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A Comparative Study on Seismic Assessment of Building Using SMA in Base Isolation and Beam Column Joints

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Abstract: The seismic design of the moment-resistant plastic frames is aimed at forcing the structure to respond to the strong action of the weak beam, in which plastic loops are expected to form into beams on the faces of the columns. The regions of the khang are described in detail in such a way that the output of longitudinal steel bars allows to dissipate the energy of the earthquake. If SE SMA is used as a reinforcement instead of steel in the right places of the hinges or in the basic insulation, it will not only be able to dissipate adequate seismic energy, but also restore its original shape after the seismic event. Due to the higher cost compared to the cost of other building materials, SMA longitudinal ribs can be used together with steel ribs in the articulated areas of the beams. Such BCJs can allow design engineers to design connections that show minor damage and mitigate joint repairs after an earthquake.
Keywords: Seismic, base isolation, SMA, beam, column & joints

I. INTRODUCTION

Common seismic design practice considers structural damage acceptable in severe earthquakes, provided that the structure is plastic enough to undergo large plastic deformations without destruction. Inelastic activity of the structure is usually intended for concentration in particularly detailed critical areas, for example. at the ends of the beams in framed structures. However, the inelastic behavior of such regions, allowing energy to dissipate, leads to significant damage to structural elements. Moreover, inter-storey drifts, which occur under strong earthquakes, cause great damage and collapse of non-structural elements, such as brick walls, partitions, etc. Radiation column connections (BCJs) in RC-motor-resisting frames are generally considered to be the weakest link in such a structural system. Beginning in the 1970s, design codes began to apply stricter seismic provisions to detail reinforcing bars in the BCJ. However, BCG remains extremely vulnerable during earthquakes. It was emphasized that earthquake-resistant structures must be sufficiently plastic, as it is difficult and expensive to build structures that can operate in an unstable mode under strong ground movement. In the conventional seismic design of RC structures, reinforcing bars are expected to dissipate energy, leading to permanent deformations due to the post-productive plastic properties of steel reinforcing bars.

II. LITERATURE REVIEV

Mumtasirun Nahar. et.al: the safety of the seismic collapse of five different types of SMA-RC beam-column connections is compared with conventional steel-RC beam-column connections by numerical analysis. Nonlinear static push analysis is performed for all types of beam column connections to determine the limit values of these connections.

Amruta Thomas and Dr. Alice Matthew: The aim of the study is to investigate the effectiveness of SMA equipped with LRB using the ABAQCUS FEM platform by developing a model of the finite elements of the conventional and SMA LRB. To analyze the response of a ten-storey building isolated from SMA LRB .

E.J Graesser and F.A Cozzzereli: New results are presented in the field of hysteretic modeling and experimental characteristics of form memory alloys (SMA). Micromechanical phase transition caused by stress occurs in SMA, which causes inelastic deformation and leads to a large energy-absorbing ability.

Meng Zhan et.al: Based on the over-reliability of the form memory alloy (SMA) and the piezoelectric transition electrodeformation (PZT), a new SMA / PZT (SPCCD) composite control device and its energy dissipation efficiency and neuronal network have been developed.

Ahmad Bashofi Habib et al. One of the most promising devices for seismic basic insulation of structures is an unrestrained elastomeric insulator (UFREI) due to low production cost and horizontal rigidity. This article explores the possibility of combining UFREI wires and memory-alloy forms (SMA) to increase the power dissipation power of the isolation system for seismic protection of the historical treasure church.

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III. SYSTEM DEVELOPMENT

Pushover analysis is a nonlinear static method used in performance-based analysis. The method is relatively easy to implement, and provides information on the strength, deformation and plasticity of the structure and the distribution of requirements that help identify critical members that can reach boundary states during an earthquake, and therefore can be given due attention during design and detail. This method involves a set of gradual lateral loads on the height of the structure. Local nonlinear effects are modeled and the structure is put forward to develop a collapse mechanism. As the load increases, weak connections and failure modes of buildings are detected. This method is relatively simple and provides information on the strength, deformation and plasticity of the structure and the distribution of requirements. This allows you to identify critical members who can reach boundary states during an earthquake by forming plastic loops.

IV. PERFORMANCE ANALYSIS

This study examines three eight-story reinforced concrete structures with a torque-resistant frame. The buildings have a uniform history height of 3.44 m with row spacing of 3.96 m and 4.67 m in horizontal and transverse directions, respectively. In the first case, the outer hinge of the column is considered, and the SMA is applied to the region using a priestly and poly formula, the second case is considered SMA with basic insulation, and the third case is considered a common case without SMA. Code ASCE-41-17 is considered with seismic zone 2 and seismic design category B. Nonlinear analysis on structures. All three structures are developed and analyzed in the SEISMOSTRUCT 2020 software.

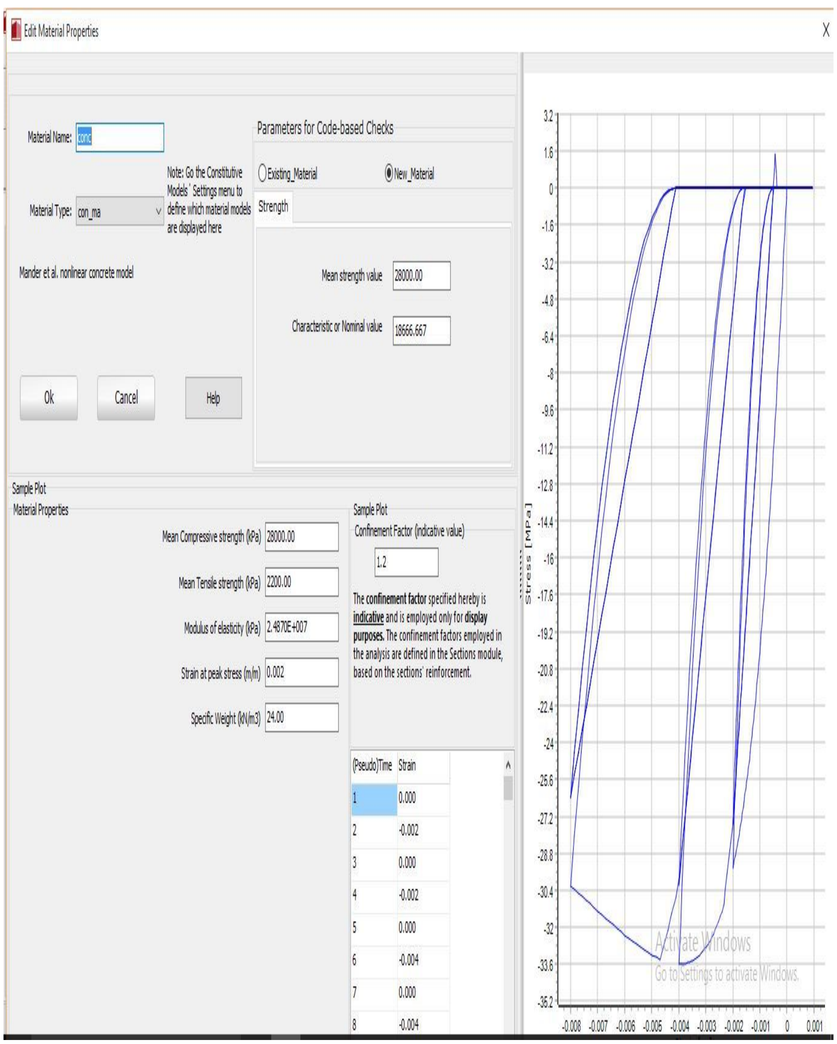

Fig.1: Mander et al nonlinear concrete model

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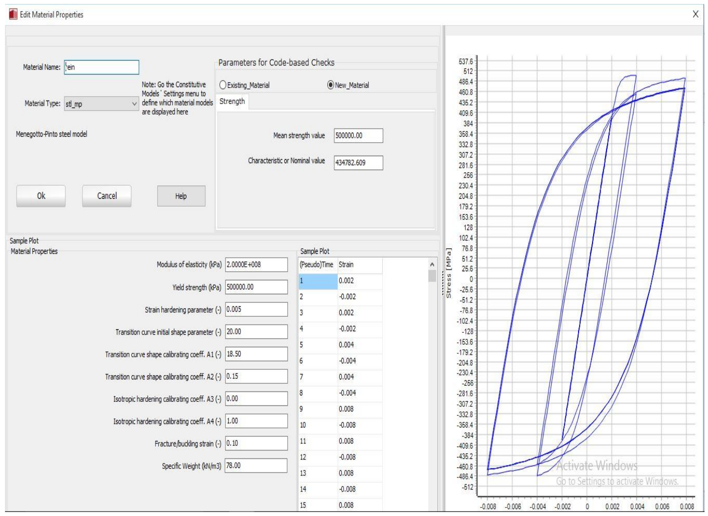

Fig.2: Monti-Nuti steel model

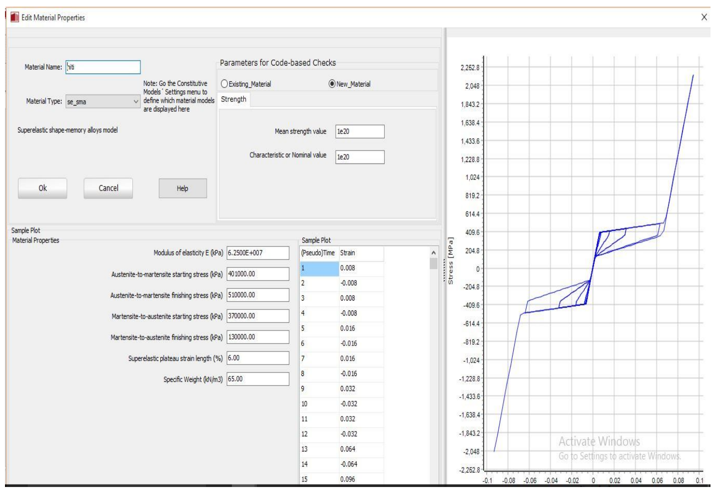

Fig.3: Shape memory alloy model

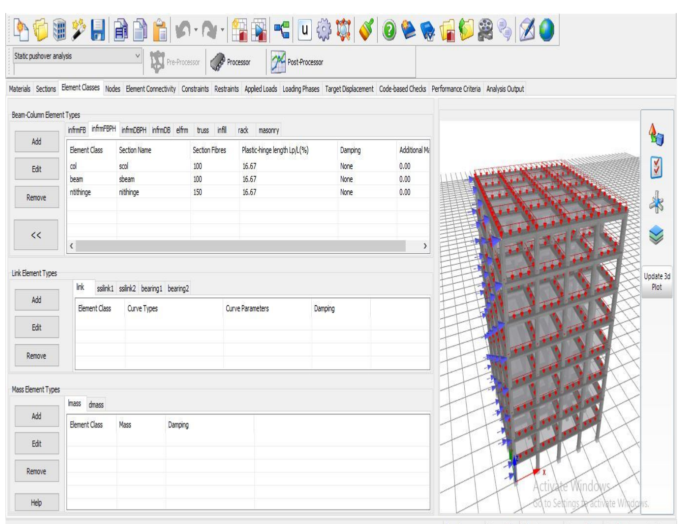

Fig.4: Defining element class for beam and column section

All the defined sections are defined with their element classes as ‘Inelastic force based plastic hinge frame element type. This is the force-based 3D beam-column element type capable of modeling members of space frames with geometric and material nonlinearities. Structural nodes are all those to which an element, of whichever type, is attached to. In fact, in SEISMOSTRUCT, it is not possible to run an analysis of any type if a node that has been defined as "structural" does not feature at least one element connected to it.

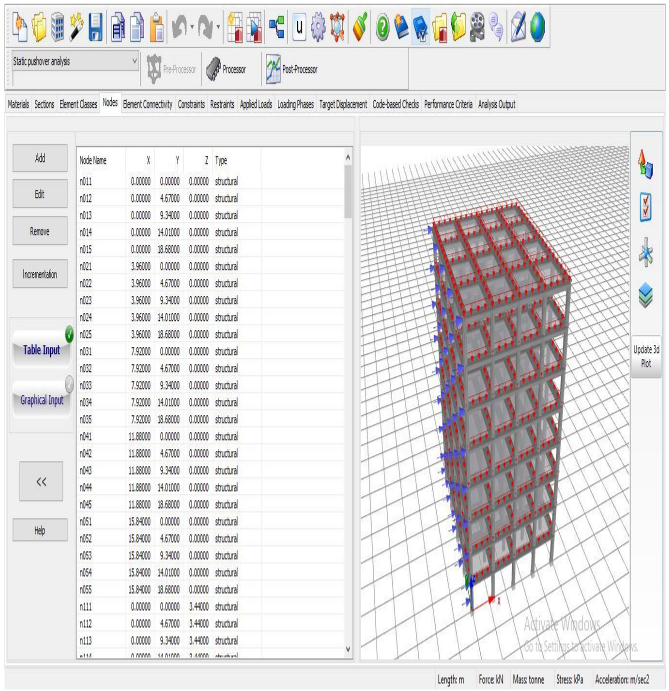

Fig.5: Defining and checking nodes assigned

V. RESULTS AND DISCUSSION

From the literature survey, it is predicted that Superelastic Shape Memory Alloys (SE SMAs) are unique alloys that have the ability to undergo large deformations and return to their undeformed shape by removal of stresses. Using shape memory alloy at beam column joint or in base isolation it is possible to keep the building safe with large deformation and time period of the building may increase using SMA in base isolation. Pushover analysis has been performed on all three G+8 structures in SIESMOSTRUCT 2020.

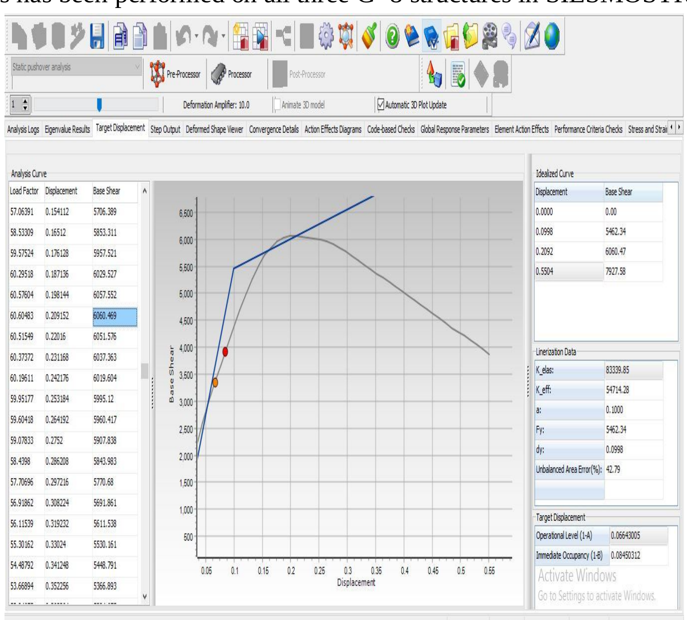

Fig.6: Obtained base shear value in SEISMOSTRUCT

Base shear is an estimate of maximum expected lateral forces on the base of the structure due to seismic activity. The base shear obtained 6060.49 KN for the structure where SMA used in beam column joints. 6751.208 KN for SMA used in base isolation and 7009.834 for the structure without SMA.

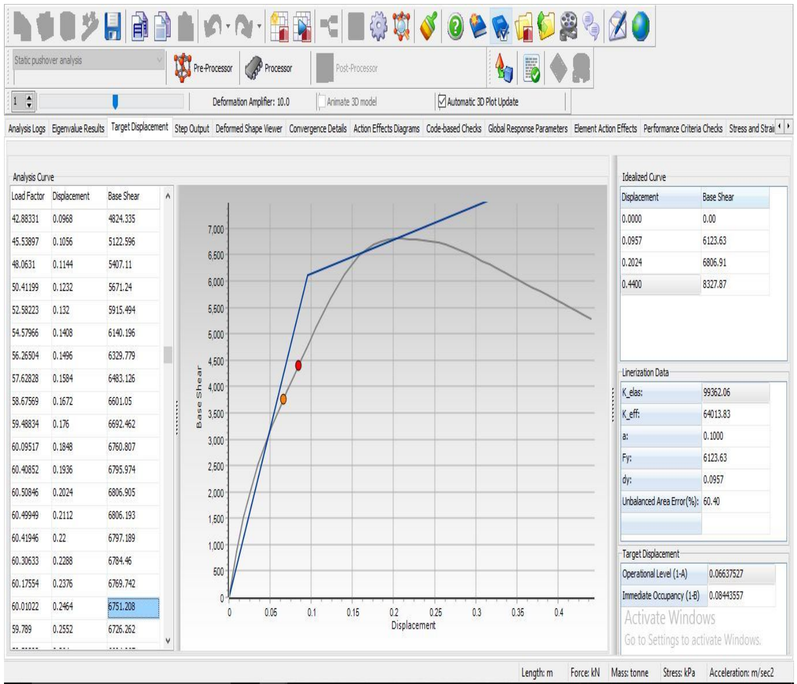

Fig.7: Obtained base shear value in SEISMOSTRUCT

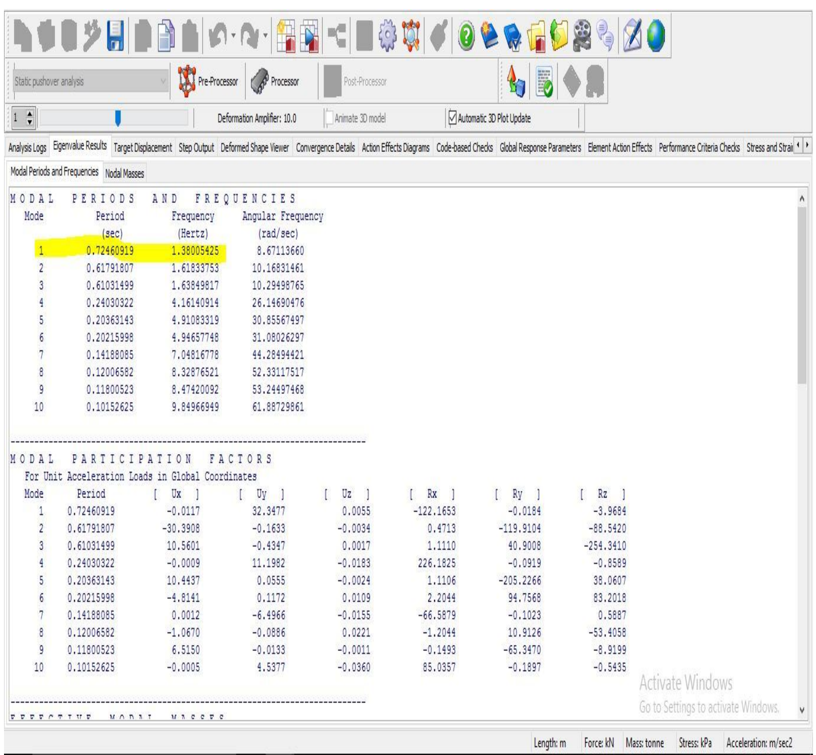

Fig.8: Obtained Eigen value results in SEISMOSTRUCT

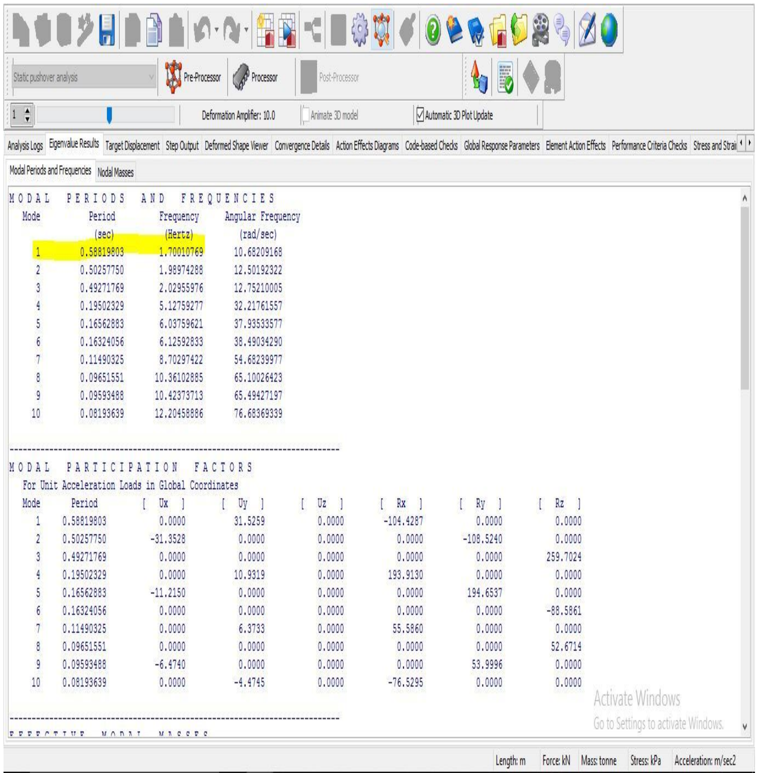

Fig.9: Obtained Eigen value results in SEISMOSTRUCT

VI. CONCLUDING REMARK

The proposed work will be helpful in understanding and performing the analysis and designing a structure with various tools effieciently. Comparative study of the results for different configurations will be helpful. Realistic behaviour of the strucutre will be assessed and design of the structure to satisfy the desired performance objective will be provided with the proposed line of action.

The results can be summarized as follow

Time period of the structure increases by the use of SMA in both structure where SMA is used which reduces the transfer of lateral forces at the time of earthquake.

Models showed reduced base shear in both structure using SMA compared to structure without SMA. Using SMA in beam column joints has less value compared to SMA in base isolation.

All the fixed base building show zero displacements at the base whereas, the base isolated building show increase in amount of Storey displacements at base.

The results show that the responses of structures can be reduced by the use of the SMA.

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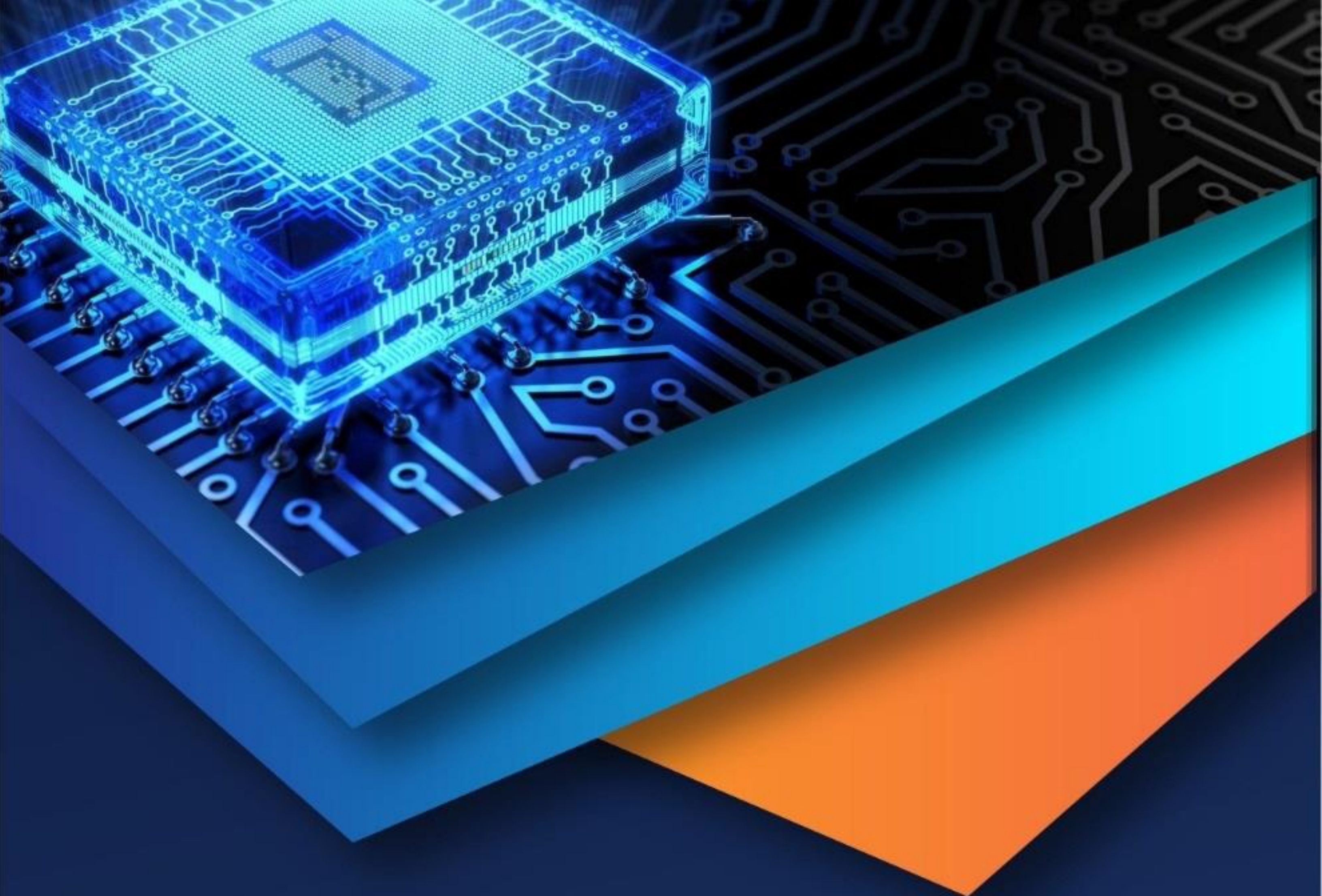

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