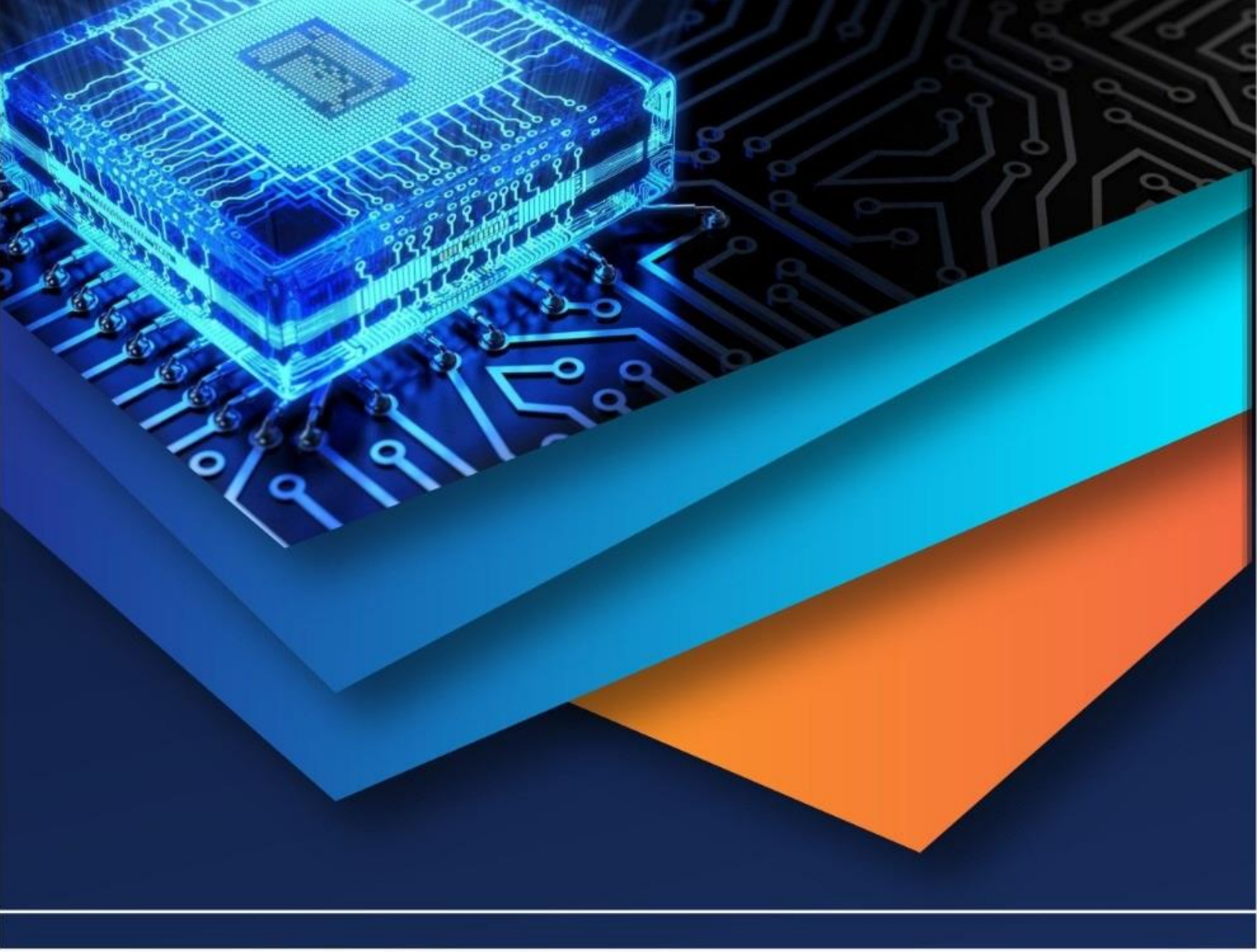

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