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Review on High Rise Building with Outrigger and Belt Truss System

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Abstract: ***In present era there is more demand of high rise building. The growing demand for high-rise buildings brings new difficulties and comes up with new safety precautions. With increase in height of structure its rigidity reduces, making it difficult to withstand with earthquake and wind effects, hence some preventative structural systems must be used. Some of them are bracings, shear wall, outrigger system and belt truss system etc.***
The outrigger and belt truss system is investigated in this study since it has been found to be the most effective method for high rise buildings and skyscrapers. To prevent story drift and the rotational action of the core caused by seismic and wind forces, the external columns in an outrigger system are attached to the main inner or outer core using outrigger beams, walls, trusses etc. at various floor levels.
All external columns that are situated at the peripheral are connected together with truss elements in a belt truss system. A number of 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. One of the best systems for controlling excessive drift and lateral displacement caused by lateral loads is the outrigger and belt truss system. By using this system, the risk of structural and non-structural damage can be reduced during small or medium lateral loads caused by either wind or earthquake load.
Keywords: Outrigger system, Belt truss system, Seismic and wind forces, lateral displacement, storey drift.

I. INTRODUCTION

The scarcity of lands in the cities as well as increasing rates of urbanization in the last few decades (due to the rapid population growth and migration of people from rural to urban regions) make high-rise buildings an effective solution to solve this problem. [Wael Alhaddad et al, 2020]. Mankind is always attracted by heights.
The skyscraper is currently the symbol of economic power and leadership. There has been a documented competitiveness among humans to claim ownership of the world's highest skyscraper. The lateral loads imposed on the structure usually influence the construction of skyscrapers.
As buildings have risen taller and narrower, structural engineers have had to work harder to achieve required drift criteria while minimizing the structure's architectural impact. As a result of this problem, the profession has offered lots of new lateral layouts that can now be found in skyscrapers all over the world. [Shivacharan K et al, 2015]. Today's modern era has made it necessary to build tall structures in order to accommodate the current population because cities are expanding quickly and the land availability is decreasing.
However, tall structure construction also brings with it a number of issues that must be resolved. The structural system of outriggers and belt trusses has shown to be an effective and economical solution for the issues associated with the construction of tall structures. [Prajyot A. Kakde et al, 2017]

A. Outrigger and Belt Truss System

The exterior and interior structural systems are combined by rigid horizontal beams known as outriggers, and the perimeter columns of the exterior structural system are connected by another rigid horizontal beam known as belt-truss in the outrigger and belt-truss system, which is a hybrid lateral load-resisting system. Outriggers and belt truss join the external and interior systems, increasing the effective depth of the structure when it cantilevers and causing them to work together against lateral loads for more effective utilization of these systems. Therefore, the primary strategy of this system is to locate strengthening stories with outriggers and belt-trusses at suitable heights to control the story displacement. All across the world, tall structures employ this method extensively.

II. LITERATURE REVIEW

A. *P. M. B. Raj Kiran Nanduri et al. "OPTIMUM POSITION OF OUTRIGGER SYSTEM FOR HIGH-RISE REINFORCED CONCRETE BUILDINGS UNDER WIND AND EARTHQUAKE LOADINGS" American Journal of Engineering Research (AJER), Volume-02, Issue-08 (2013)*

The main objective of this paper is to investigate behavior, optimum location, and efficiency of outrigger when three outriggers are used in the construction. Nine 30-story three-dimensional models are created with outrigger and belt truss systems are subjected to wind and seismic forces, examined, and compared in order to determine the lateral displacement reduction associated to outrigger and belt truss system location. By placing a first outrigger at the top and a second outrigger in the structural height, a maximum displacement reduction of 23 percent can be achieved for a 30-story model. The effect of the second outrigger system is examined, and significant conclusions are noted and drawn. It can be conclude that the most effective location of the outrigger is between 0.5 times of height of structure.

B. *Junais Ahmed Ak Yamini Sreevalli "APPLICATION OF OUTRIGGER IN SLENDER HIGH RISE BUILDINGS TO REDUCE FUNDAMENTAL TIME PERIOD" International Journal of Mechanical And Production Engineering (IJMPE), ISSN: 2320-2092, Volume-02, Issue-07 (2014)*

The structural engineers approached the new problem from an engineering standpoint and offered numerous solutions, one of which is a connected shear wall to control lateral loads caused by earthquake and wind. However, lateral stiffness of the structural system becomes more crucial when a structure is narrow in any direction, and outrigger systems are added between the core wall and external columns to give lateral stiffness. In seismically active zones or wind load dominated regions, the outrigger will efficiently limit excessive drift and deflection and reduce structure damage. This study's goal is to determine where the outrigger beams should be placed. The FEM base Etabs software is used to generate a mathematical model of 30, 40, 50, and 60 storeys for this purpose. Examined are variations in the essential time period of construction without outriggers and various outrigger locations. By positioning the first outrigger at 1/3 the height of the top storey and the second outrigger at the same height from the bottom, the building's fundamental time is reduced to its absolute minimum. Results indicate that stability is also influenced by a plan's dimension. The lateral stability of a structure is inversely proportional to its height since an increase in height with the same plan geometry results in an increase in the fundamental.

C. *Shivacharan K. et al. "OPTIMUM POSITION OF OUTRIGGER SYSTEM FOR TALL VERTICAL IRREGULARITY STRUCTURES" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume-12, Issue-02 (2015)*

In this paper, the analysis of the structure is carried out to study the behavior of outrigger and its efficiency for its optimum position at the first and second location. The purpose of this research is to study on the use of outrigger and belt truss in various locations that are subjected to wind and seismic load. To examine the efficacy of vertical irregularities in outrigger structures, a linear static analysis was carried out using ETABS2013.5. In order to accomplish this goal, the vertical irregularity structures with 30 storeys, 7X7 bays from the first to the tenth floor, 5x5 bays from the eleventh to the twentieth floor, and 3x3 bays from the twenty-first to the thirty-first floor, along with outriggers and belt truss at various floors, were examined. For the structure with the first and second location of the outrigger, the maximum Storey Shear and Axial Load of different columns are observed. It also concludes that the most effective location of the outrigger is between 0.5 times of height of structure.

D. *Srinivas Suresh Kogilgeri, Beryl Shanthapriya "A STUDY ON BEHAVIOUR OF OUTRIGGER SYSTEM ON HIGH RISE STEEL STRUCTURE BY VARYING OUTRIGGER DEPTH" International Research Journal of Engineering and Technology (IRJET), e-ISSN: 2319-1163, Volume-02, Issue-07 (2015)*

One of the best systems for high rise constructions to resist lateral forces is the outrigger system. By lowering the depth of the outrigger, an effort has been made in the current study to examine the static and dynamic behavior of the outrigger structural system on steel structures. The software ETABS v2013 models 5X5 bay 40 story steel constructions. A comparison is made between a steel structure with a central core and a steel structure with an outrigger structural system that has different outrigger depths. In addition to the full story height, the outrigger's depth is decreased to 2/3 and 1/3 of the story height. Every construction maintains a belt truss with a depth that is equal to the height of a typical storey. Lateral deflection and storey drift are two of the important variables covered in this work. According to the analysis's findings, there are only little differences in the way that lateral stresses are resisted by outriggers with full storey depth and those with reduced depth.

E. *Daril John Prasad, Srinidhilakshmish Kumar "COMPARISON OF SEISMIC PERFORMANCE OF OUTRIGGER AND BELT TRUSS SYSTEM IN RCC BUILDING WITH VERTICAL IRREGULARITY" International Research Journal of Engineering and Technology (IRJET), e-ISSN: 2319-1163, Volume-05, Issue-20 (2016)*

One of the major factors limiting the building's upward movement is its height. In today's cities, tall skyscrapers are unavoidable. As a result, the construction needs an efficient system capable of actively participating in the case of a wind or earthquake. Outrigger-belt truss systems are one example of this type of system. One of the main objectives of this article is to analyze outrigger, belt truss, and outrigger with belt truss models that all have the same location in them. A 30-story structure with vertical irregularity is subjected to seismic analysis in accordance with IS 1893 (Part-1): 2002, which compares factors such as base shear, lateral displacement, and storey drift using finite element software ETABS. A seismic analysis was carried out utilizing the equivalent static and response spectrum methods. Buildings with both an outrigger and a belt truss system perform better than those with an outrigger system alone in terms of lateral displacement.

F. *Syed Rizwan Nasir, Amaresh S. Patil "LATERAL STABILITY ANALYSIS OF HIGH RISE BUILDING WITH THE EFFECT OF OUTRIGGER AND BELT TRUSS SYSTEM" International Research Journal of Engineering and Technology (IRJET), e-ISSN: 2395-0056, Volume-03, Issue-08 (2016)*

The optimal usage of outrigger and belt truss systems for high-rise concrete buildings subjected to wind or seismic loads is investigated in this research. Seven 44-story two-dimensional models of outrigger and belt truss systems are subjected to wind and earthquake loads, then studied and compared to determine the lateral displacement reduction associated with the different types of outrigger and belt systems. The purpose of the study was to see how the outrigger system affected and performed in a 44-story structure. The outrigger system is installed at various levels across the structure's height. In all models, the depth of the Outrigger and belt trusses is equal to the height of the usual storey. Lateral deflection, storey drifts, base shear, and fundamental time periods are some of the key parameters examined in this study. From this study it can concluded that the steel outriggers are found least effective compared to Concrete one. Steel outriggers can be employed as the light weight substitute for concrete.

G. *Raad Abed Al-Jallal Hasan "BEHAVIOR OF BEAM AND WALL OUTRIGGER IN HIGH RISE BUILDING AND THEIR COMPARISON" International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD) ISSN(P): 2249-6866, Volume-06, Issue-01 (2016)*

This article compares beam and wall outrigger systems and gives an overview of outrigger systems. In this research project, a 30 story skyscraper with three structures was examined. After performing a response spectrum analysis, the behavior of the buildings was assessed by taking into account response variables including lateral displacement and story drift. This study has demonstrated that the wall outrigger structure is more effective than the beam outrigger structure. The employment of outrigger in structures, which can cleverly resolve the identified issues in high-rise projects, is one of the most efficient approaches.

H. *Akashay Khanorkar et al. "OUTRIGGER AND BELT TRUSS SYSTEM FOR TALL BUILDING TO CONTROL DEFLECTION: A REVIEW" GRD Journal for Engineering ISSN: 2455-5703, Volume-01, Issue-06 (2016)*

Building height has increased as a result of population growth, particularly in emerging nations, and this necessity has an effect on the structural advancement of tall buildings. As a building rises in height, wind and earthquake pressures become more significant. As a result, new structural systems such belt trusses and outriggers are needed to strengthen the building's stiffness against lateral loads. This study reviews a number of approaches and procedures used to look into the application of outrigger and belt truss systems in tall buildings. The many factors relating to outrigger and belt truss, such as lateral displacement, storey drift, core moment, and optimal position are reviewed. It is helpful to propose a potential solution by employing the studied approach for the design and development of tall buildings using outrigger and belt truss.

I. *Prajyot A. Kakde, Ravindra Desai "COMPARATIVE STUDY OF OUTRIGGER AND BELT TRUSS STRUCTURAL SYSTEM FOR STEEL AND CONCRETE MATERIAL" International Research Journal of Engineering and Technology (IRJET), e-ISSN: 2395-0056, Volume-03, Issue-08 (2016)*

Outrigger and belt truss structural systems are examples of structural systems that have developed over time to overcome lateral stability and sway problems. The outrigger and belt truss structural solution has proven to be the most promising in system of lateral stability and sway resistance. The present study is for a 70-story high-rise structure with a core shear wall. With a building aspect ratio of 7, a high-rise building with a floor plan of 30 m × 30 m and a core shear wall of 10 m x 10 m is considered.

The software used for this analysis is ETABS 2016 version, and it is used to study parameters such as maximum storey displacement, inter storey drift, and base shear in order to compare the building with the application of concrete and steel outriggers at various positions varying with the height of the building. From this study it can be conclude that steel outrigger and belt truss system is found to be efficient in comparison to concrete outrigger and belt truss system.

J. *Bishal Sapkota et al. "COMPARATIVE STUDY ON SEISMIC PERFORMANCE OF HIGH-RISE BUILDING WITH ENERGY DISSIPATION AND OUTRIGGER BELT TRUSS SYSTEM" International Journal of Civil Engineering and Technology (IJCIET), ISSN Online: 0976-6316 ,Volume-08, Issue-04 (2017)*

The investigation of the seismic performance of a high-rise building with an outrigger belt truss system and a damper as an energy dissipation system is the topic of this research paper. Controlling lateral deflection and inter-storey drifts in high-rise buildings subjected to lateral loads is the most difficult challenge to overcome. The use of outrigger and belt truss frameworks could improve the structural performance of a high-rise building when subjected to lateral loads. The performance of a 40-story RC structure with various numbers and positions of outrigger belt truss systems and dampers is compared to that of a conventional structure. To investigate the behavior of the building under three different seismic waves, non-linear time-history analysis was used with the software SAP2000. From this study it can be conclude that the inter-storey drift of the building with dampers as energy dissipation system is more uniform than the building with outrigger belt truss frameworks.

K. *A Suresh et al. "INFLUENCE OF CONCRETE AND STEEL OUTRIGGER AND BELT TRUSS IN HIGH RISE MOMENT RESISTING FRAMES" International Research Journal of Engineering and Technology (IRJET), e-ISSN: 2395-0056, Volume-08, Issue-04 (2017)*

This study examines how well outrigger and belt truss systems can support high-rise concrete structures that are being subjected to earthquake or wind loads. To determine the lateral displacement reduction associated to the types of outrigger and belt system, seven 44 storey two dimensional models of outrigger and belt truss systems are subjected to wind and seismic load, studied, and compared. The analysis was done to investigate the impact and effectiveness of the outrigger system in the 44-story building. The outrigger system is offered at various heights along the building's height. The depth of the Outrigger and belt trusses is maintained constant throughout all models and is equal to the height of the typical storey. Lateral deflection, storey drifts, base shear, and fundamental time periods are some of the important characteristics covered in this study. From this paper it can be conclude that X-braced Outriggers will have the least amount of lateral displacements possible compared to other Outrigger shapes in the building frame.

L. *Pankaj Sharma et al. "DYNAMIC ANALYSIS OF OUTRIGGER SYSTEMS IN HIGH RISE BUILDING AGAINST LATERAL LOADING" International Journal of Civil Engineering and Technology (IJCIET), ISSN Online: 0976-6316, Volume-09, Issue-08 (2018)*

In this study, a 180 m-tall skyscraper with 60 floors conducted a dynamic analysis of the outrigger system. First, a performance comparison between single and multiple outriggers was made. Next, analyses of several outriggers, including the X, V, Inverted V, and shear wall with and without a belt, were done. The placement of the outriggers followed Taranth's theory. ETABS software was used to examine frames with simply a shear wall core and other outrigger models, and compare various characteristics like Maximum Story Displacement, Maximum Story Drift, and Story Shears. All the models were examined using dynamic analysis for earthquake load (response spectrum) and static analysis for wind load. It was found that the number of outriggers increases the structure's resistance to lateral load. Although shear wall was utilized as an outrigger, it performed better than steel outriggers when compared to X, V, and inverted V type steel outriggers. Outriggers' impact is further increased by belt trusses or shear bands.

M. *Archit Dangi, Sagar Jamle "DETERMINATION OF SEISMIC PARAMETERS OF R.C.C. BUILDING USING SHEAR CORE OUTRIGGER, WALL BELT AND TRUSS BELT SYSTEMS" International Journal of Advanced Engineering Research and Science (IJAERS), ISSN Online: 2456-1908, Volume-05, Issue-09 (2018)*

The behavior of lateral load resisting systems has been studied using structural analysis for decades, and the outrigger structural system has played great in this regard. The purpose of this research is to investigate the effects of earthquake forces on a high-rise G+10 3D computer model RCC structure. According to the Taranath method, the outrigger placement was used. The performance of seven different cases is observed using the response spectrum method, including regular, shear core, outrigger and wall belt, and outrigger and truss belt supported systems.

These were investigated, and characteristics including base shear, column axial forces, and member shear forces were investigated. This article also discusses efficient cases for all of the parameters. From this study it can be conclude that wall belt system is more effective than truss belt system.

N. *B. Putlaiah, P. Hanuma "COMPARATIVE STUDY OF USAGE OF OUTRIGGER AND BELT TRUSS SYSTEM FOR HIGH-RISE CONCRETE BUILDINGS" International Journal of Research in Engineering and Technology (IJRET), ISSN Online: 2395-0056, Volume-06, Issue-09 (2019)*

Tall building lateral stability is an essential consideration in safe analysis and design. 3D model is generated in ETAB 2016. This paper introduces the concept of Virtual Outrigger, which is a relatively new concept. In this paper, the use of only the belt truss in the building is investigated in order to improve the building's performance under dynamic loads. The advantages of using Virtual Outriggers instead of Conventional Outriggers are highlighted. The building is strengthened in the lateral direction by installing Outrigger and Belt truss systems at every 9 to 10 storey level. For lateral stability study, two methods of analysis were used: linear static and linear dynamic for both seismic and wind. For a better understanding of tall buildings when subjected to strong seismic and wind forces, different factors such as lateral displacement, maximum storey drift, storey shear forces, storey moments, and storey overturning moments are taken into account. From this study it can be conclude that the outrigger scheme has shown to be effective in tangential freight control and to be cost-effective.

O. *A0rchit Dangi, Sagar Jamle "STABILITY ENHANCEMENT OF OPTIMUM OUTRIGGERS AND BELT TRUSS STRUCTURAL SYSTEM" International Journal of Research in Engineering and Technology (IJRET), ISSN Online: 2395-0056, Volume-06, Issue-02 (2019)*

Various analyses have shown that the structure's stability is exclusively dependent on its structural components, which are connected to one another and transfer loads. However, when the structure's height increases and it is subjected to seismic and gravitational loads, its stability decreases. On a G+10 multistory residential structure in seismic zone IV, a shear core outrigger and belt supported system is being implemented. Using the optimum location given by the Taranath approach, the general structure was compared to both wall belt and truss belt supported systems. To calculate nodal displacement, narrative drift time period with mass involvement, and beam stress values, the response spectrum approach is applied. This work employed a total of seven cases, compared them to one another, and found that the most effective case was the one covered in this article.

P. *M. Samadi, N. Jahan "DETERMINING THE EFFECTIVE LEVEL OF OUTRIGGER IN PREVENTING COLLAPSE OF TALL BUILDINGS BY IDA WITH AN ALTERNATIVE DAMAGE MEASURE" International Journal of Advanced Structural Engineering (2019)*

The findings of an analytical investigation on the effectiveness of outriggers in preventing the collapse of tall buildings with braced core systems during two sets of distant and near field earthquakes are presented in this work. As a result of the columns failing under extreme near-field conditions, NLTHA results demonstrated that tall structures with braced cores made of stronger bracing and designed in accordance with UBC97 will collapse. Similar structures may withstand the same earthquakes if they had optimal braces and were built in accordance with AISC341-16 or RC shear wall core. In order to prevent building collapse, many levels were looked at for the outrigger location along building height. Investigating the improvement brought about by the installation of outriggers required doing incremental dynamic analysis on the structural models under study. The point of structural collapse can be more precisely described by a new damage metric that has been developed for use in IDA. It was found that two outriggers, one at the second storey and the other at roughly 0.14 height of structure, must be installed in order to successfully prevent the collapse of examined structures under extreme near-field records.

Q. *Wael Alhaddad et al. "A COMPREHENSIVE INTRODUCTION TO OUTRIGGER AND BELT-TRUSS SYSTEM IN SKYSCRAPERS" Engineering Structures 27(2020)*

The outrigger and belt truss system's popularity is due to its efficiency, which has been clarified and demonstrated by a large number of studies that examined and investigated various aspects of the system. As a result, a comprehensive review is necessary to combine and summarize the important ideas and approaches from earlier studies in order to provide direction for designers and researchers, particularly those who are new to this field of research. Due to the vast research area of this system, the paper will only show the components, configurations, and types of outrigger system from various perspectives, factors that affect performance, structural behavior of the system under various loading types, the advantages and disadvantages of outrigger systems, and a

summary of the main design issues that will be discussed in later reviews. As a result, this article can be used as a focal point for researchers and designers to understand the scope of this system, as well as to avoid as many of the system's defects as possible, resulting in more efficient outrigger system use and the ability to implement this system into design provisions and guidelines.

R. *Yusuf Calayir et al. "EFFECTIVENESS OF OUTRIGGER AND BELT TRUSS SYSTEMS ON THE SEISMIC BEHAVIOR OF HIGH-RISE BUILDINGS" Journal of Structural Engineering & Applied Mechanics, ISSN: 2630-5763,Volume-03, Issue-03 (2020)*

In this paper the modal time history analysis approach was used to .investigate the linear earthquake responses of three structural models: shear wall-framed system, shear wall-framed system with traditional outriggers, and shear wall-framed system with belt trusses. The lateral displacements and drifts of structure as well as the internal forces of structural element were evaluated. These results of three structural models were compared, and the effectiveness of outrigger and belt truss systems was examined. Three real earthquake records were chosen for earthquake input. These records were scaled and used in the analysis based on the DD2 level earthquake design spectrum specified in Turkish Building Earthquake Standards (2018).

S. *B. G. Kavyashree et al. "EVOLUTION OF OUTRIGGER STRUCTURAL SYSTEM: A STATE-OF-THE-ART REVIEW" Arabian Journal for Science and Engineering (2021)*

The evolution of the outrigger structural system from the traditional outrigger to the damped outrigger concepts is presented in this work. Consideration is given to the evolution of the outrigger structural system from the conservative design as a rigid link to a virtual connection with passive control, active control, semi-active control, and hybrid control systems. The history of outriggers, types of outriggers, analyses of tall buildings without outriggers, and the development of equations for outrigger structures to facilitate analysis is briefly covered in the sections that follow. A different method for determining the ideal arrangement of outriggers in tall structures is explained. The damped outrigger system is reviewed, and an analysis of outrigger to analyze its behavior in high-rise buildings using various methodologies is mentioned. The goal of this work is to emphasize the benefits of outrigger structures with semi-active control and performance enhancement of the outrigger system with efficient devices. Improved outcomes are also shown. This evaluation also sets the door for a brand-new branch of structural control research that incorporates smart gadgets and technology.

III. CONCLUSION

According to the results of the above research, it is clear that various researchers have looked at various earthquake-related issues and have decided that outrigger and belt truss systems are more effective at withstanding lateral stress imposed on by earthquakes. Along with manual investigations, analysis is also combined using software like STAAD Pro, ETABS, etc. In order to determine where in the building the structure is displaced the least, models are created and outriggers and belt truss systems are placed at different levels. Additionally, some studies identified the ideal location for an outrigger system. The best location for the outrigger to minimize displacement is between 0.5 times heights of the structure (P. M. B. Raj Kiran Nanduri et al. 2013). With a second outrigger at 0.67h, drift and deflection are reduced by 11.5% and 12.78%, respectively. Middle height of the building is best for the second outrigger's location (Shivacharan K et al. 2015). Belt trusses alone can be used as the lateral load resisting element in structures with vertical irregularity because building with outriggers and belt trusses may be uneconomical and also decrease working space (Daril John Prasad, Srinidhilakshmish Kumar 2016). It can be used as the most cost-efficient structure because the outriggers added to a braced core wall were somewhat less successful than solid core walls at controlling lateral displacement. In comparison to seismic forces, outriggers are better at reducing the wind effect (Syed Rizwan Nasir, Amaresh S. Patil 2016). In comparison to concrete outriggers, steel outriggers are shown to have reduced storey displacement, storey drift, and base shear. In compared to concrete outrigger and belt truss systems, steel outrigger and belt truss systems are proven to be more effective overall (Prajyot A. Kakde, Ravindra Desai 2017). The least amount of lateral movement is shown by the X-braced outriggers, which are then followed by the Inverted V-braced Outriggers and V-braced Outriggers. It can be used as the most cost-efficient construction because the outriggers provided with Braced Core Walls were marginally less successful in decreasing Lateral Displacement than Solid Core Walls (A. Suresh et al. 2017). The performance of the building improves as the number of outriggers grows, and using belt trusses and shear bands in addition to outriggers is more efficient than using only outriggers. Shear walls are far more effective than steel bracings, and inverted V type steel outrigger bracing beams are the most effective among X, V, and inverted V types (Pankaj Sharma et al. 2018). However, the use of two outriggers, one at the second story and the other at a level of around 0.14 of the structure height, could prevent the collapse of the structure. However, the arrangement of the building may also affect these outrigger placements (M. Samadi, N. Jahan 2019).

The future focus of the research will be the comparison of seismic behavior of RCC high rise building with and without outrigger and belt truss system and combination of both the system for different earthquake zones and types of soil.

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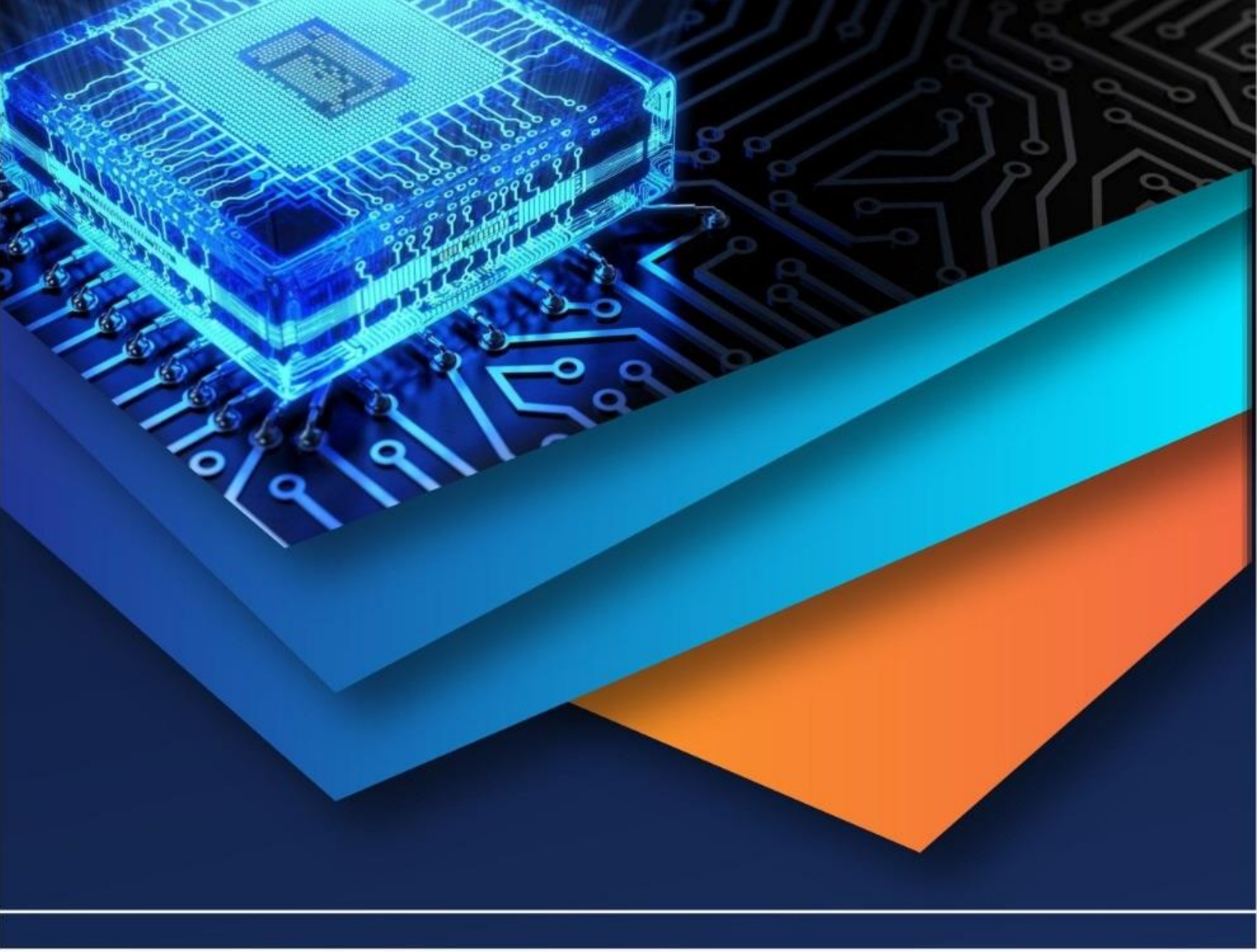

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