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Seismic Retrofitting of RC Frame Structure Using Energy Dissipation Device

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***Abstract:** This study examines the performance-based design of structure that is increasing commonly in earthquake resistance design. to ensure any structure possess earthquake resistant design, certain minimum performance objective is desired at different level of seismic excitation. With the help of some devices, Low to medium rise buildings are performing well for the seismic actions.In the present work, originally deficient RC frame is analyzed with static analysis and after this static non- linear analysis is performed in which suitable energy dissipation devices are installed sequentially. first analyzed with Viscous fluid Damper then Lead- rubber isolator is used has designed as per performance-based design criteria of G+6 RC frame building. These models are analyzed for important residential use and located at seismic zone IV. Linear static and nonlinear static methods are used to analyze the structure with help of CSI ETABSv18 software. Results which are discussed is minimum performance level, story drift,performance point and performance objective.*

After analysis of results, structure which is installed with Led-rubber bearing isolator is performed well during an earthquake and satisfy with desired minimum performance level. In case of viscous fluid damper, it is not satisfactory to achieve desired minimum performance up to this extent it helps to reduce floor acceleration.

I. INTRODUCTION

Seismic retrofitting is the modification of existing structures to make them more resistant to seismic activity, ground movement, or ground breaking caused by earthquakes. With a better understanding of the seismic needs of structures, and with our recent experiences with large earthquakes near urban centers, the need for seismic modernization is well recognized. Before the advent of modern seismic codes inthe late 1960s for developed countries (USA, Japan, etc.) and in the late 1970s for manyother parts of the world (Turkey, China, etc.), many structures have been designed without full details. and reinforced for seismic protection. In view of the impending problem, various studies have been carried out. Modern engineering guidelines for seismic assessment, modernization and recovery have been published worldwide, such as those from ASCE-SEI 41 and the New Zealand Society of Earthquake Engineering (NZSEE).

These codes must be updated regularly; such as the 1994 Northridge earthquake highlighted the fragility of welded steel structures. The retrofitting techniques described here can also be applied to other natural hazards such as tropical cyclones, tornadoes, and strong winds caused by thunderstorms. While the practice of modernizing earthquake resistance is primarily concerned with improving the structureto reduce the seismic risks associated with the use of the structure, the reduction of risksand losses due to non-trivial factors. It should also be noted that there is no such thing as a seismic structure, although seismic performance can begreatly improved with a suitable initial design or subsequent modifications.

II. OBEJECTIVES

In this project, three building structure model are considered having irregularity in plan (L - shape) and which is originally deficient to seismic loading. Static non-linear analysis i.e. (pushover analysis) is done using ETABS 2018 software. The objective of thesis are: -

1) To estimate the capacity of the structure using nonlinear analysis.
2) To obtain the performance point of building.
3) To check, building meet the minimum performance level at the moderate seismic zone.
4) To reduce the demand of structure using energy dissipation devices.

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III. SEISMIC RETROFITTING OF BUILDING

Retrofitting refers to providing something with a component or feature that was not present during design and manufacture/construction. Often used in relations to installation of new building systems, such as heating systems etc. Refurbishment implies to a process of improvement by cleaning, decorating, reequipping and may also contain elements of retrofitting.

Renovation of a project refers to the process of returning something to a good state of repair. In terms of heritage constructions, returning the project to its previous state throughretrofitting and refurbishment is called 'Restoration' or 'Rehabilitation'.

The Differences between retrofitting and refurbishment A single project may include elements of retrofitting, refurbishment and renovation. The whole process of renovating an old project into a new building containing elements of retrofitting and refurbishment is called the Rehabilitation of the project. Retrofitting is usually done to an undamaged project as a preventive measure, while on damaged and old buildings, the process of retrofitting is called Rehabilitation.

Structural retrofitting, in terms of buildings, can be broadly classified as Seismic Retrofit usually refers to modifications to make the building more resistant to seismic activity, ground motion and soil failures due to earthquakes. These retrofit methods are also applicable for other natural hazards as well. The techniques mostly achieve lateralbracing increasing lateral strength, ductility and lateral stiffness in the building.

Non-Seismic retrofit encompasses all other kinds of retrofitting ranging from damages done due to deterioration by aging, error in design, construction flaws etc. the techniques are varied, ranging from increase in size of beams and columns, to increasing concrete cover by adding layer of concrete or plaster.

IV. MODELLING AND ANALYSIS

This chapter explained that, the 3D building model is analyzed using the static nonlinear pushover analysis method. The residential building models G+6 RCC is analyzed using CSIETABS v18 software. The seismic codes are unique to the country. In India, Indian Standard for design of seismic structures IS 1893:2016 is the main standard that provides the outline for the calculation of seismic design forces.

Table 1 Analyzed model description

S. No.	Model Description	Structure Description
01	Model 1	RCC Framed structure
02	Model 2	RCC Framed structure with viscous fluid damper
03	Model 3	RCC framed structure with laminated rubber bearingisolator

Table 2 General Specification of Building	
Geometric Details	
Structure	Building Structure
Types of Buildings	RC frame structure
Plan Area	540 M^2
No. of Story	G+6
Typical Story Height	3m
Bottom Story Height	3m
Material Properties (Concrete)	
Grade of concrete	M-30
Weight per unit Volume (KN/M^2)	25 KN/m^3
Modulus of Elasticity, E (MPa)	27386.12
Poisson's Ratio U	0.3
Coefficient of Thermal Expansion, α (1/°C)	$5.5x10^{-06}$
Shear Modulus, G (MPa)	11410.89
Material Properties (Steel Rebar)	
Grade of Steel	Fe-500
Weight per unit Volume (KN/M^2)	78.5 KN/m^3
Modulus of Elasticity, E (MPa)	$2x10^5$
Coefficient of Thermal Expansion	0.0000117
Member Properties(mm)	
Slab Thickness	150 mm
Size of Beams	250x500
Size of column	450x450
Primary Load	
Floor Finishing Load (Dead Load)	1.25 KN/m^2
Live Load	2.0 KN/m^2
Wall Load (on Each Beam)	12.5 KN/m
Seismic Properties	
Seismic Zone	IV
Zone Factor (Z)	0.24
Response Reduction Factor (R)	5
Importance Factor (I)	1.5
Soil Type	II
Damping Ratio	0.05
Analysis Software: ETABS 2018	

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A. Plan And Three Dimensional View Of Building

The figure showing below the plan and three-dimensional view of all models with or without energy dissipation devices which is considered for nonlinear analysis. To achieve the desired building performance objective in a deficient building structure.

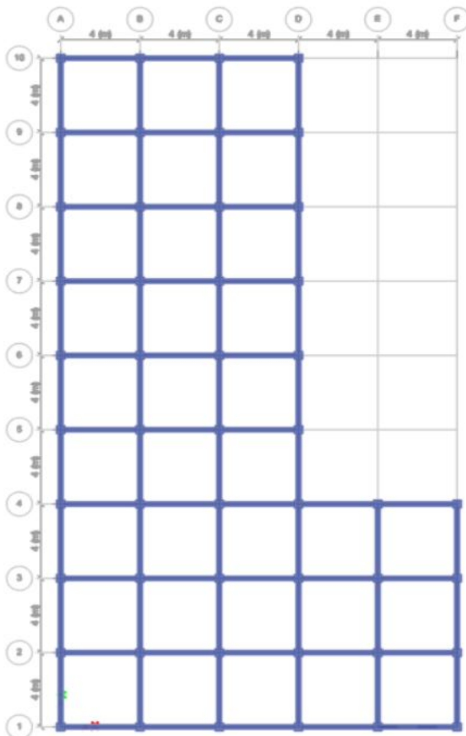

Figure 1 Showing plan of RC Building

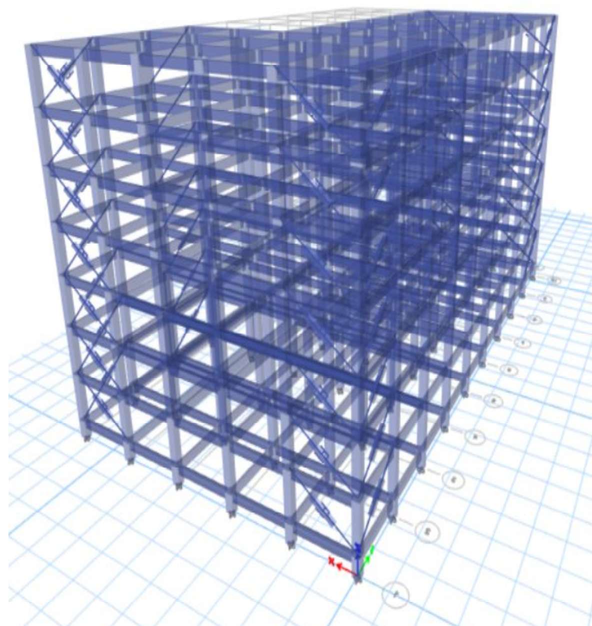

Figure 2 Showing 3DView with VFD

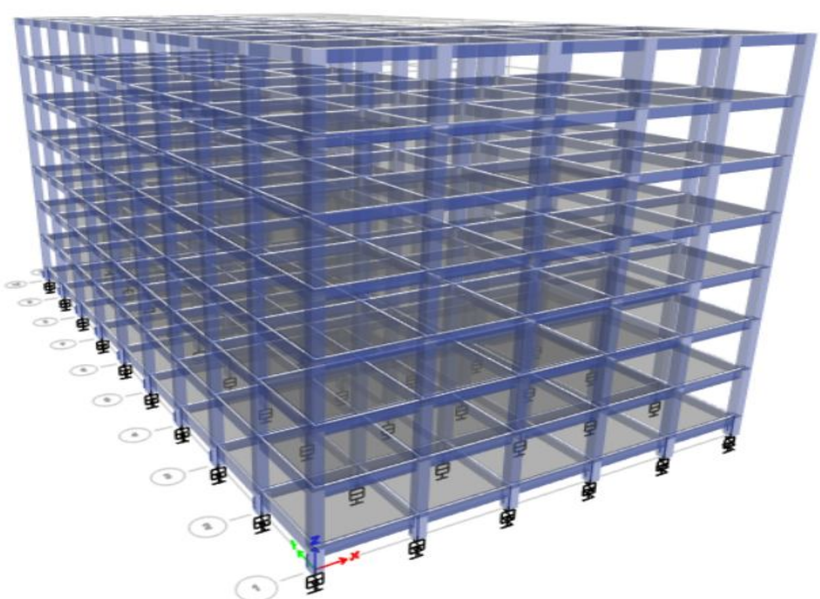

Figure 3 Showing 3D view with base isolator

V. RESULT & DISCUSSION

After Modelling and analysis of above-mentioned structures following results are deduced for Model 1, Model 2, and Model 3 for G+6 stories structure. Results are then compared to assess the structural responses on the basis of story displacements, base shear, hinge results & performance point.

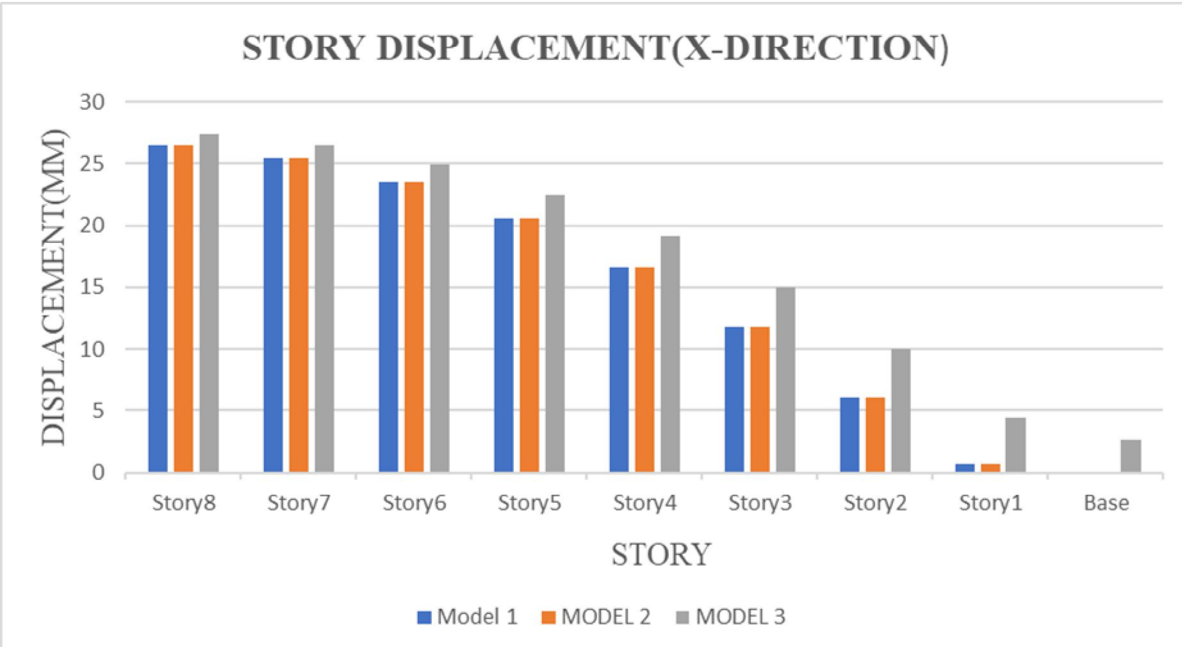

Figure 4 Showing story displacement of all three model in (X-direction)

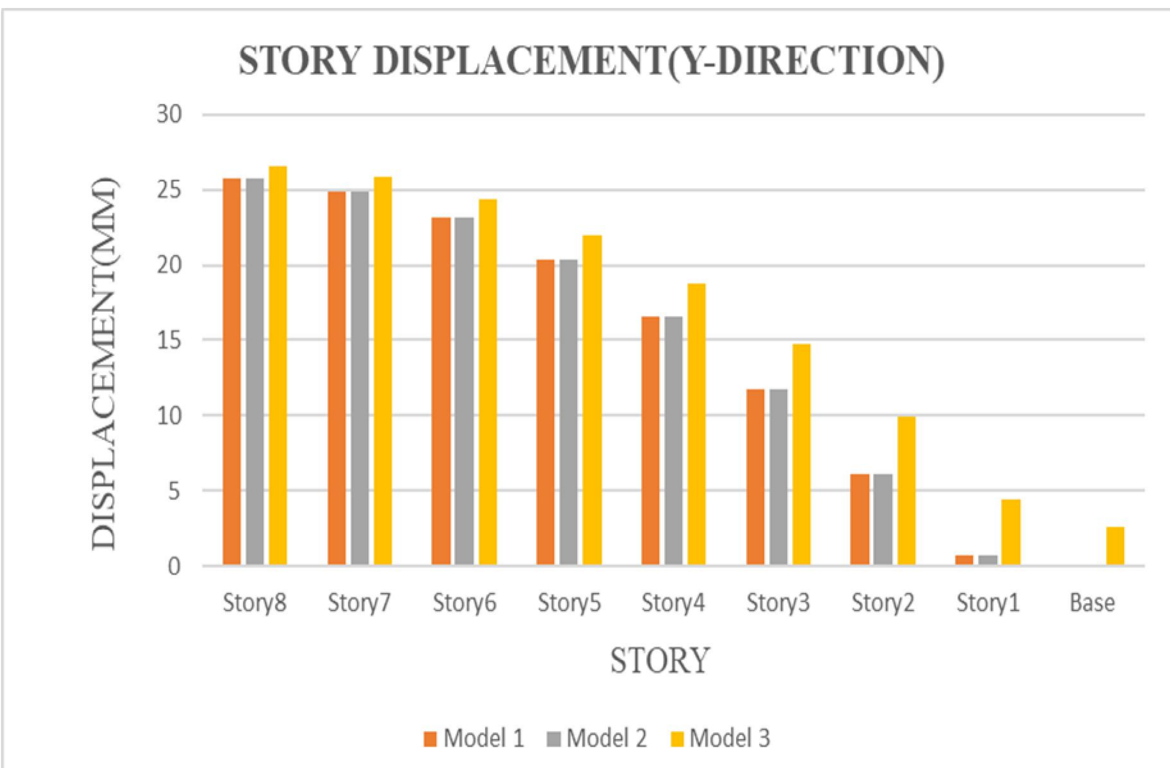

Figure 5 Showing story displacement of all three model in (Y-direction)

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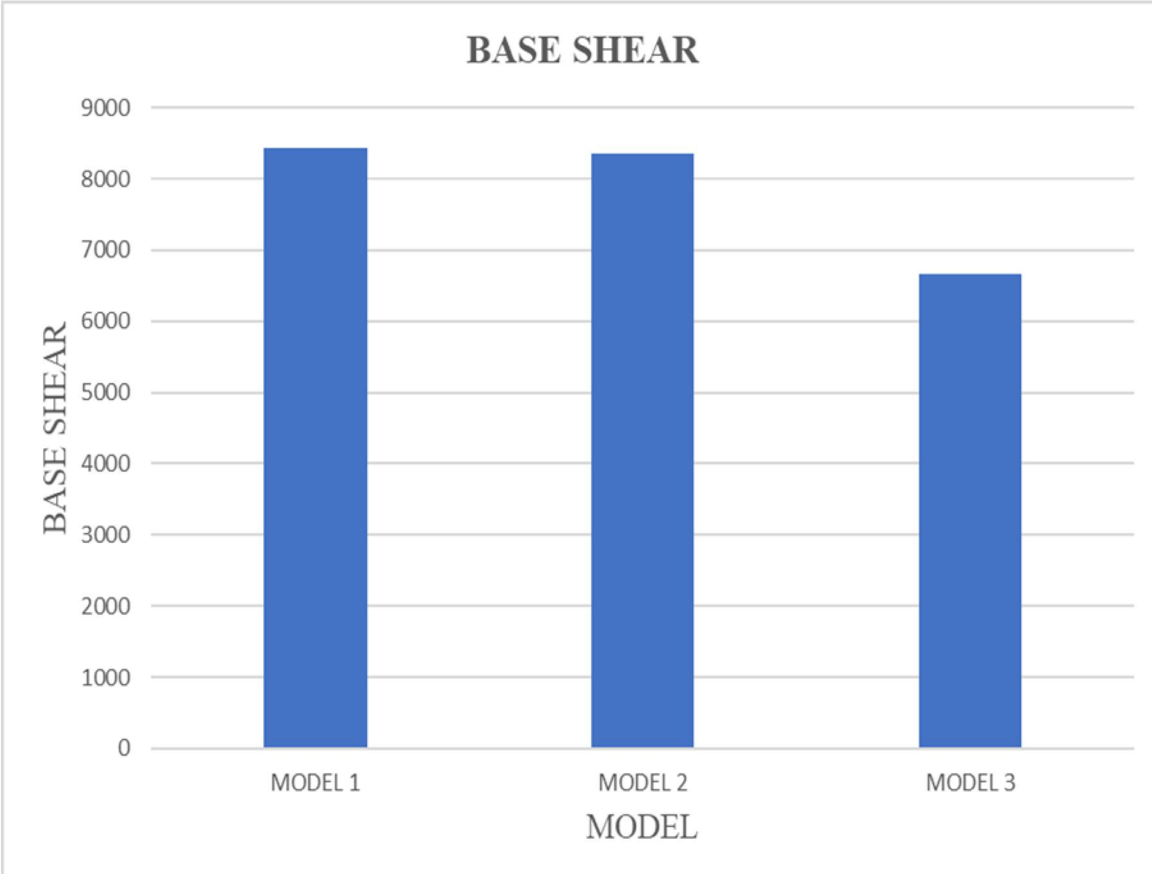

Figure 6 Showing base shear of all three model

Figure 7 Showing performance point of all three model

VI. CONCLUSION & FUTURE SCOPE

A. Conclusion

1) Deflection of the stories from the initial position is termed as story displacements and its maximum value is obtained at the top story. the maximum value of story displacement in x-direction in model 3 is 27.43, where as in model 1 & model 2 are same.
2) The maximum value of story displacement in y-direction in model 3 is 26.589, where as in model 1 & model 2 are same.
3) The value of base shear under nonlinear static analysis are reduced about 1% in model 2 and 21% of model 3 as compare to model 1.
4) The reduction of base shear is due to installed devices. Viscous fluid dampers ineffective to reduced base shear up to some extent but are effective in controlling other story parameter. In model 3 base shear reduced considerably, due to installing led rubber isolator.
5) The performance point, in first model taken as step 10 (which actually lies between steps 9 and 10), 99% of hinges are within LS and 91% within IO performance level. A Δroof top of 0.246 m, with the height of the building up to roof top h (which excludes the staircase tower room) being 22.2m, gives a Δroof top to h ratio of 0.01108 (in an average sense) which lies within the performance level of IO.
6) The performance point, in second model taken as step 10, of hinge results (which actually lies between steps 9 and 10), 98% of hinges are within LS and 91% within IO performance level. A Δroof top of 0.228 m, with the height of the building up to rooftop h (which excludes the staircase tower room) being 22.2m, gives a Δroof top to h ratio of 0.010270 (in an average sense) which lies within the performance level of IO.
7) The performance point, taken as step 11, of hinge results (which actually lies between steps 10 and 11), 100% of hinges are within LS and 88% within IO performance level. A Δroof top of 0.300 m, with the height of the building up to rooftop h (which excludes the staircase tower room) being 22.2 m, gives a Δroof top to h ratio of 0.01351 (in an average sense) which lies within the performance level of IO.
8) After performing displacement control push over analysis on all model it is observe that, model which is deficient to lateral load initially is not perform well. To satisfy the minimum performance criteria. After installing device (damper) in second model, formation of hinges at collapse level is further increasing which are inappropriate.
9) In third model, hinges are formed in the immediate occupancy level (IO level), which is the minimum performance requirement of any important structure to meet the essential services at the time of emergency.
10) The hinges at performance point of all model at different level are showing the structure performance against inelastic responses.
    a) In first model, 92% of hinges at(A-IO) level, 7% of hinges lies in the (IO- LS) range & 1% of hinges at CP level.
    b) In second model, 92% of hinges at(A-IO) level, 7% of hinges lies in the (IO- LS) range & 1% of hinges at CP level.
    c) In third model, 89% of hinges at(A-IO) level, 11 % of hinges lies in the (IO- LS) range & no hinges at CP level.

B. Scope of Future Work

The following enlist point work is taken under future to extend the topic further whichare as follows:

1) For the Viscous Fluid Damper and Led rubber bearing isolated model considered in these studies are inelastic and Nonlinear static analysis; this provides a further scope tostudy this problem using an inelastic dynamic for all models.
2) Address dynamic analysis to simulate the site-specific other criteria which are not accommodated in nonlinear static analysis.
3) To meet the minimum performance level under the MCE/DBE case other requirement need to be checked.
4) Investigation of different EDD's for finding the best suitability of seismic retrofitting technique.
5) Use the other combination of one or more energy dissipating device for achieved minimum performance level for given guidelines of different manufactures and compare them.

C. Summary

The procedure of analysis using ETABS 2018 software to obtains results from the analysis. The considered models are analyzed and comparative results were developed using pushover analysis. It is found that, the model in which dampers are installed are suitable to reduce drift limit while the model in which base isolation is used. Base shear reduces significantly compare to other considered model and performance objective are attained due to installation of such devices.

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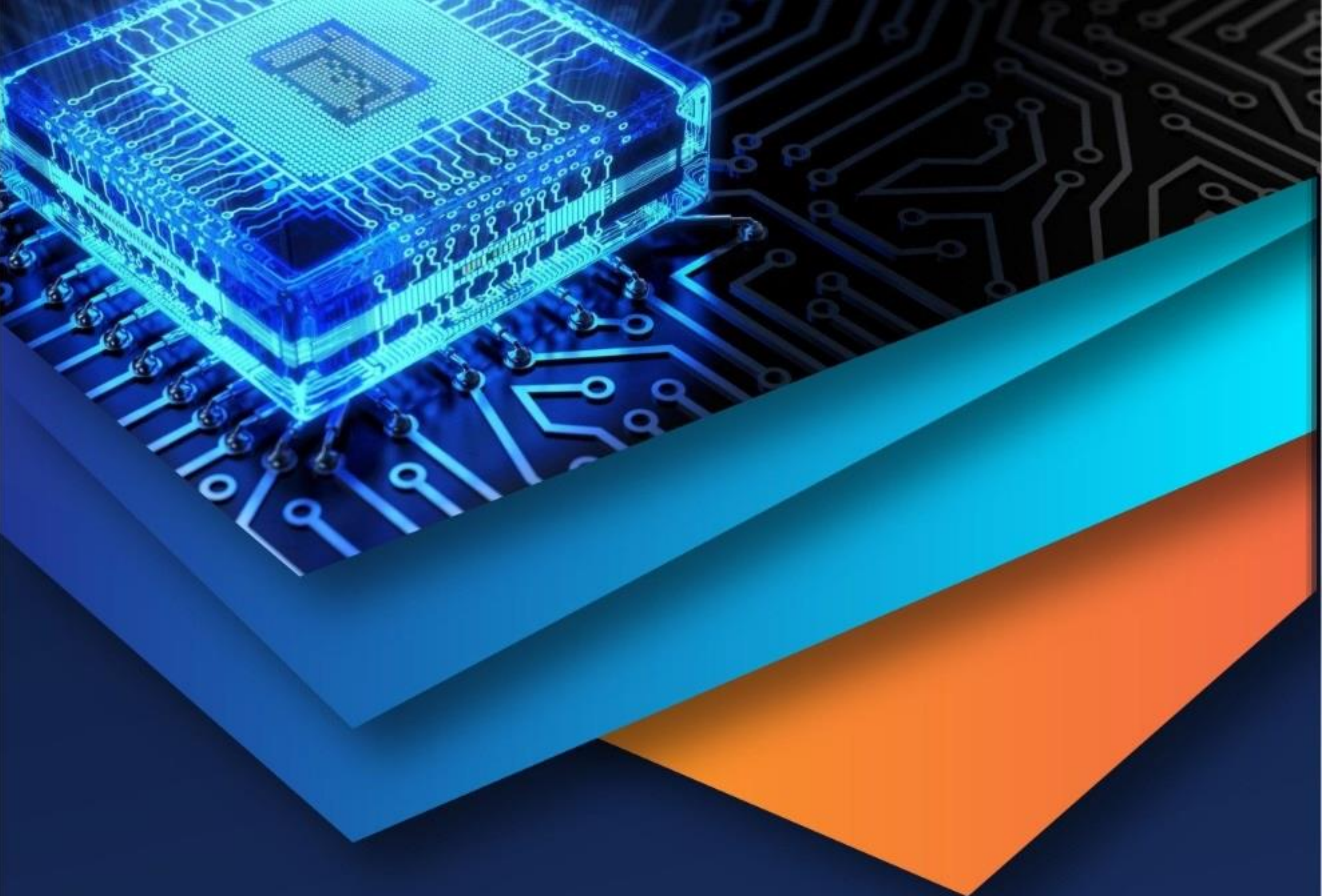

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