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Modelling & Comparative Analysis of Bridges for Dynamic & Seismic Loads using SAP2000

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Abstract*: A bridge is a structure which is built over some physical obstacles such as a body of water, valley, road and railway, its purpose is to provide crossing over that obstacle. Numerous bridges are in exist namely Arch Bridge, Girder Bridge, Suspension bridge, Cable stayed Bridge, etc. Design of bridges varies depending on the function of the bridge, the nature of the terrain where the bridge is constructed and anchored, the funds available to build it. Structural analysis is a process to analyze a structural system to predict its responses and behaviour by using physical laws and mathematical equations. The main objective of structural analysis is to determine internal forces, stresses and deformation of structure under various load effects. In the present study, Girder Bridge and Cable stayed bridge are modelled and comparative analysis is carried out for dynamic and seismic loading conditions. A comparison is made between the bridges for dead load, live load, seismic load and combined loads. The bridge which can sustain maximum load with minimum deflections is found out.
***Keywords*: Cable stayed bridge, Girder Bridge, Dynamic analysis of bridges, Seismic analysis of bridges, SAP2000.**

I. INTRODUCTION

A bridge is a structure built to span physical obstacles without closing the way underneath such as a body of water, valley, railway or road, for the purpose of providing passage over the obstacle. Designs of bridges vary depending on the function of the bridge, the nature of the terrain where the bridge is constructed and anchored, the material used to make it, and the funds available to build it.

A. Types of bridges

There are various types of bridges classified based on span, materials, types of bridge structures, functions, utility and position etc.

B. Bridges by Structure

1) Girder bridge
2) Cable stayed bridge

C. Girder Bridge

In Girder Bridge the deck slab is supported by means of girders. Steel box girders and steel and concrete composite box girders are used for long spans, where the self weight of the bridge needs to be minimized, and for situations where their excellent high torsional stiffness is of particular benefit.
The clean lines of box girders bridges, usually with no visible external stiffening, is generally considered to give a excellent appearance and durability, since there are no traps for dirt and moisture.
This article illustrates a few examples of box girder construction for bridges. For highway bridges, the structural configuration is usually of a reinforced concrete deck slab, carrying the traffic, on top of steel girders.
The deck slab acts compositely with the steel girders. For spans in the range 45 to 100m, multiple girders are used, with the slab spanning transversely between the webs. For such configurations, relatively narrow rectangular steel box sections have sometimes been chosen, as shown right.
However, such sections are rather small and introduce significant hazards for access for construction and maintenance and are rarely chosen now for this span range. The girder bridge is shown in Figure1.

Fig-1: Girder Bridge

D. Cable Stayed Bridge

Cable-stayed bridges have a structure with several points in each span between the towers supported upward in a slanting direction with cables, and consist of main towers, cables, and girders. Main towers are classified into such types as single-column, double-column, H-shaped, A-shaped, inverse Y-shaped, portal, and diamond. Cabling methods include single-plane suspension, double-plane suspension, fan pattern, and harp pattern. In general, the span applied to cable-stayed brides ranges from about 130 to 500 meters. Each tower has cables that connect it to the bridge. These cables exert a tension that keeps the bridge in place. Compare this to a suspension bridge, which has cables that run from each tower to the next one, and secondary cables that connect to the bridge itself. In the cable-stayed bridge, the cables deliver all of the weight of the bridge to the towers, and therefore, the bridge doesn't need to be anchored to the shores. The cable-stayed design uses less steel cable than a suspension bridge, and is faster and easier to build. In the schematic, you can see how the forces keep the bridge up. The cables experience tension, and the towers experience compression. The cables pull down on the towers, and the towers must be built to resist. The deck of the bridge can experience both tension and compression forces (usually one on the top and the other on the bottom). The cable stayed bridge is shown in Figure2.

Fig-2: Cable stayed Bridge

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II. METHODOLOGY

The methodology of the project is shown in the flowchart given Figure3

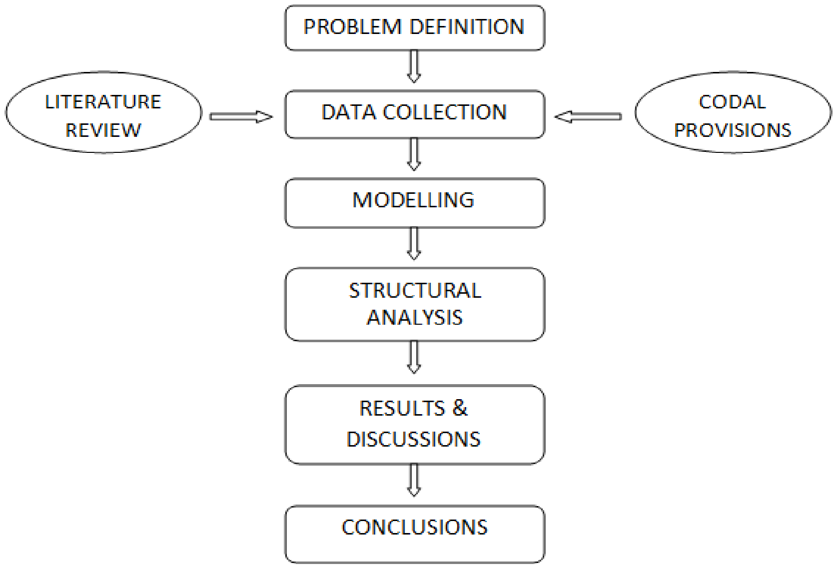

Fig-3: Methodology

A. *Problem Definition*

With the growing population, there is a need for effective use of land. Bridges are such structures which provide the elevated way between two points. Bridges helps in saving time, reducing traffic, reducing collisions. So bridges have to be designed with utmost care & importance. In this study, Bridges are designed to span a given distance while supporting a maximum load using minimum materials. Two bridges with same span and same loading conditions are taken, they are modelled in SAP2000 and analysis is done. The best suitable bridge with less deformation is found out based on test results.

B. *Data Collection*

The data and specifications required for modelling of bridges are shown in Table1.

Table1. Design input Parameters

Sl no	Parameters	For Cable Stayed Bridge	For Girder Bridge
1	Length	300m	300m
2	Width	10m	10m
3	Height of the pylon	80m	0
4	Girder type	Slab Deck	Precast concrete U girder Girder Top Width= 10m Girder Top Width=5m Girder Height=2.1m

C. *Loading Conditions*

The loads are applying the bridges are shown in Table2.

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Table2. Load Parameters

Load Type	Loading
Vehicle Load	IRC class AA loading
Seismic Load	IS 1893 (Part 1) Zone factor 0.10
Combination Load	1.2xDead Load+1.6xLive Load+0.6xSeismic Load

D. Modeling

The modeling is done in SAP2000; the modeling procedure is shown in Figure-4:

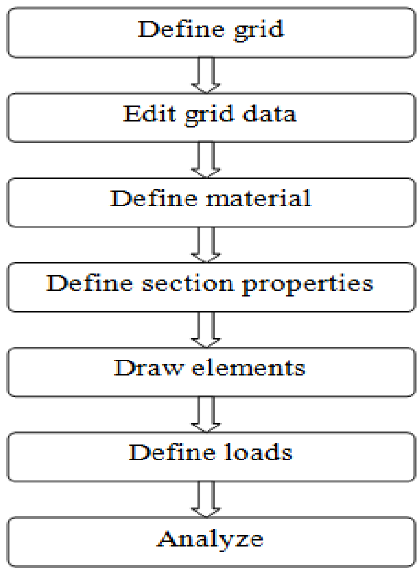

Fig-4: Steps in Modeling

3D Model in sap 2000

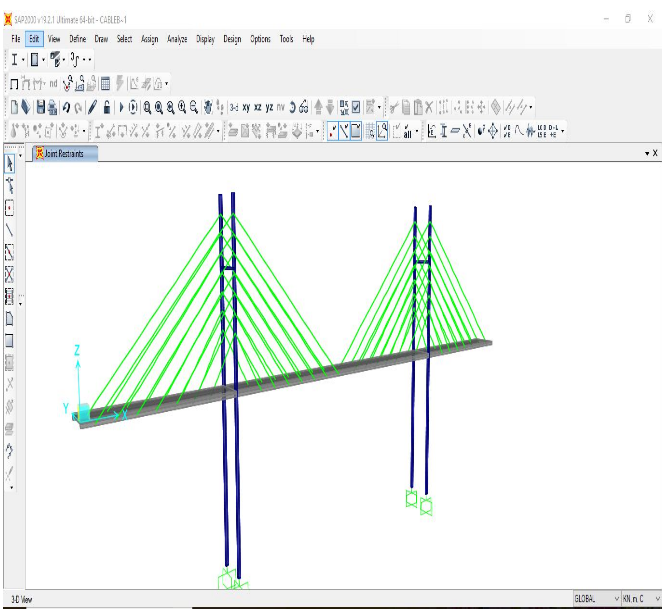

Fig-5: Cable stayed Bridge 3D- Model

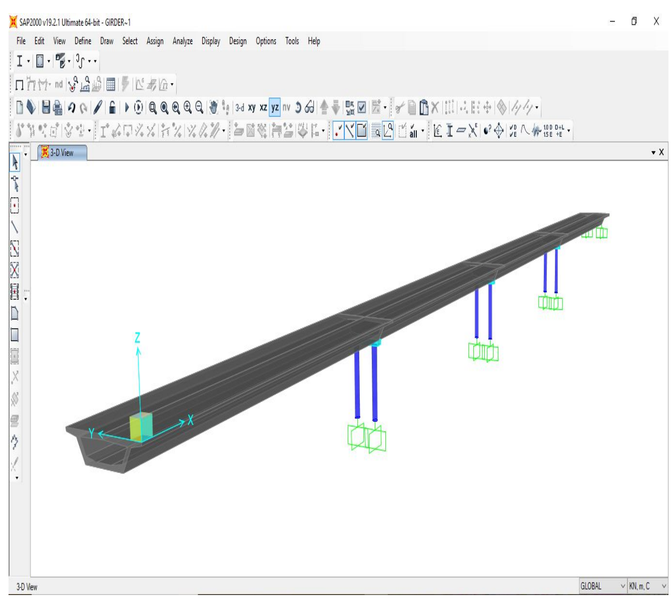

Fig-6: Girder Bridge 3D- Model

2D Model in sap2000

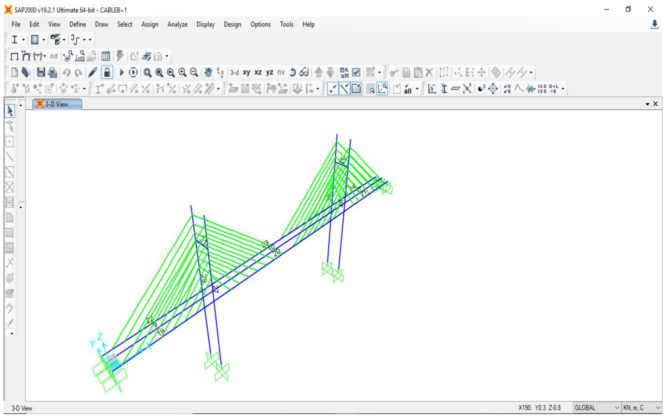

Fig-7: Cable stayed Bridge 2D- Model

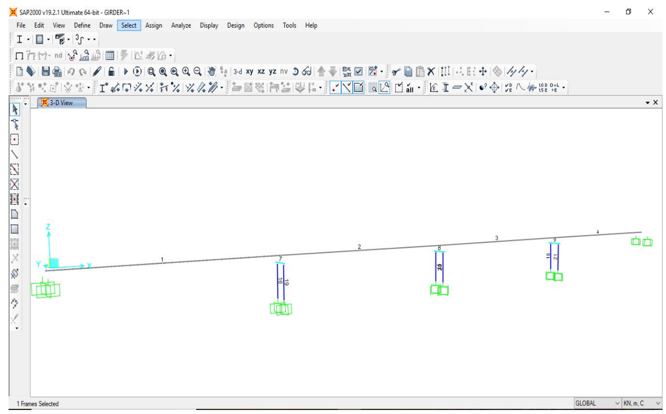

Fig-8: Girder Bridge 2D- Models

E. Results and Discussions.

1) Bending Moment results

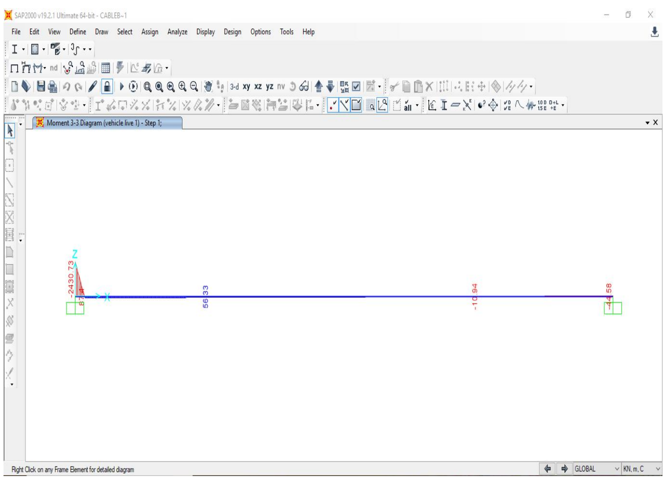

Fig-9: Bending Moment of Cable stayed Bridge Vehicle Load

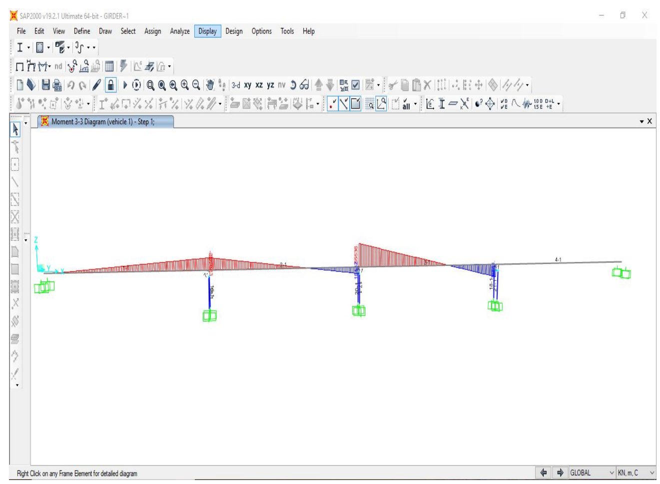

Fig-10: Bending Moment of Girder Bridge Vehicle Load

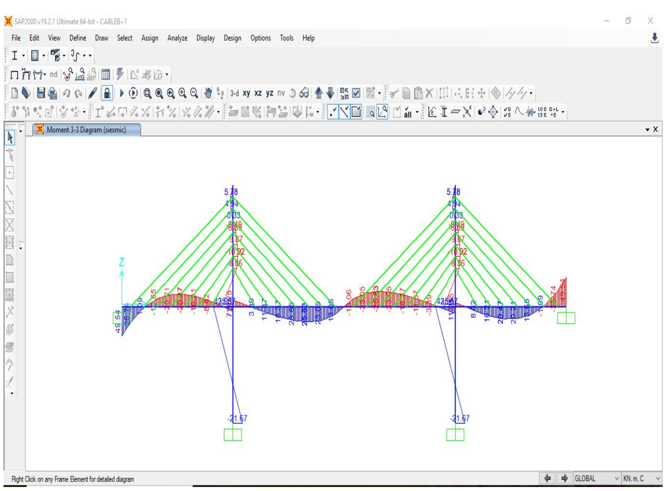

Fig-11: Bending Moment of Cable stayed Bridge Seismic Load

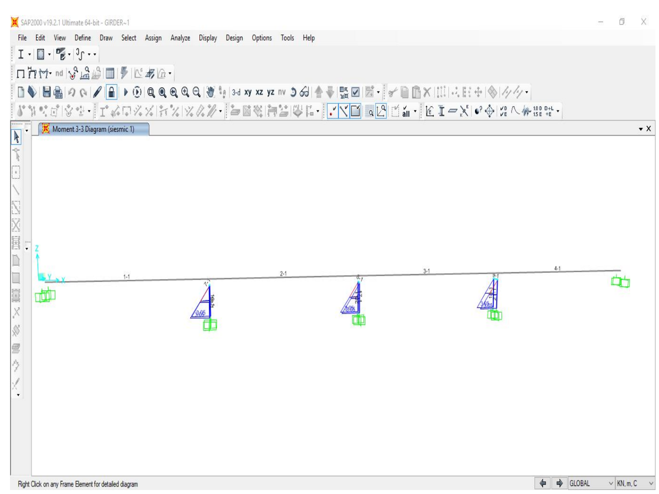

Fig-12: Bending Moment of Girder Bridge Seismic Load

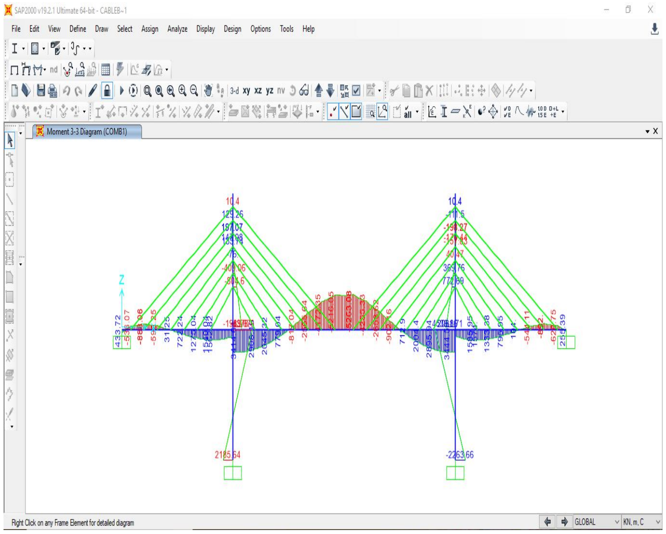

Fig-13: Bending Moment of Cable stayed Bridge Combination Load

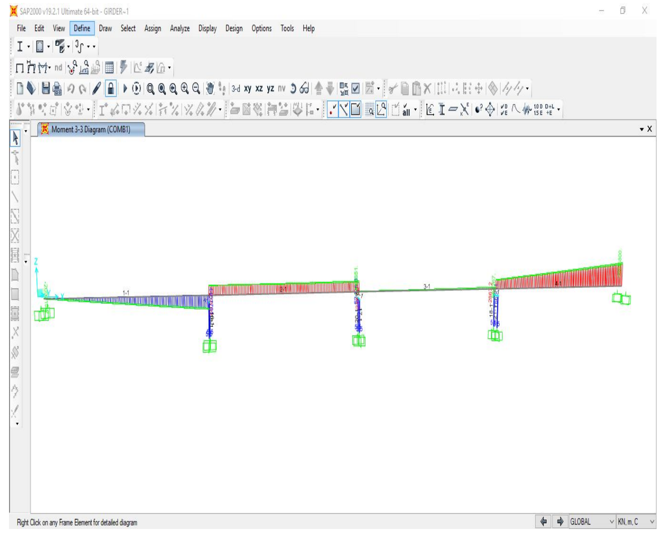

Fig-14: Bending Moment of Girder Bridge Combination Load

2) Bending Moment results Graph

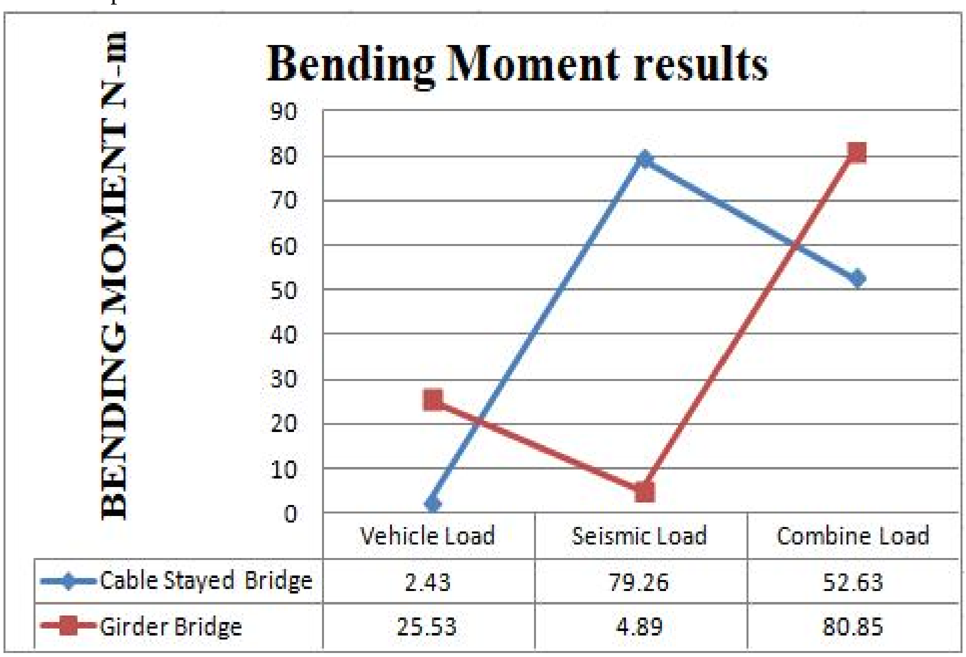

Fig-15: Comparision graph of Bending Moments

Cable stayed bridge and Girder Bridge are modelled using SAP2000 and compared for the same loading conditions. Based on the analysis the following conclusions are drawn. is observed that for the same loading conditions and design input parameters, Girder Bridge is giving minimum deformations than Cable stayed Bridge.

III. CONCLUSIONS

A. Based on the Results, the Following Conclusions are Drawn.,

1) For the same loading conditions, it is found that Girder Bridge is giving minimum deformations than Cable stayed Bridge.
2) For the same loading conditions, it is found that Cable stayed Bridge is giving minimum deformations than Girder Bridge at the piers.
3) Deformation values are decreased by 47.72% for Girder Bridge compared to Cable stayed Bridge.
4) Shear force values are increased by 70% for Girder Bridge compared to Cable stayed Bridge.

IV. ACKNOWLEDGEMENT

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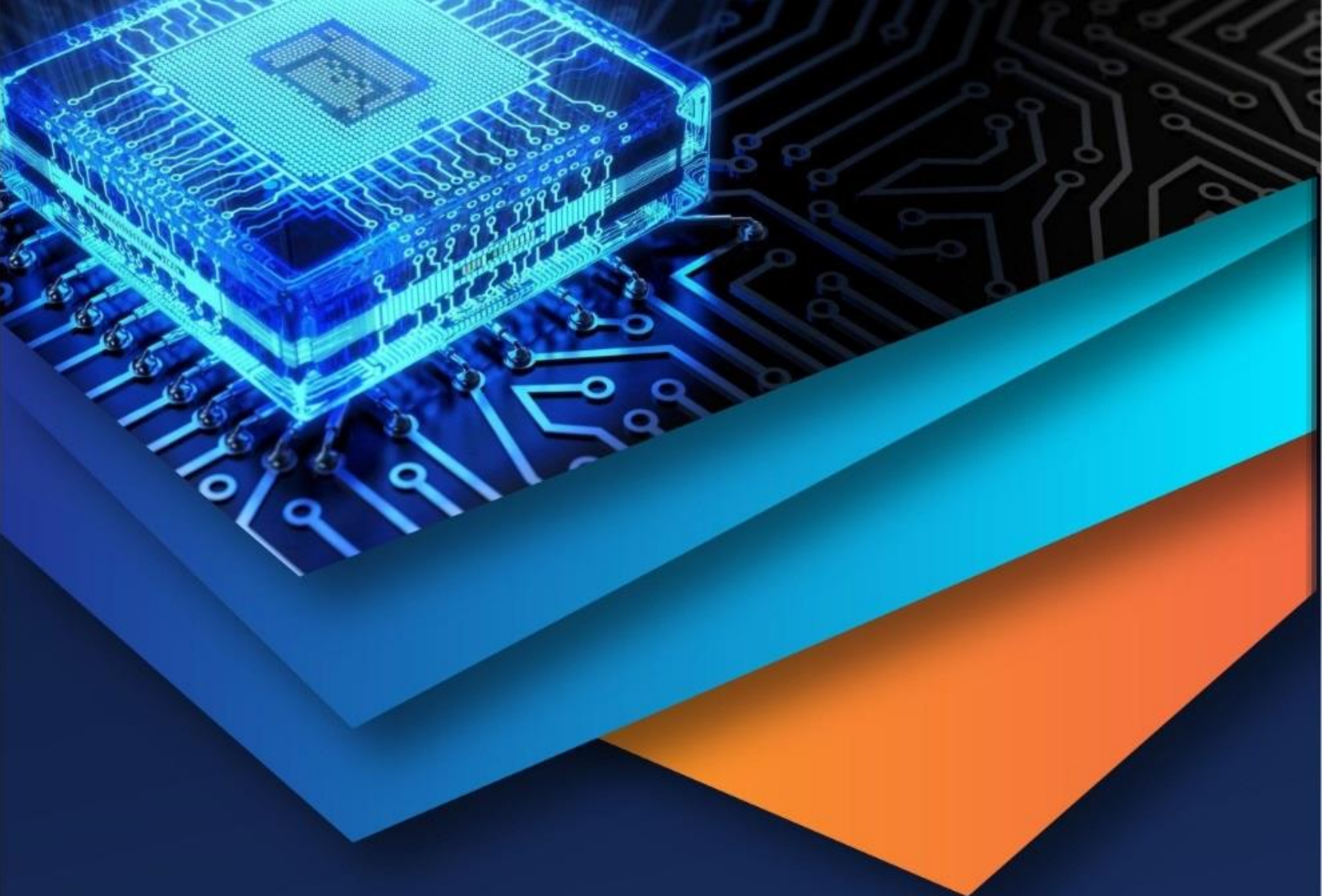

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