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Seismic Behaviour of Building with Soft Storey: Review

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Abstract: ***The high-rise building in which ground storey consists of open space is known as building with soft floor. Such floor plays an important role in seismic performance of the building. This is due to the abrupt changes in lateral stiffness and strength caused by such storey. In the present era there is increase in population, finding parking for flats in congested areas has become a significant issue. As a result, erecting multistory structures with an open first floor is now a widespread practice. These Buildings that have all upper storeys enclosed by masonry walls but no infill masonry walls in the ground story are referred to as "Soft Storey" or "Open Ground Storey Buildings." Compared to regular buildings, irregular structures the drift is observed to be effectively reduced by larger columns, while the shear force and bending moment on the first floor are increased. During a violent earthquake, the Soft Storey buildings function poorly. Understanding the behavior of is this study's primary goal to the building in a seismically active area and to assess the effects of Storey overturning moments, Storey drift, displacement, and design Base shear. For comparison, G-15 story building with five completely distinct shapes a square, an L-shaped building, a T-shaped building, a plus shape building and a C-shaped building is used. ETABS 2018 version is used to analyze the entire set of models. Dynamic Analysis has been examined in the current work to assess the deformation of all five-shape building with and without soft storey considering at different level. When the soft story is offered at a higher level, displacement is reduced. Several studies on this subject that have been done in the past are reviewed in this paper. Reviewing research papers let us know about the conclusive results, which served as the basis for the objective of our future study.***

Keywords: Soft Storey, Irregular shapes, Seismic and wind forces, lateral displacement, storey drift.

I. INTRODUCTION

Now a days construction of multistoried Reinforced Concrete (RC) frame buildings is becoming common in India. The most common type of vertical irregularity occurs in buildings that have an open ground story. Many buildings constructed in recent times have a special feature that the ground stories are left open for the purpose of parking, reception etc. Such buildings are often called open ground storey buildings. The first stories become soft and weak relative to the other upper stories, due absence of masonry walls in the first stories. Structurally those unbalances are unhealthy and soft storey buildings are well known for being susceptible to collapse through past earthquake. Soft story is provided in the multi-story buildings depending on the needs of the occupants in the building. For Ex: providing car parking at the basement or the stories used for commercial purpose. A soft story is defined as “If the story is lesser than 70% stiff than that of the story exactly above or lesser than 80% stiff as the average three story above it, is known as soft story”. Due to the lesser stiffness in this story the lateral forces due to earthquake must be resisted by columns and if these columns are weak then this will lead to the severe damage or collapse of the building. The fundamental earthquake resistant design concept is the strong columns-weak beams criteria, to ensure safety of the occupants, during earthquake the beams yield before the columns get collapsed.

The behavior of the structure and degree of damages of the multi storied buildings depends on the capacity of structural members undergoing the process of deformations in elasticity during seismological ground motions. The collapse or the damage of the high rise building due to soft storey is very often, the ground floor soft story during earthquake fail to resist the lateral earthquake forces. Since the distribution of the lateral forces in the high-rise buildings is dependent on the mass and the stiffness of the building. The soft story which has less stiffness depends upon the column to resist the lateral forces.

A. Building with Soft Storey

Modern seismic design algorithms allow engineers to compute design forces and displacements using either linear or nonlinear analysis. Linear static analysis, linear dynamic analysis, nonlinear pushover analysis, and nonlinear time-history analysis are the four types of analysis. These techniques are used to design and analyze framed structures such as buildings and bridges. To be completely applicable by design engineers, the two nonlinear methodologies require advanced models and advanced nonlinear procedures. The influence of urbanization has been increasingly widespread in recent years.

The concept of performance-based design evolved when designers started realizing that the conventional code design method was not always the most appropriate method.

Different structures have different performance requirements, and it is not appropriate that the same prescriptive criteria to be used for designing different structures. According to the code guidelines base shear is calculated based on importance factor, Zone factor, and Average response acceleration coefficient (Sa /g). Calculated base shear is distributed to floor levels which depend on the amount of mass present at storey level and its height.

After the analysis for lateral forces gives design forces and moments and combined with forces and moments due to dead load and live loads according to load combinations stated in IS 1893(Part 1): 2016. It is very important to study the seismic behavior of RC structures for different functions in terms of responses such as Base shear, storey displacement and storey drift etc. Seismic analysis is needed to calculate the seismic response of the building, seismic analysis is part of the process of structural design where the earthquake is prevalent.

II. LITERATURE REVIEW

1) Ankita R Uplenchwar. "SEISMIC ANALYSIS OF A STRUCTURE WITH SOFT STOREY AND FLOATING COLUMN" The International Journal of Progressive Research in Science and Engineering (IJPRSE) Volume-3, Issue-7 [2022]

In this paper, study on behavior of structure having soft story and floating column is to be analyzed. An investigation is performed on analytical model of a multistorey building recognizing the presence of a floating column and soft storey using the software ETABS. To study the effect of earthquake on this kind of buildings, Equivalent static analysis and Response spectrum analysis have been considered. The parameters like storey drift, storey shear, buliding torsion, storey moment have been studied in detail.

2) Pravesh Gairola "SEISMIC ANALYSIS OF OPEN SOFT STOREY BUILDING FOR DIFFERENT MODELS" International Journal of Engineering Research & Technology (IJERT)Volume. 8 Issue -05[2019]

In this paper an investigation has been made to study the seismic behaviour of soft storey building with different models (Bare frame, Infill frame, Bracing Frame, Shear wall frame) in soft storey building when subjected to earthquake loading. It is observed that, providing different models improves resistant behaviour of the structure when compared to soft storey provided. With the availability of fast computers, so that software usage in civil engineering has greatly reduced the complexities of different aspects in the analysis and design of projects

3) Aradhya B M S1, Dr. B Shivakumara Swamy. **"**STUDY ON SOFT STOREY EFFECT OF PLAN REGULAR AND IRREGULAR RC FRAMED STRUCTURES UNDER DIFFERENT SEISMIC ZONES USING RESPONSE SPECTRUM METHOD OF ANALYSIS.". International Research Journal of Engineering and Technology (IRJET) Volume- 06 Issue-09 [2019]

Multi-story buildings with an open first floor is a prevalent design element in urban areas of India and the modern globe. owing to the benefit of having open space for parking and commercial purposes. And due to a variety of factors, including the lack of necessary site measurements and aesthetic considerations, irregular plan structures are increasingly widespread in metropolitan areas today. Open-story buildings and buildings with irregular plans should not be constructed in seismically active areas. The goal of this project is to examine how a reinforced concrete frame building (G+13) with a soft story, bare frame, and masonry wall infill performs. According to IS 1893-2002 (part 1), linear dynamic analysis (response spectrum analysis) is performed using the software SAP2000.

4) Mahesh Pawar. Akshay Mahajan. "SEISMIC VULNERABILITY OF COLUMN IN MULT STORY BUILDING WITHOUT INCLUDING SOFT STORY AND INCLUDING SOFT STORY AT DIFFERENT LEVELS". International Journal of Engineering Research & Technology (IJERT) Volume- 3, Issue-8 [2019]

The current analytical study investigates the impact of a few buildings with soft storey behaviour parameters. With the aid of the computer programme E-TABS 2016, the entire building is modelled. Utilizing comparable static analysis, parametric studies on displacement, inter-storey drift, and storey shear have been conducted to examine how these characteristics affect the behaviour of structures with soft storeys. Three models were used to analyse the chosen building.

5) Md. Hussain. "SEISMIC ANALYSIS OF MULTISTOREY BUILDING WITH AND WITHOUT SOFT STOREY". International Journal of Research in Advent Technology. Volume-6, Issue-8 [2018]

The performance of the structure was examined by considering ground storey, ground and 1st storey, 3rd and 4th storey, ground and 6th storey, 6th storey, 12th storey, and ground, 1st, and 2nd storey as soft storeys in this project. A model of G+12 storeys was created and analysed for tall structures including soft storey for different levels using ETABS. Point the soft storey at the characteristic to better understand it. In this study, the equivalent static approach and the response spectrum method were both applied.

6) Shamshad Ali. "ANALYSIS OF BUILDING WITH SOFT STOREY DURING EARTHQUAKE". International Research Journal of Engineering and Technology (IRJET)Volume-3, Issue-4 [2017]

Due to the lack of infill walls, there is a break in the structure's rigidity at the soft story. Though it can be present on any other storey level of the building, the soft or weak storey is most frequently seen on the ground floor. This effort involved a seismic investigation of the impacts of soft story building frames on G+6 buildings. By converting the soft story to different floors, five versions were produced. When considering soft storeys with the same floor heights, the impact of infill walls has been disregarded. To analyse the building, STAAD PRO v8i is used. The information is set down in. The data is organized by storey drift, displacements, and base shear.

7) B. Lalitha Chandrahas, P. Polu Raju. "BEHAVIOUR OF SOFT STOREY RC FRAMED BUILDING UNDER SEISMIC LOADING**".** International Journal of Civil Engineering and Technology (IJCIET), Volume-4, Issue-8 [2017]

The demand for the construction of commercial floors and parking facilities in the building's lower stories has increased because of India's urbanisation. For the structure under consideration, the behaviour of RC-framed buildings with soft storeys has been observed in terms of hinge formation patterns, total lateral drift, storey shear, overturning moment, and duration. It has been found that the infill wall significantly affects the frame's rigidity and lateral resistance.

8) Ahmed Vaqhar Kazim. "SEISMIC ANALYSIS OF IRREGULAR (L-SHAPED) RCC BUILDING" Journal for Research Volume 02, Issue -12 [2017]

In this paper study on three new R.C.C. buildings with an unsymmetrical plan (L-shape) that were constructed in accordance with IS 456:2000 is examined in this study: 4, 8, and 20 storey buildings are used to cover the whole range of low, medium, and high-rise building designs. Six models for each building were used to incorporate various modelling concerns. These models included the bare frame (without infill), an infill membrane, and an infill that replaced an analogous strut in the prior model.The pushover analysis has been carried out using ETABS, a product of Computers and Structures International. Buildings located in Zone-III have been analysed Comparative study made for bare frame (without infill), having infill as membrane, replacing infill as an equivalent strut. The results of analysis are compared in terms of Base Shear, Storey Displacement and Drift Ratio.

9) Rezarta Uruci, "EFFECTS OF SOFT STOREY IRREGULARITY ON RC BUILDING RESPONSE". International Balkans Conference on Challenges of Civil Engineering, 3-BCCCE [2016]

In this study, the soft story effect under seismic loads in low and mid-rise buildings of Albanian construction practise is considered among all these abnormalities. For the two types of structures, 3 and 6-story frames representing low and mid-rise buildings, respectively, several Nonlinear Static (Pushover) Analyses are performed for regular frames, frames with soft story due to higher height and lack of masonry infill walls in ground story, or due to the presence of both cases. ETABS programme has carried out the analysis. The analysis' findings show that low- and mid-rise buildings with soft story irregularity because there are no infill walls and higher ground levels story are more vulnerable during earthquakes.

10) S.P. Nirkhe"SEISMIC BEHAVIOR OF SOFT STOREY BUILDING WITH STATIC AND DYNAMIC EARTHQUAKE LOADING". International Journal of Structural Engineering and AnalysisVolume-2, Issue-2 [2016]

The need for open-story workplaces at different levels of the structure and ground-level parking overrides the technical community's cautions against such designs on a functional and social level. The use of software in civil engineering has significantly reduced the complexity of many projects analysis and design components since the invention of fast computers. In this research, an analysis of the seismic response of soft story buildings with various configurations under static and dynamic earthquake loading has been conducted. It has been found that adding infill enhances the structure's resistance behaviour as compared to using a soft storey.

11) Ghalimath A.G. "ANALYTICAL REVIEW OF SOFT STOREY". International Research Journal of Engineering and Technology (IRJET)Volume-2, Issue-6 [2015]

The author of this study made note of the distinction between a soft storey and a weak storey, as well as the discussion of an IS code rule relating to soft story. The seismic performance of a high-rise building is significantly influenced by its soft story. This continuity is what causes multi-storied structures to collapse structurally when subjected to seismic loads. Numerous existing reinforced concrete buildings are susceptible to damage or possibly collapse after a large earthquake, as demonstrated by recent earthquakes that happened. While soft story damage and collapse are most frequently seen in buildings, they can also occur in other kinds of structures.

12) Mohammed Rizwan Sultan. "DYNAMIC ANALYSIS OF MULTI-STOREY BUILDING FOR DIFFERENT SHAPES" International Journal of Innovative Research in Advanced Engineering (IJIRAE) Volume-2, Issue-8 [2015]

Buildings with irregularities are susceptible to seismic damage, as evidenced by past earthquake disasters. To reduce the seismic damage to structures, it is crucial to detect the structural response to earthquakes, even in high seismic zones. The most crucial goal of this research is to understand how the structure behaves in high seismic zones and to assess Storey overturning moments, Storey drifts, displacements, and design lateral forces. For comparison purposes, a 15-story building with four completely distinct shapes—a rectangle, an L, an H, and a C is employed. ETABS was used to analyse the entire set of models. In the current work, comparative dynamic analysis has been used to examine the deformation of the structure in each of the four situations.

13) Umesh P. Patil. "ANALYSIS OF G+15 RCC AND COMPOSITE STRUCTURE HAVING A SOFT STOREY AT GROUND LEVEL BY RESPONSE SPECTRUM AND EQUIVALENT STATIC METHOD USING ETABS 2013".

International Research Journal of Engineering and Technology (IRJET), Volume-2, Issue-3 [2015]

In this paper, to evaluate and compare the seismic performance of G+ 15 storeys made of RCC and composite structures ETABS 2013 software was used for the purpose. Both steel and concrete composite structures and RCC structures were having soft storey at ground level, structures were in the region of earthquake zone III on a medium soil. Equivalent static and response spectrum method is used for analysis. Storey drift, bending moment and shear force, are considered as parameters. When compared composite structures shows better performance than RCC.

14) Ari Wibowoa "COLLAPSE BEHAVIOUR ASSESSMENT OF PRECAST SOFT STOREY BUILDING." The 5th International Conference of Euro Asia Civil Engineering Forum (EACEF-5) [2015]

In the present paper, an investigation is carried out to In-depth theoretical models that considered ground slab interaction effects, P-Delta effects, and rocking behaviour were created. The precast soft storey structure had a significant displacement capacity beyond the conventional definition of failure used in high seismic regions, where failure is deemed to occur when the system's horizontal resistance capacity is reduced to 80% of the nominal capacity, according to experimental results and a comparison with theoretical model predictions. To allow for some prudence, it is suggested that the nominal failure point be lowered to a displacement limit established at the smaller of the displacement associated with 40% of the peak strength or 60% of the column width.

15) Mr. Raghavendra S. Deshpande "SEISMIC ANALYSIS OF REINFORCED CONCRETE BUILDING WITH SOFT FIRST STOREY". International Journal of Scientific & Engineering Research [IRJET] Volume-5, Issue-5 [2014]

In the present paper, an investigation is carried out to examine the behaviour of various alternative models of same reinforced concrete moment resisting frame building with an open first storey & unreinforced masonry infills in the upper stories. The structural action of masonry infill panels of upper stories has been considered by modelling them as equivalent diagonal struts. The parameters discussed include fundamental natural periods, stiffness of open first storey in relation to the upper storey, lateral displacements, inter-storey drift by linear elastic analysis using ETABS analysis package. It is noticed that significant change in stiffness between the soft storey and upper storey is responsible for increasing the strength demand on first storey columns.

16) Susanta Banerjee. "INELASTIC SEISMIC ANALYSIS OF REINFORCED CONCRETE FRAME BUILDING WITH SOFT STOREY. International Journal of Civil Engineering Research, [ISSN] Volume-4, Issue-5 [2014]

This paper presents the importance of infill wall stiffness in the modelling and of preventing the indiscriminate use of soft first storey in the buildings. Due to computational elastic analysis is concerned by building codes. In this study inelastic damage indices of element, storey, and overall building subjected to ground motion are analysed.

Dynamic characteristics and damage pattern of soft storey building are evaluated when infill wall stiffness is considered. Modelling and analysis of the building are performed by nonlinear analysis program IDARC 2D. Response parameters such as floor displacement, storey drift, and base shear are also obtained.

17) Neelam V. S. PATNALA. [2014] "EFFECT OF SOFT STOREY IN A STRUCTURE PRESENT IN HIGHER SEISMIC ZONE AREAS". International Institute of Information Technology. Voiume-, Issue-[2014]

In this paper the study the comparative study between three types of arrangements; type I: structure with infill walls in all floors, type II: structure with open ground storey, type III: structure with open ground storey and columns designed for increased forces. It is observed that there is an increase in maximum load carrying capacity for the type III structure as compared to type II structure with no considerable change in behaviour of the two types of structures. It can be concluded that the increase in design forces of the columns at open ground storey may not lead to the safety as of structure type I.

18) Devendra Dohare. "SEISMIC BEHAVIOR OF SOFT STOREY BUILDING: A CRITICAL REVIEW". International Journal of Engineering Research and General Science Volume 2, Issue 6[

Modern multi-story buildings in Indian cities frequently include soft first floors. Even though multi-story structures with soft storey floors are prone to collapsing during earthquakes, emerging nations like India continue to construct them frequently. In this research, an analysis of the seismic response of soft story buildings with various configurations under static and dynamic earthquake loading has been conducted. When compared to a soft story, it has been found that adding infill improves the structure's resistance.

III. CONCLUSION

The inadequate performance and the huge number of collapsed buildings during past earthquakes because of diverse structural irregularities. Soft story irregularity is one of the main irregularities affecting the damages of the buildings during an earthquake, it has also been studied from different researchers. Presence of soft story irregularity effects the seismic performance of the frame, it both weakens and softens the system. Soft story due to absence of masonry infill walls (SSW) at the ground story is found to be more destructive than the soft story due to greater height (SSH) of the story in both cases low and mid-rise buildings, 3-and 6-story respectively. (Rezarta Uruci, Huseyin Bilgin 2016). The building without soft storey is found to be safer during strong ground motions as compared to building having soft storey at any floor. The building having soft storey at any floor is vulnerable for damage during earthquake due to lack of stiffness of soft storey. The drift is maximum at the floor having soft storey as compared to adjacent floor levels. (Shamshad Ali, Farhan Malik, Tanmay Sonone 2017). Models with soft storey shows higher value of storey drift than models without soft storey, therefore avoid soft storey in the buildings under higher seismic zones and increase the lateral stiffness of the storey by providing shear wall, bracings etc. (Aradhya B M S, Dr. B Shivakumara Swamy, 2019) By providing infill at specific locations in first storey and stiffening the first storey columns by increasing the size, there is significant increase in the stiffness, reduction of lateral drift demand, in the first storey column. Infill increases lateral resistance and initial stiffness of the frames, so they appear to have a significant effect on the reduction of the lateral displacement. (Raghavendra S. Deshpande, 2014).

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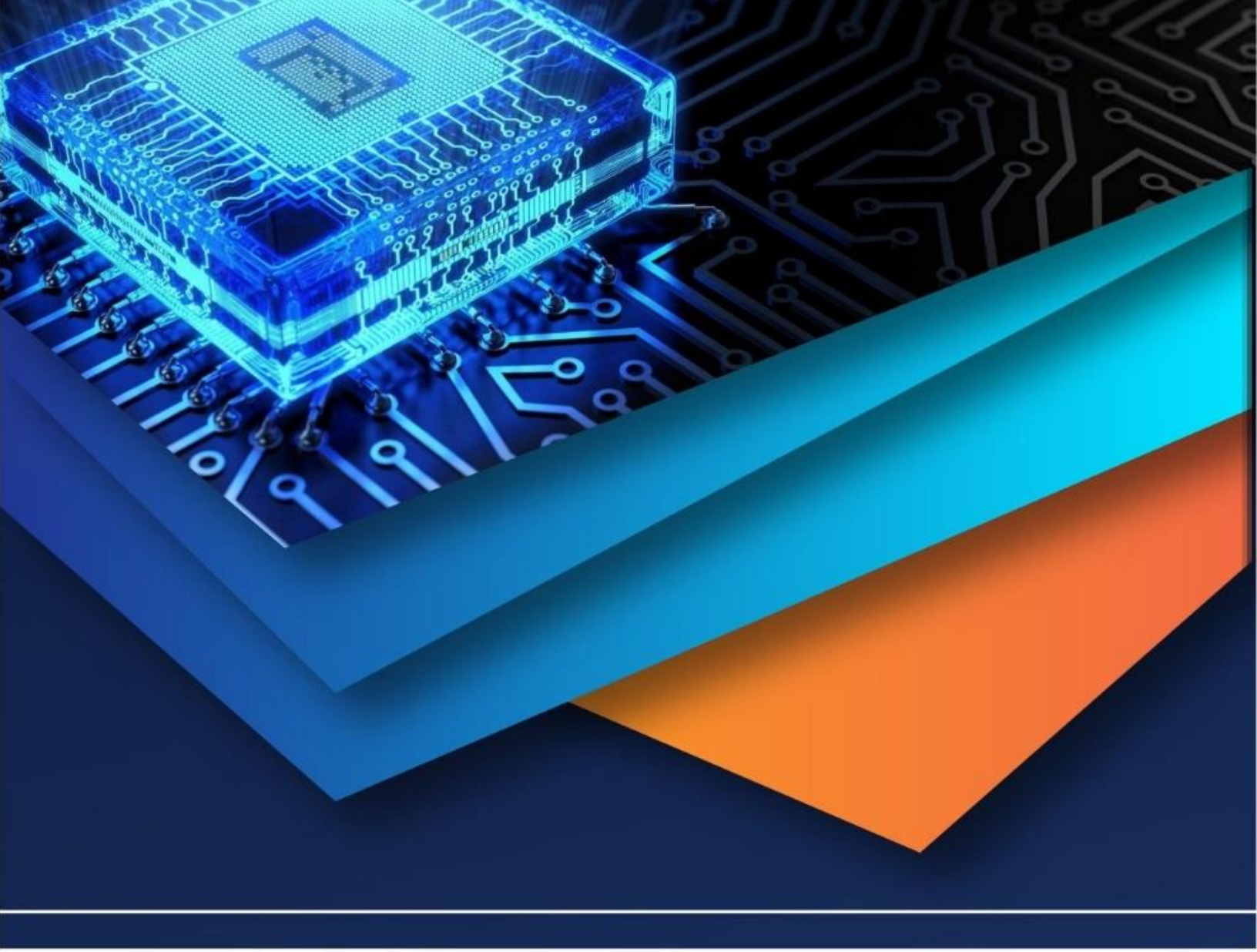

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