iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 **Issue:** IV **Month of publication:** April 2019

DOI: https://doi.org/10.22214/ijraset.2019.4594

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 7 Issue IV, Apr 2019- Available at www.ijraset.com

A Parametric Study on Bridge due to Dynamic Loading

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Abstract: A Bridge is a structure built to span physical obstacles without closing the way underneath such as a body of Water, Valley or Road for the purpose of providing Passage over the Obstacles. In this Project we consider the different Configuration with varying spans and corresponding height of Bridge in Order to asset the dynamic response of Bridge.

This project is concerned with the performance of three types of bridges with varying spans under seismic induced dynamic loads. Seismic loads are considered as per IS 1893(part1):2002. The finite element analysis of bridges involves modal analysis, response spectrum. The results obtained from the analyses are compared and the conclusions are drawn.

Keywords: Deck Slab, Deck Slab with Arch, Deck slab with Truss, Modal analysis, Seismic analysis

I. INTRODUCTION

A bridge is a structure built to span physical obstacles without closing the way underneath such as a body of water, valley, or road, for the purpose of providing passage over the obstacle. There are many different designs that each serve a particular purpose and apply to different situations. 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.

The Design of Bridges varying depending on

A. Function of the Bridge
B. Nature of the Terrain
C. Materials used for construction
D. Funds available

In our project parametric studies is carried out on two-lane Bridge. The Bending moment and Shear force values are calculated using Courboun's method, Guyon massonet method.

These values are also compared with STAAD-PRO results. By considering various types of loads and involves mode shape, Natural period, Seismic force and behavior of the bridge under seismic loads.

II. SCOPE

The scope of this research is to carryout finite element analysis on Bridge Models due to seismic and dynamic loads. Three types of Bridge models are considered in this study with varying Span and constant width.

III.OBJECTIVES

The main objectives of the thesis are summarized in the following:

A. Three types of Bridges are considered in this study as given below
1) Deck Slab
2) Deck slab with Steel Truss.
3) Deck slab With Steel Arch.
B. Load calculation of Bridges for normal load condition as per IRC: 61996, IRC: 24-2001, IS 875(part3):1987 and seismic load as per IS 1893(part1):2002 are considered.
C. Typical Deck bridge model is considered from for validation.
D. Finite element analysis includes the modal analysis, and seismic analysis.
E. Results obtained from the seismic loads are compared and conclusion is drawn.

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IV. PARAMETRS OF BRIDGE

Three types of Brides are considered in this Project as given in table1

Properties

1) 1Clear Roadway = 7.5m
2) Concrete Grade = M40 Steel Fe 550
3) The Slab is supported on four sides by beams
4) Thickness of Slab, H =370 mm
5) Thickness of Wearing Coat, D = 80mm
6) Depth of Main Girder =100mm for every meter (Assumption)
7) Width of girder = 2.5
8) Kerb on boat side = 0.5x0.6

The support conditions are considered to be fixed.

Table 1: Types of Bridges for Parametric study

Sl.No.	Bridges	Parameters of Bridges
1	Deck slab	A typical Deck model is a 7.5m width which includes Two lane road and Krebs as well pedestrians And it consist of Support at 25m interval and in the boat the direction(longitudinal and lateral) provided T beam girders. With varying span (50m,75m,100m)
2	Deck With Arch	It consists of Deck with Steel arch. With varying span (50m,75m,100m)
3	Deck with truss	It consists of Deck with Truss. With varying span (50m,75m,100m)

A. Types of Loads

The following are the various loads to be considered for the purpose of computing stresses, wherever they are applicable.

1) Dead load
2) Live load
3) Impact load
4) Seismic load
5) Wheel load

B. Load Calculation

Preliminary Details

Clear Roadway = 7.5m

Concrete Grade = M25 Steel Fe 415

Dead load of Deck Slab

The Slab is supported on four sides by beams

Thickness of Slab, H = 200mm

Thickness of Wearing Coat, D = 80mm

Dead Load

1) Weight of Deck Slab = 0.200 X 24 = 4.80 KN/m2
2) Weight of Wearing Course = 0.08 X 22 = 1.76 KN/m2
3) Total Weight = 6.56 KN/m2

TOTAL LOAD ON PANEL = 4 X 2.5 X 6.56 = 65.6KN

LOADS ON LONGITUDENAL GIRDERS

Parapet railing = 0.7 kn/m

Wearing Coat (0.08x1.1x22) = 1.96 kn/m

Deck Slab (0.2x1.1x24) = 5.280 kn/m

Kerb = 7.20 kn/m

TOTAL LOAD= 15.166 kn/m

Total Dead load on Girder = (2x15.116) + (6.56x5.3) =65 kn/m

Dead load on each girder 65/3 =21.66 kn//m

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V. FINITE ELEMENT ANALYSIS

The finite element method (FEM) is a powerful technique originally developed for numerical solution of complex problems in structural mechanics, and it remains the method of choice for complex systems. In the FEM, a structural system is modelled by a set of appropriate finite elements interconnected at points called nodes. Elements may have physical properties such as angle sections, coefficient of thermal expansion, density, Young's modulus and Poisson's ratio.

The most commonly used numerical approximation in structural analysis is the Finite Element Method. Structural analysis is mainly concerned with finding out the behaviour of a structure when subjected to some action. This action can be in the form of load due to the weight of the bridge, Impact load, live load, wind load and some other kind of excitation such as an earthquake. The distinction is made between the dynamic and the static analysis on the basis of whether the applied action has enough acceleration in comparison to the tower natural frequency. In this research the Dynamic analysis includes are modal analyses, response spectra analysis.

The three models of bridges are shown in figure from 1 to 3

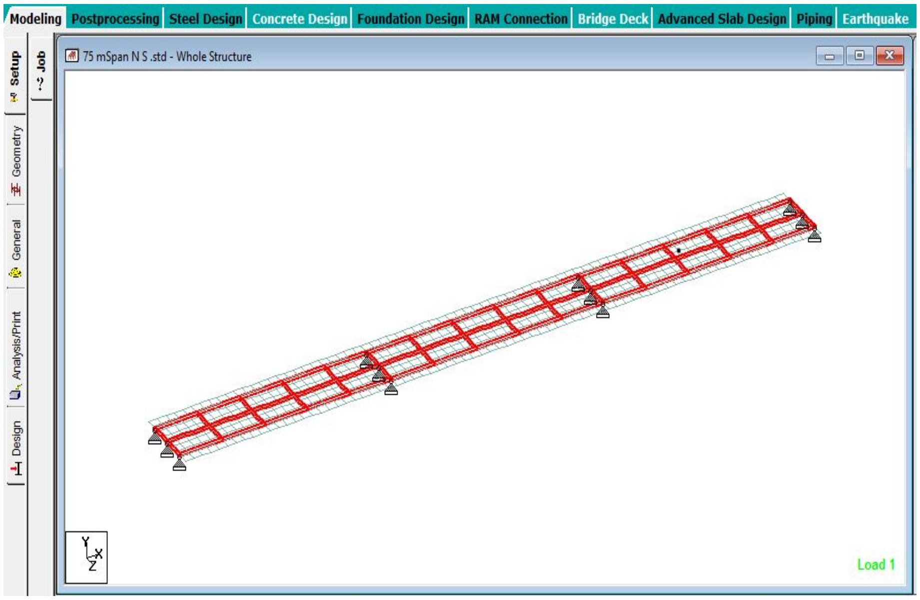

Figure 1: Deck Slab

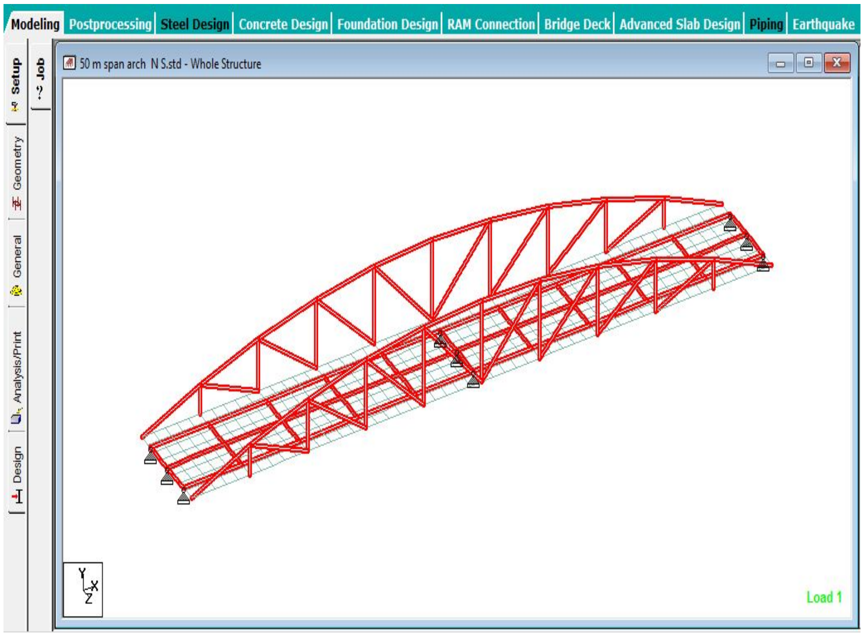

Figure 2: Deck Slab with Arch

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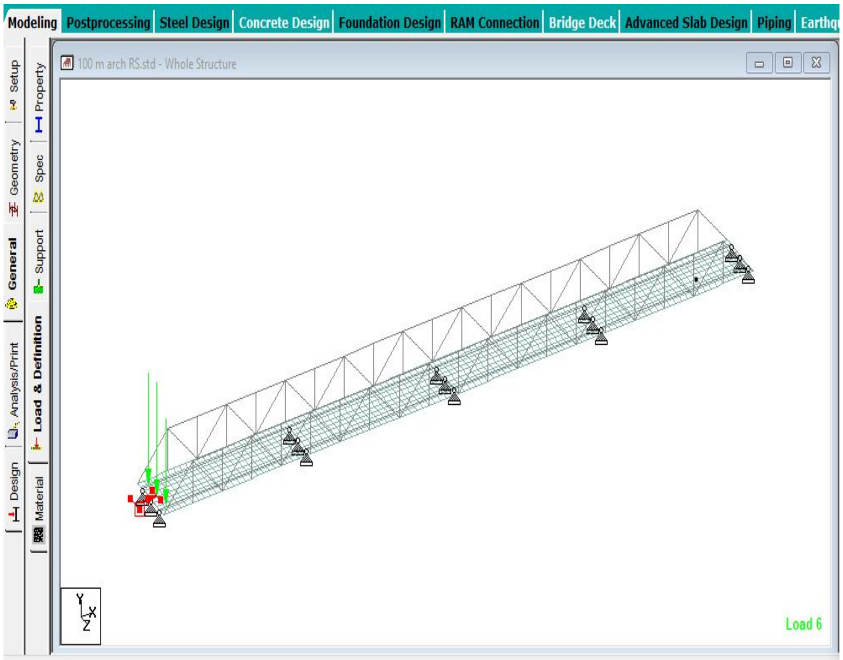

Figure 3: Deck Slab with Truss

VI. RESULTS AND DISCUSSION

A. Modal Analysis

The fundamental frequency for all the bridges is obtained from the modal analysis. The first modal frequencies for all bridges are given in table 2

Table 2: Modal Frequencies for Bridges

Sl No	Span (m)	Modal frequencies		
		Deck Slab	Deck Slab with Arch	Deck Slab with Truss
1	50	14.571	2.264	8.863
2	75	9.199	1.080	5.092
3	100	6.204	0.795	7.863

Above results shows that as the span increases the modal frequencies reduces which indicates the reduction in stiffens.

B. Response Spectrum Analysis

The Response Spectrum analysis is performed on the all three types of bridges for all the seismic zones as per IS 1893(part1)-2002 Maximum displacements are taken at pivotal points for zone V. Maximum displacements of three type bridges are shown in figure 4 to 6 respectively. Table 3 gives the maximum displacement values for all bridges.

Table 3: Maximum displacement for Bridges

Sl No	Span (m)	Maximum displacement in mm		
		Deck Slab	Deck Slab with Arch	Deck Slab with Truss
1	50	14.415	6.136	3.148
2	75	19.926	12.743	8.416
3	100	26.84	20.47	18.948

Above results shows that as the span increases the displacement also increases.
The Maximum displacements results for all types of bridges with varying height as shown in figure from figure 4 - 7

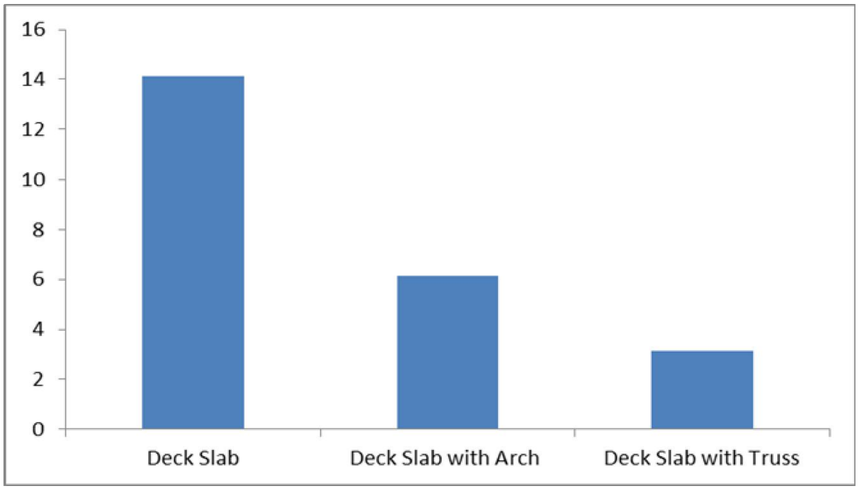

Figure 4: Maximum displacements for 50m Span with different bridges.

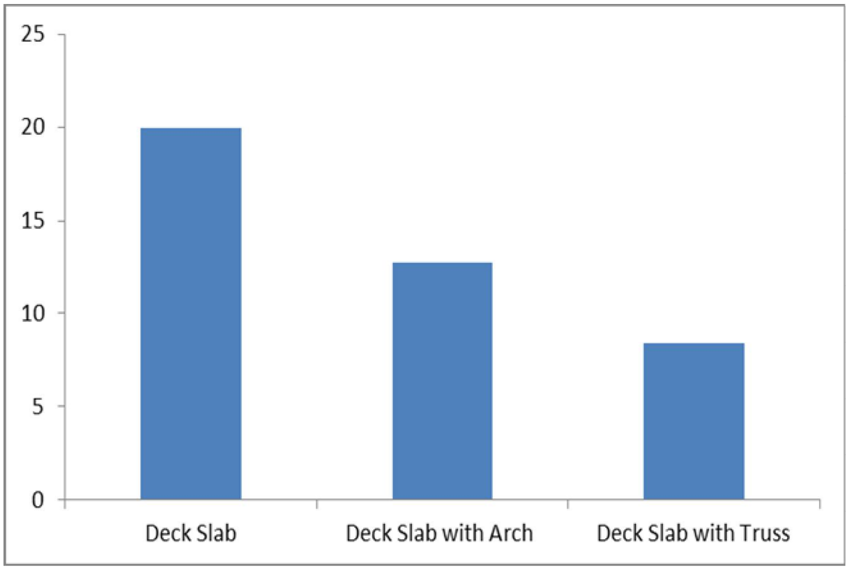

Figure 5: Maximum displacements for 75m Span with different bridges.

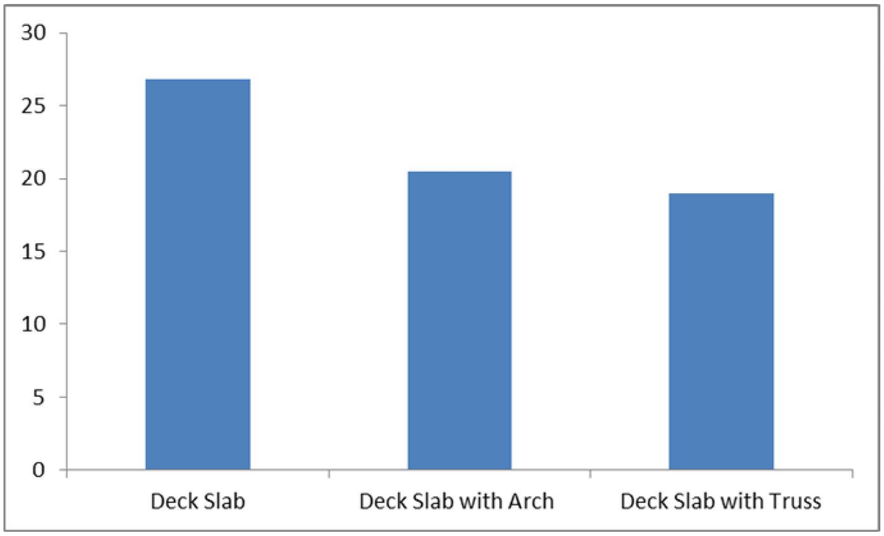

Figure 6: Maximum displacements for 100m Span with different bridges.

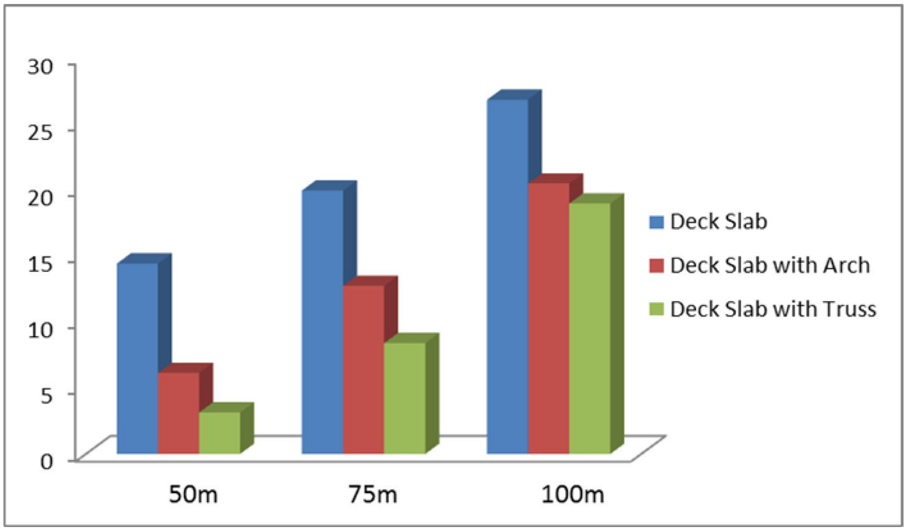

Figure 7: Maximum displacements for all Spans with different bridges

VII. CONCLUSION

The following conclusions are made for different bridges with varying spans are given below.

A. Response spectrum is generated as per IS 1893(part1):2002 which are adopted for seismic loads in finite element analysis.
B. A typical Deck Bridge model finite element model is validated by comparing the results with the literature.
C. Result from the modal analysis shows that as the span increases the natural frequencies reduces which shows the reduction in stiffness. The modal frequencies obtain for all the Bridge model lies in the peak range of response spectrum, which needs to be further analysed under dynamic loads.
D. Response spectrum analysis result clearly shows that the displacement increases as the Span increases.
E. The maximum displacement in the Deck slab from 50m to 100m increases by 84.21%, Deck slab with Arch from 50m to 100m increases by 233.6% and Deck slab with Truss from 50m to 100m increases by 501%.

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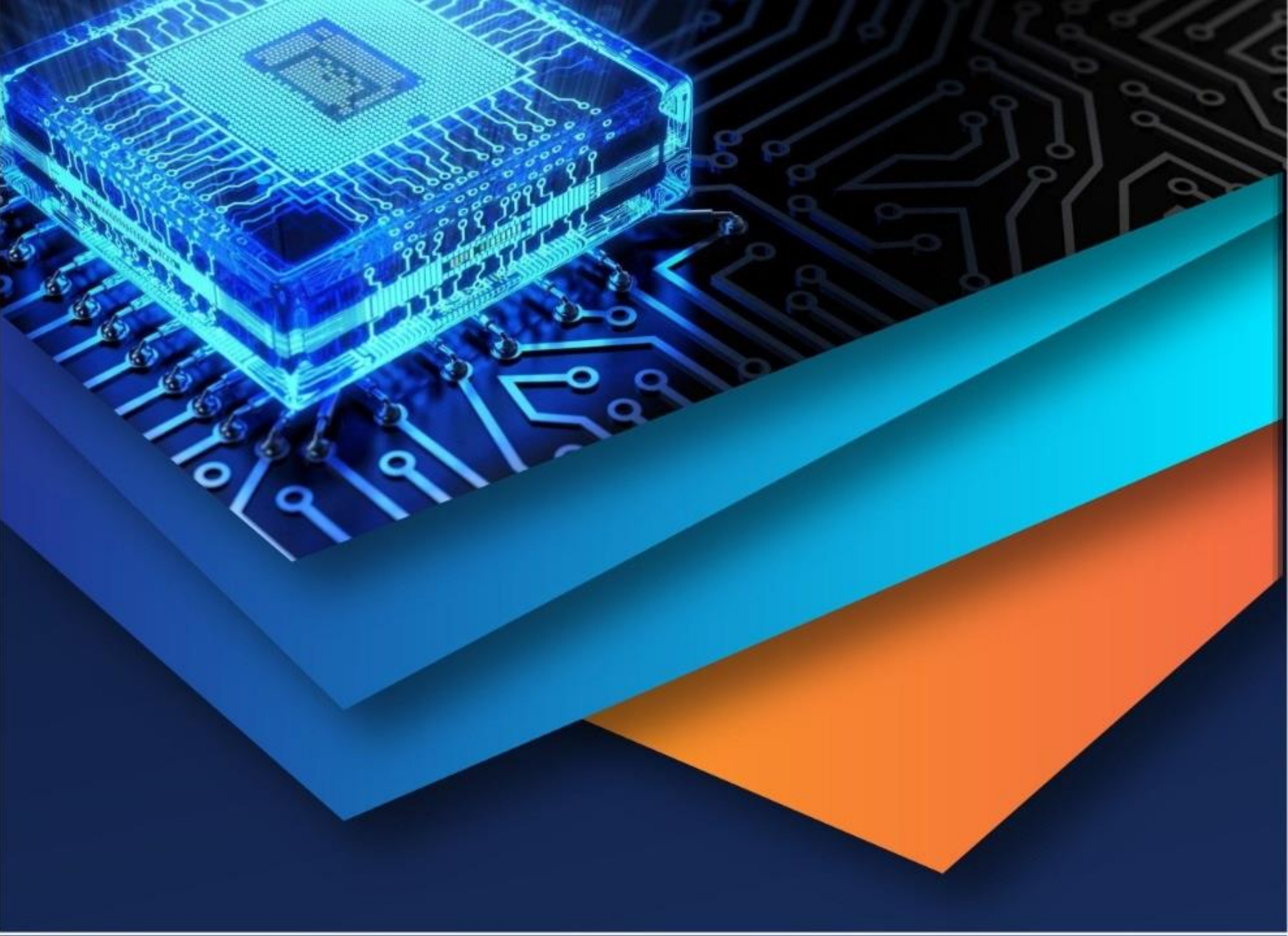

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