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Rehabilitation Assessment on Seismically Damaged Irregular Bridge

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Abstract: Bridges are lifeline structures and their performance is critical during and after the earthquake. The RC Bridge decks, supported on unanchored elastomeric pad bearings are free to move over substructure during an earthquake. Excessive deck displacement causes unseating and sometimes complete collapse of the deck leading to closure of the bridge for long periods. The problem worsens for irregular bridge with significant variations in the pier/pile heights. For that type of bridges base isolation techniques are the best method to protect it from earthquake and for a partially damaged building retrofitting techniques are best to protect further damages for working condition. We are here to discuss the rehabilitation assessment of seismically damaged irregular bridge namely changappa bridges by isolation technique and retrofitting technique.
Keywords: RC Bridge, elastomeric pad bearings, bridges base isolation techniques, retrofitting technique

I. INTRODUCTION

The bridge is a rigid structure which built on obstacle for providing the passage over an obstruction. The required passage may be for railways, roads, canals, pipelines etc. There are different types of bridges each serves a specific purpose and selected at different situations. Bridges and flyovers are major assets of any country and failure of such structures during seismic event leads to economic loss to the country and traffic disruptions to the general public. Despite their importance, these key infrastructure assets have been designed for many years, neglecting the fact that loads and geo-hazards may change drastically and thus significant upgrades may be required during their service life. Societies expect accelerated constructions, minimal damage and rapid upgrading for bridges which are sources of transportation and thus must be designed to face very strong earthquake in order to avoid permanent drift which are beyond repairs. Collapse of whole bridge caused by extended damage of the piers and/or unseating of the superstructure caused by insufficient deformation capacity of the bearing and other destruction of bridge structure often occurs in an earthquake .The concept of ductility is used in the conventional design of bridge pier wherein the pier reinforcement is detailed to develop flexural plastic hinges at the base and top of pier. Although bridges designed in this manner may undergo damages due to severe earthquake excitations. Rocking isolation in the form of structural rocking or geotechnical rocking of the bridge pier experience far less damage when subjected to high intensity earthquake ground motion with added bonus of pier that re enter due to the increased period of vibration owing to the flexibility of the resilient pier .

II. PREVIOUS RESEARCH

Nirav Thakkar and Durgesh C. Rai, (2014) gathered a study about Seismic vulnerability of an Irregular bridge with elastomeric pads. This study is conducted at chengappa bridge. From their study they found that the unsatisfactory seismic performance of chengappa bridge during the 2004 earthquake is due to the irregularity in the pier height and lack of restrainers to arrest the deck displacement. Under this earthquake the bridge will experience d the collapse of decks and unseating with elastomeric pad bearings. By providing the restrainers improve the deck displacement. Nonlinear force–deformation behavior of elastomeric pa bearings modeled usingFriction Isolator link element of SAP 2000 was able to predict the observed response in the 2004 Sumatra-Andaman earthquake for comparable ground motions. Under design level earthquake ground motions, the model predicted that the bridge will experience unseating of the decks and possible collapse of decks, indicating the higher vulnerability of irregular bridges with elastomeric pad bearings. Due to absence of displacement arresters, there is greater likelihood that the bridge will experience problems like unseating and collapse of more than one deck. For irregular bridges, requirement of minimum seating width shall be addressed separately from regular bridges considering the out-of-phase movement of piers. With the provision of restrainers, dynamic characteristic of the bridge was significantly improved and the shear pin helped in reducing the transverse displacement demand of the deck slab. Bridge codes should emphasize on requirement of anti-dislodgement devices, such as, shear keys and links or cables to arrest excessive displacement of the bridge deck.

III. OBJECTIVE

The objectives which is considered for the finite element analysis are,

A. Replacement of elastomeric pad bearing by using Friction pendulum bearings to obtain a minimum deck displacement and economic conditions
B. Seismic retrofitting using dampers by different parameters like deck positions

IV. MODELING AND ANALYSIS OF METALLIC PIPE DAMPER

The bridge is modeled in SAP2000.Drawing is done by Auto cad and it is imported to the software. All members are drawn in different layer. Long girder, Cross girder, Pile cap, Pile ,Pile connecting beam, Pier, Pier cap are the members

1) Length -268m RC bridge
2) 12 cast in place piers
3) Precast girder
4) Cast in site slab
5) Deck slab -9.3 m wide , divided in to 20.6m span
6) Expansion gap – 50mm
7) Slab thickness- 200mm
8) Slab support on 4- 1.35 m deep I girder at 2.3 m spacing
9) Pier diameter- 1.5m connected by 1.8m wide and 0.8m deep pier cap beam
10) At foundation 4 pile of 0.8m diameter

Time history analysis

Time history analysis is a step-by- step analysis of the dynamic response of a structure to a specified loading that may vary with time. Time history analysis is used to determine the seismic response of a structure under dynamic loading of representative earthquake. We are providing elcentro earthquake to find the displacement of bridge deck which is built-in software SAP2000 and elcentro earthquake has a zone factor nearly equal to 0.36 corresponding to zone V

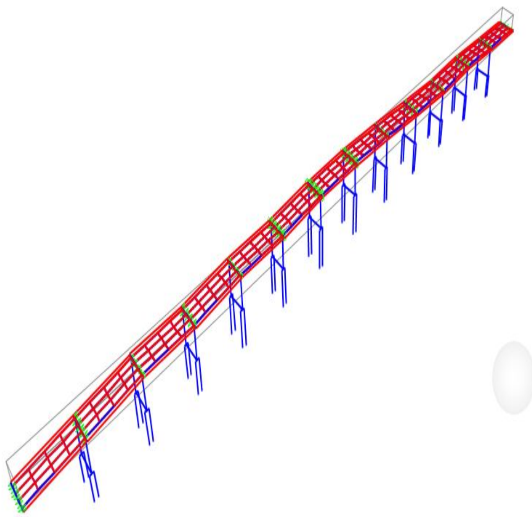

Fig.1. model of bridge by using triple pendulum friction isolator

A. Case 1 Replacement of elastomeric pad bearing by using Friction pendulum bearings to obtain a minimum deck displacement and economic conditions

In here we are replacing the existing elastomeric pad bearing using triple pendulum bearing for getting the economic conditions as well as to reduce the displacement of deck slab. For that 16 models are considered for the analysis from that best 2 models are give the minimum displacement and economic condition. The model details are discussed in table 1 sown below

TABLE I
MODEL DETAILSE

Models	Replacement details of elastomeric pad bearing
M1	Replaced at deck 7
M2	Replaced at decks 6,7
M3	Replaced at decks 6,7,8
M4	Replaced at decks 5,6,7,8
M5	Replaced at decks 5,6,7,8,9
M6	Replaced at decks 6,7,8,9
M7	Replaced at decks ,7,8,9
M8	Replaced at decks 2,4,6,8,10,12
M9	Replaced at decks 1,3,5,7,9,11,13
M10	Replaced at one side of each deck slab
M11	Replaced at zig zag deck slab
M12	Replaced at one side of longitudinal deck slab
M13	Replaced at decks 3,5,7,9
M14	Replaced at decks 5,7,9
M15	Replaced at decks 4,6,8
M16	Replaced at decks 6,8

The best condition occurs in model M2 and in M3

V. CASE 2 SEISMIC RETROFITTING USING DAMPERS BY DIFFERENT PARAMETERS LIKE DECK POSITIONS

In here viscous dampers are used to retrofitting the Changappa Bridge. At 2004 earthquake the bridge deck as a maximum displacement 235mm at deck 7 is taken to bring the deck slab of the bridge to working condition retrofitting techniques are tested here. The details about viscous damper are shown in the Fig.2 and Fig.3 Almost 10 models are considered in ere and their details can be seen in Table2

Model no	Replacement details of elastomeric pad bearing
M17	Replaced at deck 7
M18	Replaced at decks 6,7
M319	Replaced at decks 6,7,8
M20	Replaced at decks 5,6,7,8
M21	Replaced at decks 5,6,7,8,9
M22	Replaced at decks 6,7,8,9
M23	Replaced at zig zag deck slab
M24	Replaced at one side of longitudinal deck slab
M25	Complete replacement
M26	Replaced at one side of each deck slab

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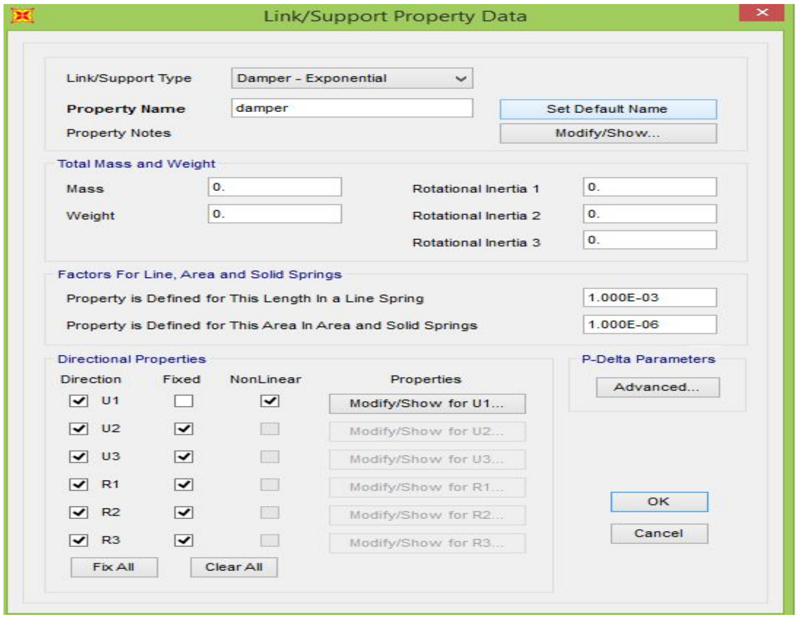

Fig. 2 support property of damper

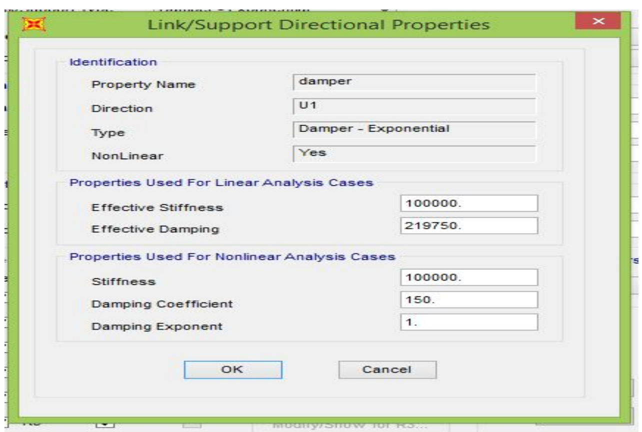

Fig.3 directional properties of damper

VI. RESULT AND DISCUSSION

Influence of passive controlled metallic pipe damper in a building is analysed using nonlinear pushover analysis. For that the dampers are installed in single frame to find its energy dissipation capacity. As a result of this analysis in ANSYS software the ultimate load carrying capacity of DPD and improved pipe damper is obtained. To study these three objectives are considered such as the nonlinear lateral resisting capacity of dual pipe damper, nonlinear investigation of pipe damper with increase in number of metallic pipe in damper and the nonlinear investigation of pipe damper with various bracing configurations.

A. Case 1 Replacement of elastomeric pad bearing by using Friction pendulum bearings to obtain a minimum deck displacement and economic conditions

In here we are find the maximum deck displacement of deck slab under elcentro earthquake by replacing the elastomeric pad bearing by triple friction pendulum bearings. In here we are taken about 16 models but from the 16 model best results give only the 2 models model M2 and M3 and tat case are detailed discussed here It is coded that for smooth working of a bridge the deck displacement must be less tan 200mm. so by considering the 200mm as cut off we are discussing the deck displacement and at which deck the maximum occurred and which deck are have value more than 200 mm are found and variation of the deck displacement are represent in the graph also. The details of deck displacement for are shown in Table 3 and its graphical representation also shown below graph Fig 4 for model M2 which has a replacement of elastomeric pad bearing at 6,7 by triple friction pendulum bearing

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TABLE IIII
deck displacement for triple friction pendulum bearing replaced at deck 6,7

Deck number	Deck displacement in mm
1	19.1
2	89.4
3	132.7
4	141.4
5	179.7
6	136.1
7	181.1
8	227.4
9	156
10	127
11	136.3
12	112.7
13	48
14	26.4

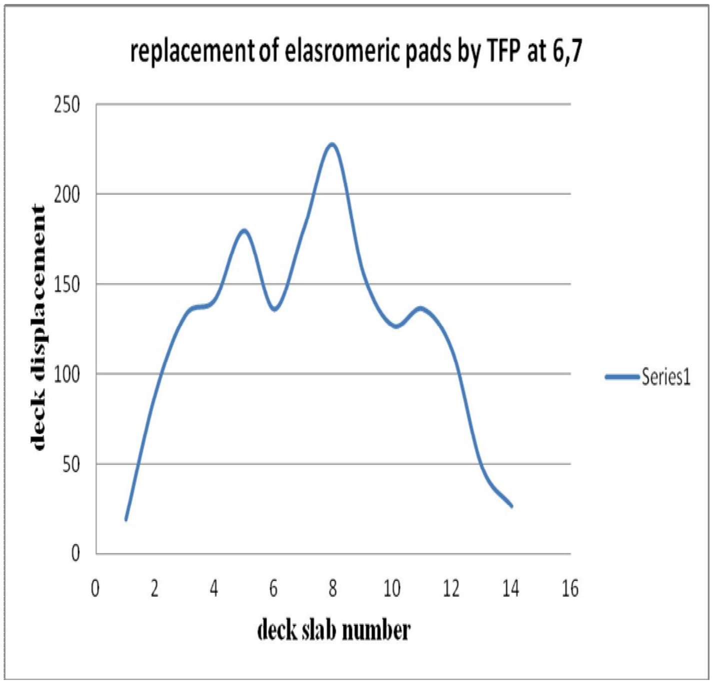

Fig. 4 graph of deck displacement under replacement of elastomeric pad by TFP

When we check the values deck displacement it is found that the maximum deck displacement is shifted to deck 8.so now we are considering the model M3tat is the replacement of elastomeric pad bearing by triple friction pendulum bearing at deck slab 6,7 and 8. The details of deck displacement for are shown in Table 4 and its graphical representation also shown below graph Fig 5 for model M3 which has a replacement of elastomeric pad bearing at 6,7 and 8 by triple friction pendulum bearing

TABLE IV
deck displacement for triple friction pendulum bearing replaced at deck

Deck number	Deck displacement in mm
1	19.5
2	89
3	132.7
4	142.5
5	177.7
6	134.4
7	183.5
8	174.1
9	158.4
10	138.4
11	135
12	102.2
13	41.8
14	21

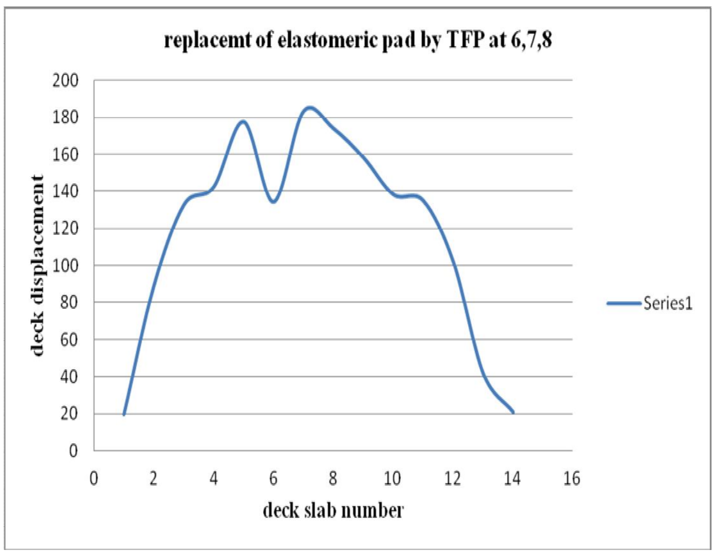

Fig. 5 graph of deck displacement under replacement of elastomeric pad by TFP at 6,7,8

By checking the two case we can see that model M3 has all deck displacement less than 200mm so we can compare the model M2and M3.

B. Case 2 Result of Seismic Retrofitting Using Dampers By Different Parameters Like Deck Positions

In here we are find the maximum deck displacement of deck slab under elcentro earthquake by replacing the elastomeric pad bearing by viscous damper. In here we are taken about 10 models but from the 10 model best results give only the 2 models model M18 and M19 and that case are detailed discussed here It is coded that for smooth working of a bridge the deck displacement must be less tan 200mm. so by considering the 200mm as cut off we are discussing the deck displacement and at which deck the maximum occurred and which deck are have value more than 200 mm are found and variation of the deck displacement are represent in the graph also. The details of deck displacement for are shown in Table 5 and its graphical representation also shown below graph Fig 6 for model M18 which has a replacement of elastomeric pad bearing at 6,7 by viscous damper at it is retrofitting technique applied to any bridge

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TABLE V
Deck displacement for damper replaced at deck 6,7

Deck number	Deck displacement in mm
1	39.2
2	116.8
3	122.9
4	163
5	179.1
6	108.3
7	117.2
8	195.1
9	175.3
10	117.3
11	137.8
12	119.3
13	49.9
14	29.8

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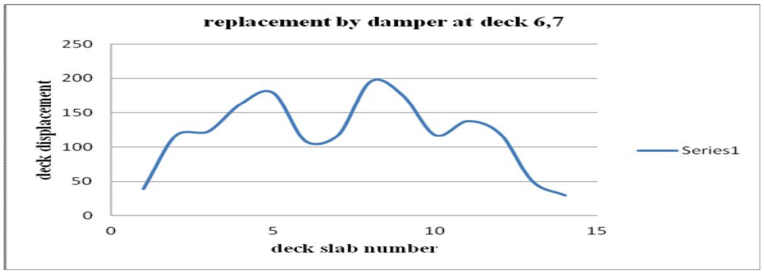

Fig. 6 graph of deck displacement under replacement of elastomeric pad by damper at 6, 7

When we check the values deck displacement it is found that the maximum deck displacement is shifted to deck 8.so now we are considering the model M19tat is the replacement of elastomeric pad bearing by viscous damper at deck slab 6,7 and 8

TABLE VI
Deck displacement for damper replaced at deck 6,7and 8

Deck number	Deck displacement in mm
1	43
2	124.7
3	123.2
4	179.6
5	182.9
6	112.6
7	112.3
8	108.5
9	160.7
10	140.5
11	118.2
12	135
13	66.6
14	46.3

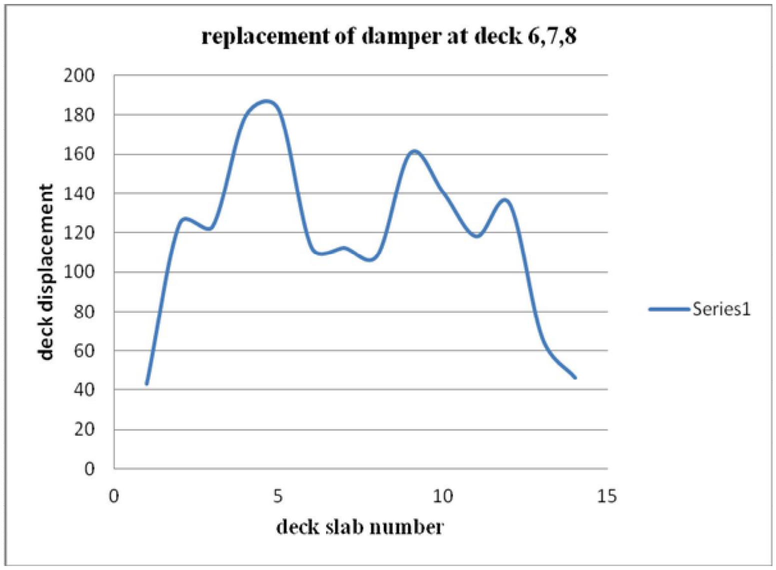

Fig. 7 graph of deck displacement under replacement of elastomeric pad by damper at 6,7and 8

By checking the two case we can see that model M19 has all deck displacement less than 200mm so we can compare the model M18and M19 by the

VII.CONCLUSION

For the chengappa bridge the deck slabs are unseated at the 2004 earthquake The elastomeric pad bearing isolators in the bridge can only control up to a limitand it can be see that at deck 7 the most venerable case of damage happed as adeck displacement of 233.1mm which is more than 200mm unseating of deck slab taken place **.**Due to that a more suitable isolators can be used on the bridge and Triple friction pendulum bearing isolators are more capable than other isolators in bridge and use of triple friction pendulum bearing isolators are not much economical instead of using elastomeric isolators all over bridge So that use of TFP only at the venerable deck slabs that is at deck slab 6,7,8 will lead to most economic and efficient method to control deck displacement**.** When we use the TFP at only the deck 6, 7 we can see that the deck displacement will increases towards deck 8 and will reduce when we use TFP at deck 6,7,8. Instead of using TFP when we use damper as a retrofit we can get efficient and most economic model with much less deck displacement . when we use damper at 6,7 we can see the sift of maximum deck displacement to deck 8 so that replacement elastomeric pad bearing at deck slab 6,7 and 8 will give most economical and efficient model that is model M19

VIII. ACKNOWLEDGMENT

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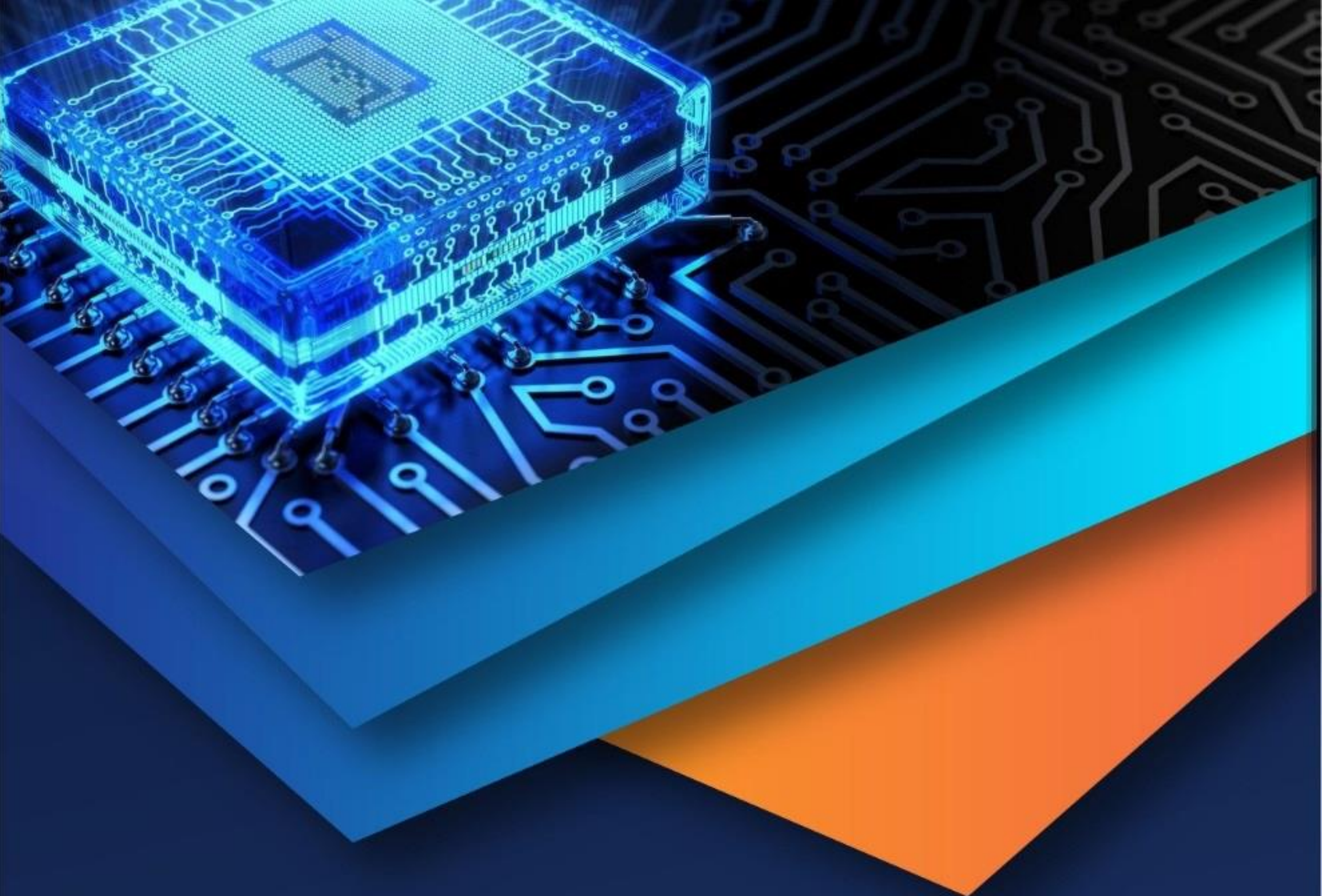

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