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Development of Axle Load Spectrum to Improve Road Pavement Analysis

Mazhar Khan[1], Rawid Khan[2]
[1]*PG student,* [2]*Professor, Department of Civil Engineering, University of Engineering & Technology, Peshawar, Pakistan.*

Abstract: ***This research covers characterization of truck traffic data for WIM station installed at N-5 highway (Pakistan's longest highway of length 1819KM extending from Karachi to FATA) in terms of vehicle class distribution, hourly distribution factors, monthly distribution factors, axle load spectra for each vehicle class and each axle of vehicle class to facilitate analysis and design in new Mechanistic-Empirical Pavement Design Guide. Overloading being a major issue in both developed as well as developing countries, so overloading considerations have also been incorporated in terms of percentage of overloaded vehicles for each vehicle class, percentage of overloading based on legal (NHA legal gross vehicle weight) and observed gross vehicle weight for each vehicle class, percentage of average observed load to maximum observed loads for each axle of each vehicle class, comparison of GVW with maximum and average observed GVW. To obtain the traffic data, weigh in motion station is installed by National highways Authority at Mulla Mansoor Attock District, Punjab on N-5 which notes down traffic parameters for vehicles moving on both south and north bounds. The data used in this research work is from January 2018 to December 2018 (12 months) of the respective WIM Station.***

Keywords: Axle Load Spectra, Gross Vehicle Weight, Equivalent Static Axle Load, Weigh in Motion

I. INTRODUCTION

The Islamic republic of Pakistan is a territory (land area 796,000 km²) located north-east of the Arabian Sea and extending towards the Himalayas on the border of China. The Country has four provinces (Punjab, Sindh, Baluchistan and Khyber Pakhtunkhwa), two territories (Islamabad Capital territory and Federally Administered Tribal area and the Pakistan's part of Kashmir (Gilgit Baldistan). Pakistan is the sixth most populated country in the world with population of 207,774,520 persons.

Roads paly vital role in developing and growing economy of a country. For a developing country like Pakistan, road network should be laid enough to incorporate the requirements of the country. The importance of road network can judged from the fact that inland freight and passenger traffic are carried over about 96% and 92% respectively. In Pakistan more than 60% individuals live the rural areas and they need proper road network to move from village towards city from their livelihood and carry agriculture products. Roads are the cheapest and easiest mode of transportation in Pakistan that's why preferred by many individuals.

The total length of roads across the country is about 264,000 Km. these roads are under National Highway Authority, Provincial authorities, cantonment boards etc.

A. Research Strategy

N-5 is one of the most strategic highway of Pakistan which is one of the main routes for traders and other stakeholders to move their goods among the different provinces of the country. N-5 extends from Karachi (Sindh) to Torkham (FATA) with length of 1819KM and passing through the main economic hubs of Pakistan.

Keeping in view the research goals and objectives, a comprehensive strategy was made which included:

Study of literature about the pavement design and analysis approaches in Pakistan and other countries, Road network of Pakistan is studied, AASHO road test is briefly discussed, MEPDG and related terms were discussed briefly. (HDF) and (MDF) are also discussed WIM station is also studied along with history, strengths, shortcomings, applications, components and factors influencing WIM devices were also studied, Axle Load Spectra were plotted for single, tandem and quad axle for each class of vehicles and for both bounds of N-5 highway, Percentage of overloaded vehicles, variation of legal axle load with respect to average observed and maximum observed loads at WIM station were also studied, Truck factor for each vehicle class and also variation of truck factor with respect to pavement surface course thickness and modulus of subgrade was also established.

Flow chart diagram of the methodology adopted in this work is illustrated below:

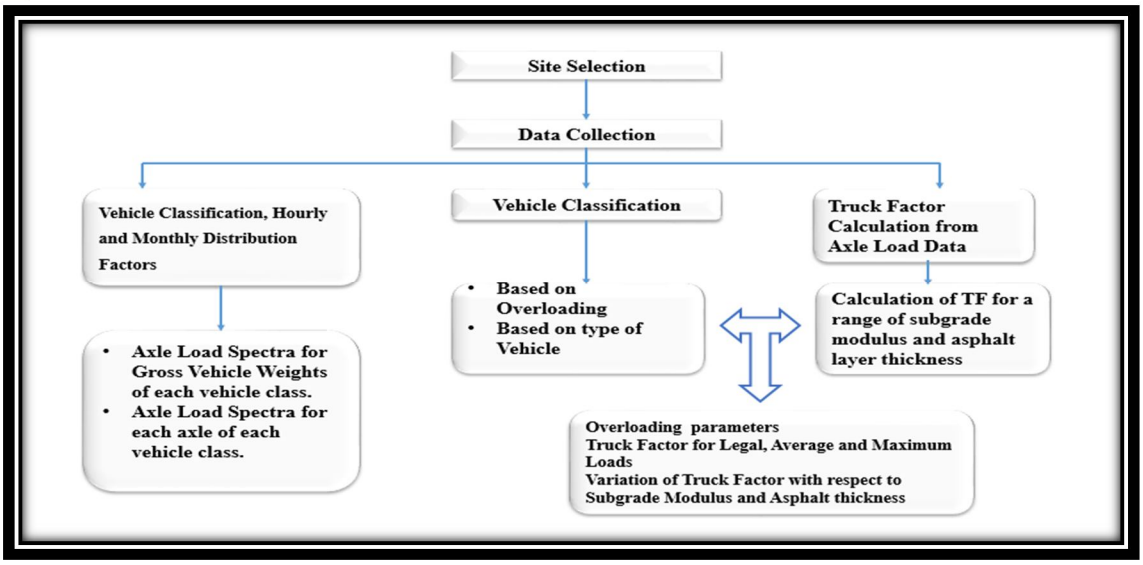


Fig. 1 Methodology of Research Work

B. Selection of Site

Road network in Pakistan is very good and it was not too easy to select a proper site. First of all, to incorporate all sorts of commercial vehicles moving on roadway through all seasons of the year, we selected N-5 highway for data collection.

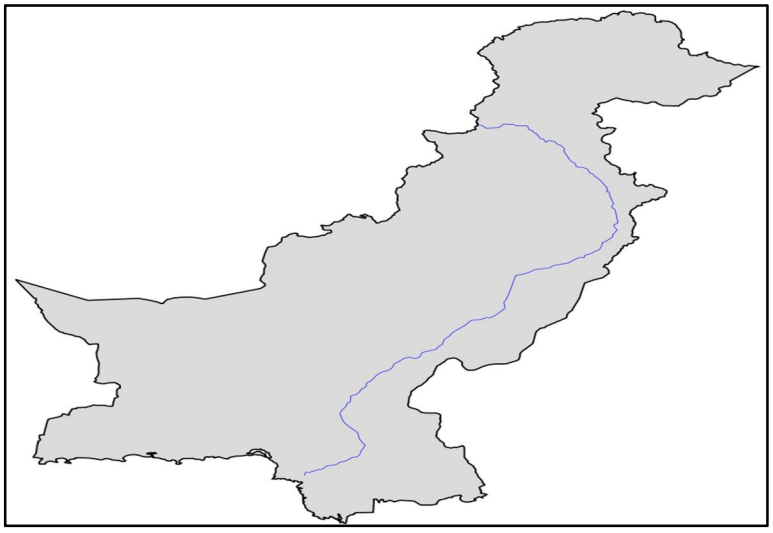


Fig. 2 N-5 Highway on Google Map

C. Results and Discussions

The traffic data collected from Mulla Mansoor WIM station was analyzed and the following results were obtained:

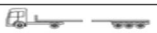
Table I
Monthly Distribution Factors (MDF) For N-5 Highway

Month	MDF	Month	MDF
January	0.71	July	0.87
February	0.76	August	1.02
March	1.28	September	1.12
April	1.18	October	1.03
May	1.2	November	0.97
June	0.96	December	0.9

Table Ii
Hourly Distribution Factors (HDF) For N-5

Hour	HDF	Hour	HDF	Hour	HDF
12 AM- 1AM	1.2	8 AM- 9AM	7.92	4 PM-5PM	5.22
1 AM- 2AM	1.1	9 AM- 10AM	8.25	5 PM-6PM	4.23
2 AM- 3AM	0.95	10 AM- 11AM	7.42	6 PM-7PM	4.18
3 AM- 4AM	0.73	11 AM- 12PM	6.63	7 PM-8PM	3.67
4 AM- 5AM	0.69	12 PM-1PM	6.38	8 PM-9PM	3.45
5 AM- 6AM	0.95	1 PM-2PM	7.55	9 PM-10PM	2.22
6 AM- 7AM	2.45	2 PM-3PM	7.8	10 PM-11PM	2.17
7 AM- 8AM	7.8	3 PM-4PM	5.3	11 PM-12AM	1.74

Table III
NHA Vehicle Classification

Class of Vehicle		Maximum Load per Axle (kN)					
		1st Axle	2nd Axle	3rd Axle	4th Axle	5th Axle	6th Axle
B2		53.94	117.68	...	...	...	...
BH3		53.94	107.87	107.87	...	...	...
S123		53.94	107.87	107.87	101.33	101.33	101.33
S113		53.94	117.68	101.33	101.33	101.33	...
S112		53.94	117.68	107.87	107.87	...	...

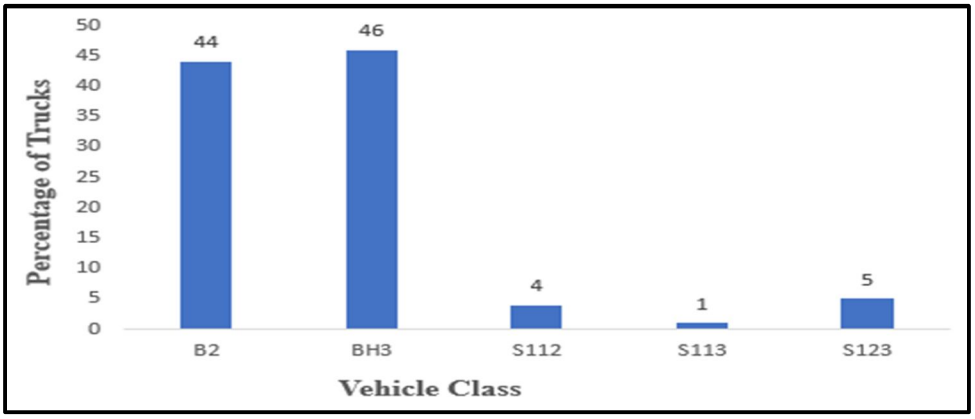


Fig. 2 Percentage of Vehicle Classes

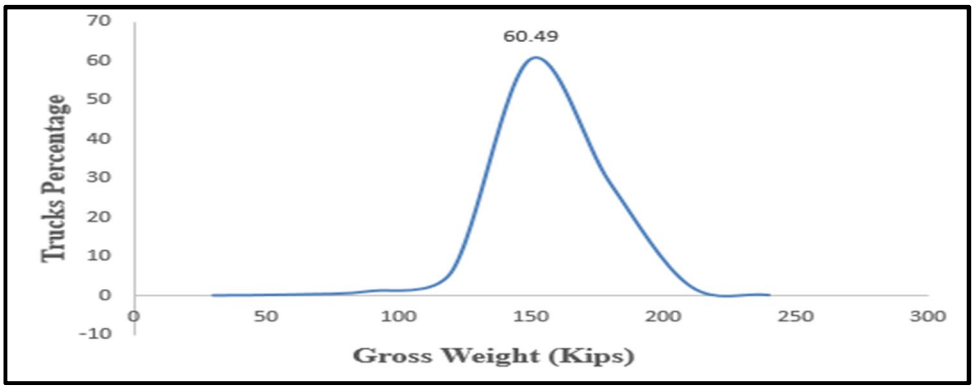


Fig. 3 Load Spectra for Gross Weights of 6-Axle Vehicles

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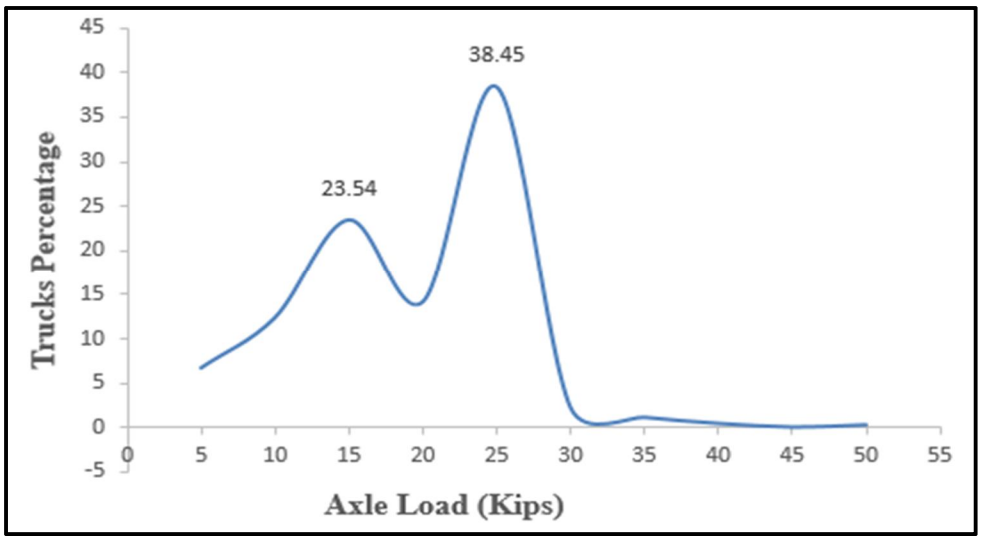

Fig. 4 Single Axle Load Spectra for 2-Axle Vehicles

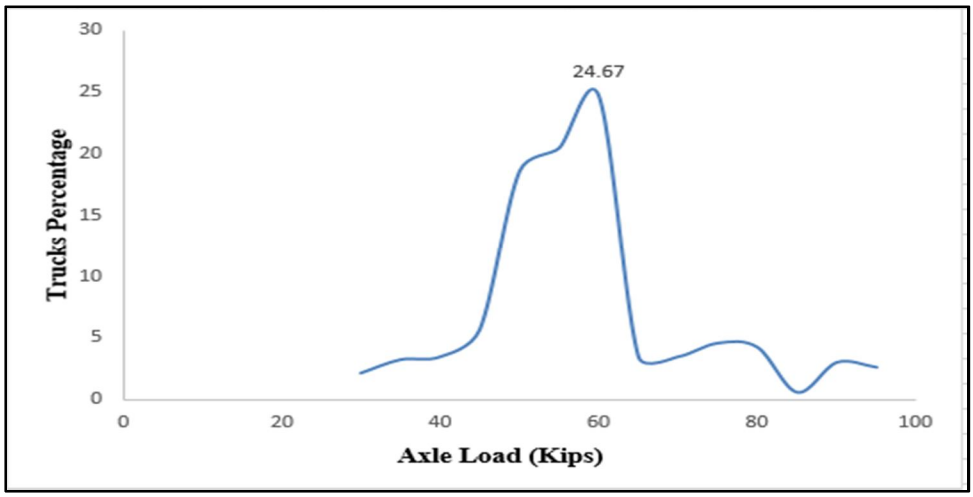

Fig. 5 Tridem Axle Load Spectra for 5-Axle Vehicles

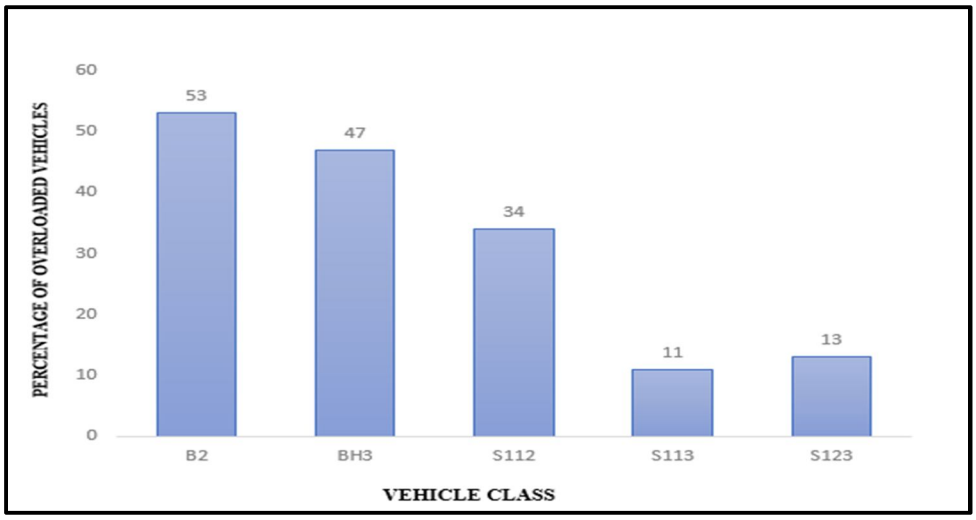

Fig. 6 Percentage of Overloaded Vehicles

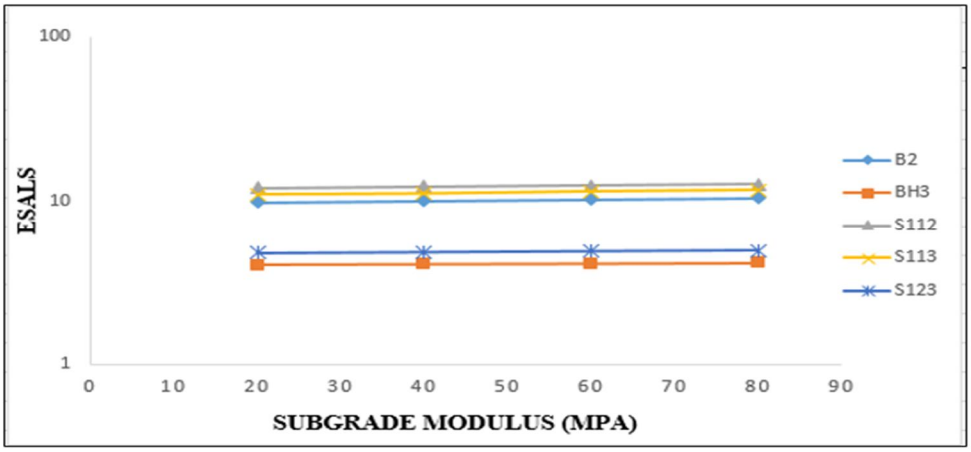

Fig. 7 Variation of Truck Factor with Subgrade Modulus

II. CONCLUSION

From the data recorded at WIM station showed that vehicles class BH3 is in excess followed by vehicle class B2 with percentage 46% and 44% respectively. This shows deviation from study done by Raheel et al. (2018) which showed higher percentage of B2 class. The truck data showed lower percentage of S113 (5-axle vehicles) of 1%.

The Hourly Distribution Factor is maximum for 8AM to 9AM with value 7.92 and minimum between 4AM to 5AM with value 0.69. Monthly distribution is maximum for March with value 1.28 and minimum for January with value of 0.71. For combined vehicles, the maximum percentage of single axle loads is observed to be 41.19% for 25 Kips (North Bound), maximum percentage of tandem axle loads is 40.39% for 80 Kips (North Bound) and maximum percentage of quad axle loads is 21.09% for 90Kips (North Bound). Axle load spectra for single axle loads mostly follow normalized distribution while for tandem and quad axle loads normalized distribution is not followed. Truck factor is maximum for S112 followed by S113 and B2. It can be deducted that truck factor is more for 2-axle vehicle as compared to 6-axle trailer, this is because of the presence of 2 and 3 axles which carry more are to distribute the axle loads. The impact of overloaded vehicles is reduced by decreasing truck factors for various vehicle classes. This is achieved by increasing asphalt layer thickness. The increase in subgrade modulus has a minimal effect on truck factor value

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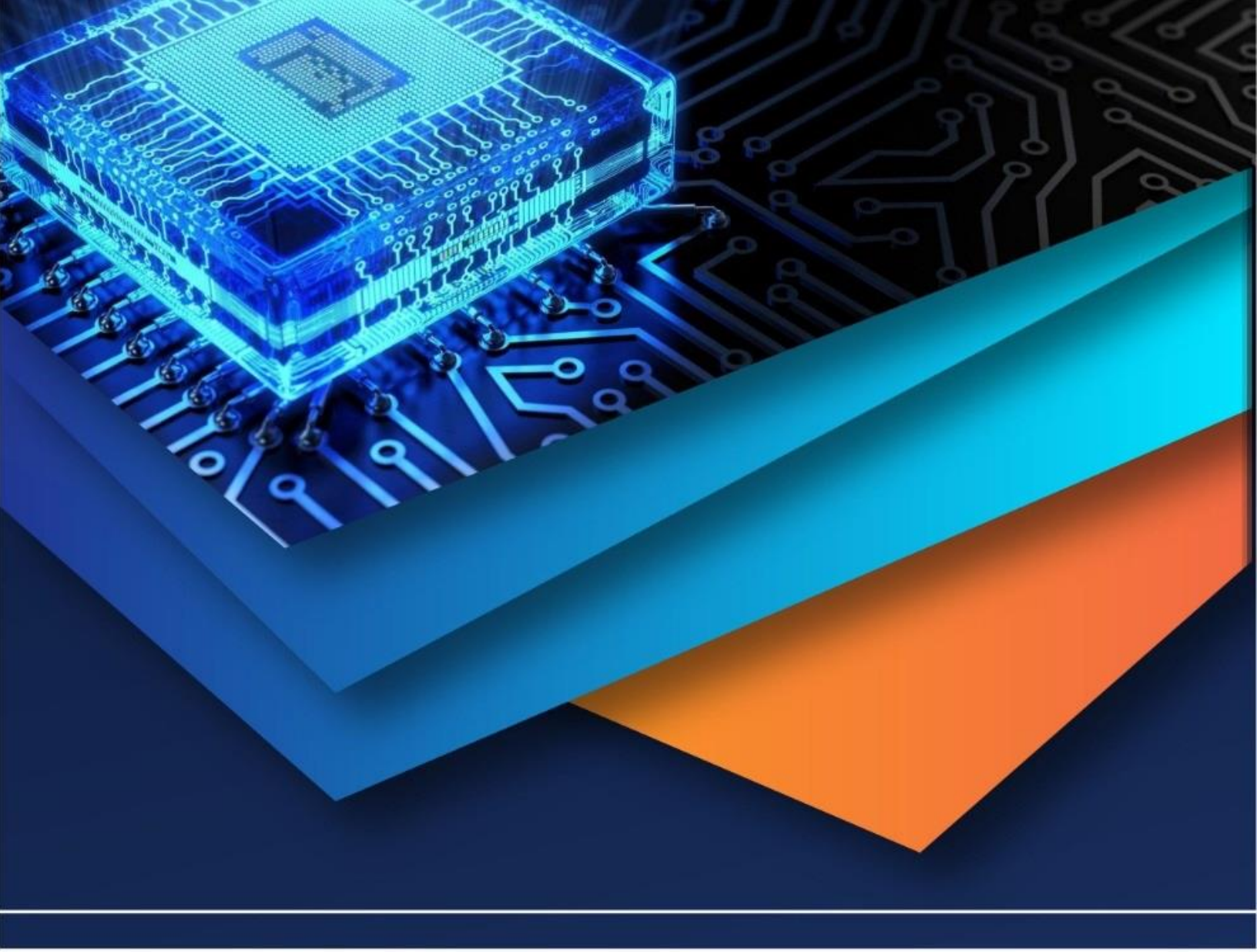

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