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Assessment of Noise Pollution in a School Building - A Case Study

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Abstract: ***Rapid Urbanization and economic growth of the country has led to increase in vehicular population thereby increasing noise levels. Schools' buildings especially located at major roadside are often subjected to higher outdoor noise levels wherein the performance of the student is reported to be decreased. Assessment of noise pollution in a school building and providing necessary mitigating measures are deeply felt to prevent deterioration of performance and health. Hence the present study is envisaged to investigate the impact of noise pollution on children in school building located along the roadside. A 12-hours measurements study is recorded in 30 minutes interval using DAWE (Model No. 1421C) sound level meter in Chaitanaya International High School for duration of one month. This study concern with measurement noise levels, its sources, and investigate the effects of noise in the working environment of school building. The study revealed that the L_{Aeq} values are between 66 ± 3.7 dBA which are higher compared to permissible values (50 dB (A) during the day and 40 dB (A) at nights) prescribed the Central Pollution Board, New Delhi. On studying the annoyance level, the respondents claimed that the road traffic noise, chatter in the classroom and scraping sounds from tables and chairs are the most annoying noise sources.***
Keywords: Noise Pollution, school noise, Noise Indices, A- weighted level, Environment

I. INTRODUCTION

Noise pollution is now recognized worldwide as a major problem with respect to human health and quality of life in any urban area. The increment in noise pollution has tremendously raised, but received lesser attention than other hazards. The rise in noise pollution led to a successive increment in health threats and most of the researches are directed towards finding the causes of noise pollution and understand them correctly to develop adequate suitable solution for such unwelcome matter. It is also making a harmful effect on future generation and has socio-cultural, aesthetic, and economic effects (1). However, in comparison with other pollutants, the control of environmental noise has been hampered by insufficient knowledge of its effects on humans and of dose–response relationships, as well as by a lack of sufficient data, especially in developing countries like India (1, 2).

Previous studies on noise conducted in different cities regarding different aspects of noise pollution recognized vehicular noise as a major source of noise pollution (3, 4). Noise caused by the road traffic noise is now days become the nuisance that is faced by the most of the roadside schools. School administration and students situated along the roadside are constantly complaining about increasingly problems face due to traffic noise. The adverse effect of environmental noise is reported on the growing children's performance; personality, mentality and physical health of children are being recently recognized. (5). No study is reported on assessment of noise pollution and level annoyance in schools in Nagpur. Chaitanaya International High School, is considered as a study area for the present study since it is one of the school which is located on busy roadside with lot of noise pollution. On field study is conducted to measure noise levels to assess noise environment in the study area and Noise Pollution Levels (L_{NP}) and Traffic noise index (TNI) of the locations surveyed are determined (1).

II. EXPERIMENTAL PROCEDURE

Instrumentation for the field measurements consisted of precision-grade sound level meter DAWE (Model No. 1421C). The measurements were made at all sampling locations. The instrument was held comfortably in hand with the microphone pointed at the suspected noise source at a distance not less than 1 m away from any reflecting object. *SPL* (Sound Pressure Level) measurements were recorded at intervals of 30 minutes for a period of 12 hours at all sampling locations. This procedure was carried out for morning (6:00–12:00 a.m.), and afternoon (12:00–6:00 p.m.). From these readings, commonly used community noise assessment quantities like the exceedance percentiles $L_{10,}L_{50}$ and $L_{90;}$ The A-weighted equivalent sound pressure level, L_{Aeq}; The daytime average sound level, L_D; The noise pollution level, L_{NP}; and The Traffic Noise Index TNI are computed.

III. NOISE DESCRIPTORS

Noise descriptor such as L_{10}, L_{50}, L_{90}, L_{Aeq}, L_{NP} and TNI were recorded. Baseline sound levels are monitored for the different periods of the day, namely: morning, and afternoon time readings.

Definition for the noise descriptors are presented as follows:

L_{10}**:** Defined as the level in dB (A) exceeded over 10% of the time, during every hour period of 12 hours from 6:00 a.m. to 6:00 pm on a typical working day.

L_{50}**:** Defined as the level in dB (A) exceeded for 50% of time. This represent noise level is near to the mean level for dense population.

L_{90}: It is the level exceeded for 90% of the time; it is often referred to background noise level.

L_{Aeq}: The constant level that would produce the same amount of energy at the measuring point as the actual fluctuating level during the measuring period.

L_{NP}**:** It takes account the variations in the sound signal and hence it should serve as a better indicator of pollution in the environment for both physical and psychological disturbances of People, and

TNI: The traffic noise index (TNI) is a method used to estimate annoyance responses due to traffic noise (6).

These noise measures are defined as follows:

$$L_{Aeq} = 10 \log10_{*}[1 / N\sum_{i=1}^{N}(\text{antilog}(L_{Ai}/10))_{*} n_i] \quad (1)$$

$$L_D = 10 \log10_{*}[1 / 2*(\text{antilog} (L_{AeqM}/10) + \text{antilog} (L_{AeqA}/10)] \quad (2)$$

$$L_{NP} = L_{Aeq} + (L_{10} - L_{90}) \quad (3)$$

$$\text{TNI} = 4 (L_{10} - L_{90}) + (L_{90} - 30) \quad (4)$$

Where

L_{Ai} is the *i*th A-weighted sound pressure level reading decibels,

N is the total number of readings,

L_{Aeq} is the A-weighted equivalent sound pressure level,

L_{AeqM} is the equivalent sound pressure for the morning measurement,

L_{AeqA} is the equivalent sound pressure level for the afternoon measurement,

L_D is daytime noise level,

L_{10} is the noise level exceeded 10% of the time,

L_{90} is the noise level exceeded 90% of the time,

L_{NP} is noise pollution level.

L_{DN} is day–night noise level.

IV. ASSESSMENT OF NOISE POLLUTION

Table 1 shows the mean computed values of the noise level descriptors for all the sampling location within school building. A glance through Table 1 shows that the L_{Aeq} ranges from 59 dB (A) to 73 dB (A) and the noise pollution level, *L*NP ranges from 71 dB (A) to 87 dB (A). The factors responsible for differences in noise level in the different sampling location surveyed include site location and presence of sources of intrusive noise. The high noise pollution levels and L_{Aeq} at the entrance of the school building and followed by playground due to road traffic and the different activity of the school children. Therefore, apart from noise due to student's activities, there is traffic noise from vehicle horns, engines, and traffic volume. The respondents claimed that the road traffic noise, chatter in the classroom and scraping sounds from tables and chairs were the most annoying sound sources. The spatial – temporal analysis indicated the higher noise pollution level during the afternoon period is 87dB (A) at facades of the premises of the school building and 82 dB (A) at the classroom which is facing to the main road when windows are open. The higher noise pollution level (L_{NP}) during the morning period of 85 dB (A) and 76 dB (A) is obtained at playground and classroom respectively and scraping of table and chairs by the students at the time of non-lecture hours is found to be the main source at that moment.

Meanwhile at the same sampling locations the L_{Aeq} value observed as 73 dB (A) and 66 dB (A) due to the same sound sources of noise. The L_{90} value shows the noise level between 51dB (A) to 66 dB (A) occurs due to the normal work activity and normal conversation.

The results of the global descriptive analysis of all the sampling locations where the measurement is performed are presented in Table 2. The mean values of each noise descriptors are obtained as the arithmetic mean of all measurement performed during one month. The noise levels for both morning time and afternoon time are higher than those recommended by authority for all the locations surveyed. Tables 2 show that the average L_{Aeq} ranges from 65 to 76 dB (A) at playground, 61– 70 dB (A) at classrooms, 57–64 dB (A) at H.M. room, 53–63 dB (A) at staff room.

Table 1: Mean Noise Levels [dB (A)] at different sampling locations.

	Morning						*Afternoon*					
	L_{Aeq}	L_{10}	L_{50}	L_{90}	L_{NP}	*TNI*	L_{Aeq}	L_{10}	L_{50}	L_{90}	L_{NP}	*TNI*
Locations:												
Entrance Gate	74	77	73	68	84	76	74	79	72	66	87	89
Play Ground	73	76	71	64	85	82	74	77	70	64	86	84
C.R. Facing to Main Road	66	68	63	57	76	70	66	74	61	58	82	92
C.R. Not Facing Main Road	63	65	61	56	72	64	63	70	58	55	78	84
C.R. First Floor	64	68	59	53	79	83	62	64	57	54	71	62
Office	63	65	58	52	76	75	60	66	55	51	75	81
H.M. Room	64	67	62	55	76	73	61	67	58	54	74	77

Table 2: Descriptive statistical results calculated for all measurement performed.

Parameter	L_{Aeq}	L_{10}	L_{50}	L_{90}	L_{NP}	*TNI*
Mean	66.21	70.5	62.7	57.86	78.64	78.36
Median	66.09	70.4	61.86	56.45	78.35	78.2
Std. Dev.	5.21	4.99	6.16	5.41	5.05	7.58
Range	14	14	18	17	15	28
Minimum	60	65	55	51	72	64
Maximum	74	79	73	68	87	92
Kurtosis Co-eff.	-1.16	-1.37	-1.08	-0.71	-1.3	-0.15
Variance	2.71	24.89	37.91	29.21	25.48	57.48
Skewness	0.73	0.59	0.70	0.77	0.58	0.034

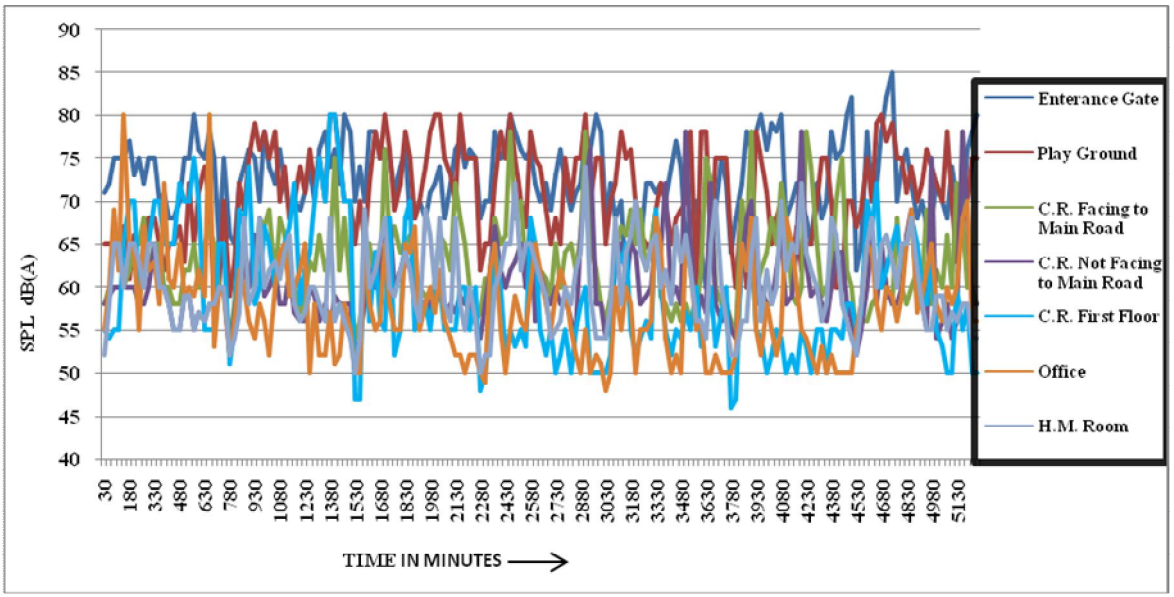

Fig. 1: Plot shows SPL variation over measurement period at various sampling locations.

Sound Pressure Level (SPL) measured at various sampling locations of a school building are shown in Figure 1. The mean value of the different noise parameter are given in Table 1 which are analyzed from the data measured. L_{eq} between 63 dB (A) to 74 dB (A) is found at these locations during morning hours when most of the activities was performed.

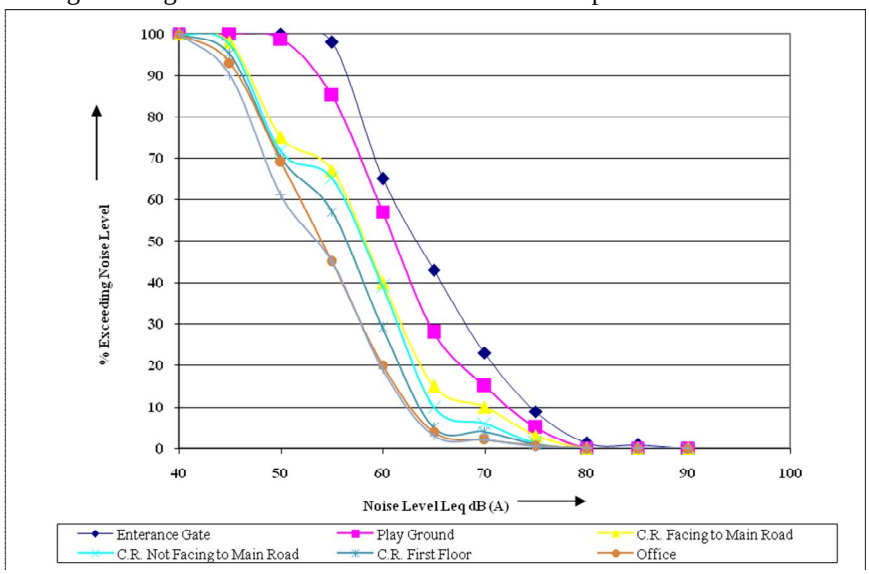

Fig. 2: Plot shows % Exceeding Noise Level over measurement period at all sampling locations.

To understand the percentage of time the noise level exceeded a particular value, Figure 2 is plotted. It reveals that, the noise level limit of 45 dB (A) is always exceeded over the entire measurement period. On comparing the selected stations, it is observed that noise level of 66 to 69 dB (A) remained during most part time of measurement period at classroom and staff room, where as noise level of 58 to 60 dB (A) exceeds 50 % of time of measurement period at the office block and H.M. room. A noise level of 75 dB (A) exceeded 16.30 % of times during the entire measurement period except at the playground. The maximum recorded at any time is 85 dB (A) at facades off school building.

Influence of the characteristics of the locations and period of the day on noise pollution levels L_{NP} and L_{Aeq}. The environmental sound levels measured at a given location depend on a number of specific variables. In particular, many authors have found that the observed sound levels are mainly related to road traffic characteristics, and especially traffic volume, vehicle horns, rolling stock and tires, unmuffled vehicles, etc. (1, 7). Several studies have demonstrated that the urban conditions of a given area are also a very important factor influencing the environmental noise levels (8). There is variation in the noise levels with the period of the day and the nature of the location. In general, there is high noise pollution levels (*L*NP) in the daytime (12:00 noon –4:00 pm) compared with the morning time (7:30 am–10:00 am).

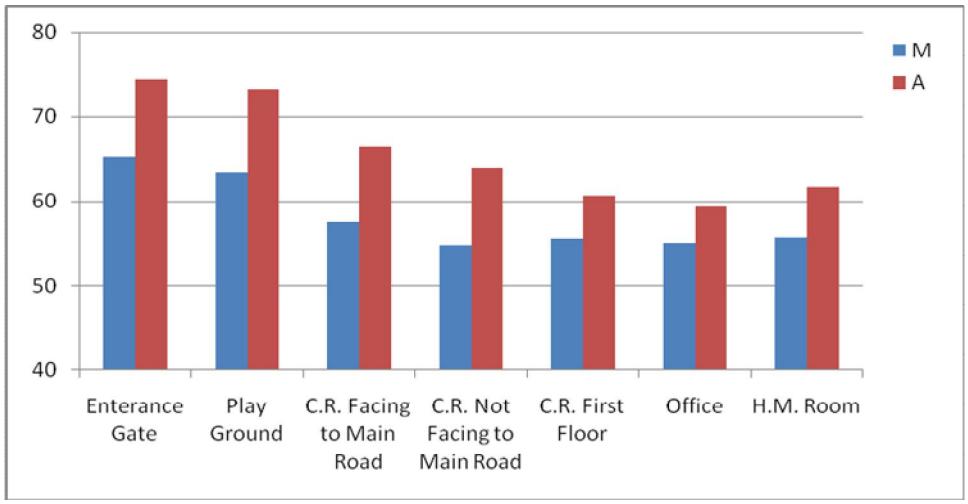

Fig. 3 Variation of Equivalent noise levels (L_{Aeq}) with location and period of the day

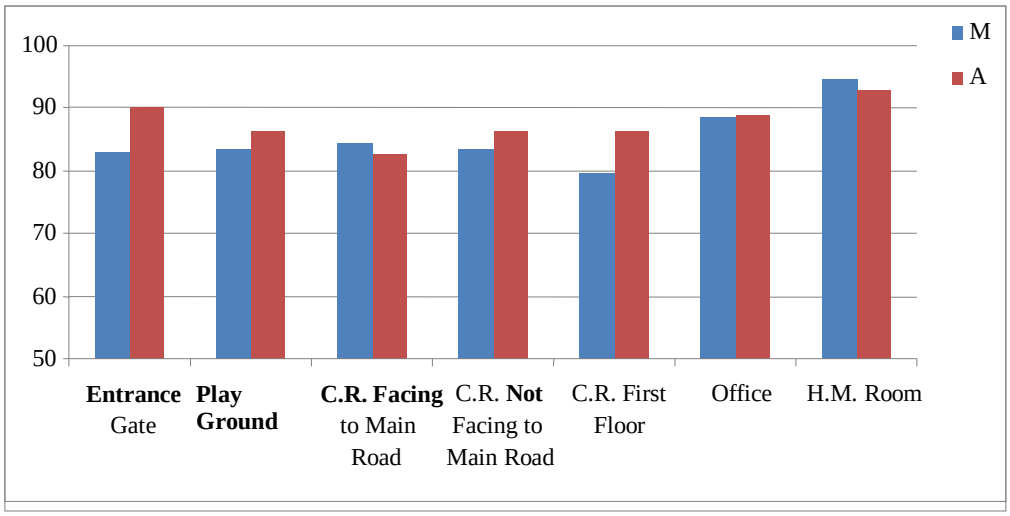

Fig. 4 Variation of Noise Pollution Levels (L_{NP}) with location and period of the day.

Figure 3 and 4 shows the variations of equivalent noise levels and noise pollution levels with locations and measurement period of the day. At playground, classroom facing to main road, internal classroom, office block and staff room, both the L_{NP} and L_{Aeq} rise from morning and reach peak values in the afternoon, but descend in the evening to low levels. The high noise pollution levels in the morning and afternoon at all the sampling locations can be justified as a result of morning rushing hours of students, staff, and traffic volume. The noise pollution levels in the evening time (4:30 pm–6:00 pm) at office, classroom, and playground areas are generally low. This is because the majority of the students and staff are not available at this time. At the time of measurement, the highest and lowest noise pollution levels are 87 dB (A) and 72 dB (A) respectively. Highest noise equivalent levels are 74 dB (A) during entire measurement period. Playground and classroom facing to the main road were found to be the noisiest sites with peak noise levels (L_{10}) of 77 dB (A) and 74 dB (A), respectively, compared to the peak noise value in the internal classroom and the classroom at first floor of 65 dB (A) and 68 dB (A) respectively. The high noise pollution values of these sites may be a result of the noise produced by various activity carried by students and the working staff. Noise from surrounding activity is found to be another source creating substantial amount of noise.

In most countries, noise regulations suggest that the maximum outdoor noise level for educational building should be 55 dB (A) equivalent noise levels. This means that over 55 dB (A) outdoor equivalent noise levels at the facade of educational buildings will cause a decrease in educational efficiency. In India, the Noise Pollution (Regulation and Control) Rules, 2000 and Noise Pollution (Regulation and Control) (Amendment) Rules, 2010 have been framed under the ambit of Environment (Protection) Act, 1986. The ambient levels of noise for silence zones such as educational buildings is about 50 dB (A) during the day and 40 dB (A) at nights [7].

Table 3: Analysis of variance for noise pollution level (L_{NP})

Source of Variation	SS	DF	MS (MS=SS/DF)	MSR ($MSR_c=MS_c/MS_r$)	$MSR_{tabulated}$ ($F_{0.1,1,12}$)	Sig.
Column	730.69	$C-1=1$	243.56			
Residual	384.75	$(N-1)-(C-1)=12$	32.06	**7.60**	2.61	0.004
Total	1115.44	$N-1=13$				

Table 4: Analysis of variance for Traffic Noise Index (**TNI**)

Source of Variation	SS	DF	MS (MS=SS/DF)	MSR ($MSR_c=MS_c/MS_r$)	$MSR_{tabulated}$ ($F_{0.1,3,12}$)	Sig
Column	380.64	$C-1=1$	380.64			
Residual	366.57	(N-1) –(C-1) =12	30.55	12.46	2.61	0.004
Total	747.21	N -1 = 13				

The noise levels in all the locations surveyed, except are higher than the recommended level of 50 dB (A) for day time and 40 dB (A) for night time. The noise level is about 1 to 26 dB (A) over than the recommended level prescribed by the regulatory authority. To ascertain the significant difference in the noise level exposure in all the locations surveyed throughout the day (from morning to evening time), statistical analysis of variance for single factor experiment, using F-distribution, was carried out on L_{NP} and TNI. Tables 4 and 5 are analysis of variance tables for noise pollution levels L_{NP} and TNI, respectively. At 90 % confidence level, the mean square ratio (MSR) calculated for L_{NP} is 7.60, while the tabulated value is 2.61 (9). Similarly, at the same confidence level, the MSR calculated for L_{Aeq} is 12.46 and the tabulated value remains as 2.61. Since, in the two cases, the calculated MSR is greater than the tabulated value, there is a significant difference ($P < 0.05$) in the noise pollution level (L_{NP}) and TNI in the locations surveyed based on the data analysed at 90% confidence level.

V. CONCLUSION AND REMARK

The present study shows that the noise level in the school is exceeded (rang 63-74 dB) compared to permissible value (50 dB) all the time, prescribed by the CPCB norms. This study shows that the noise levels in the classroom facing to main road have higher value (66 dB) compared to the standards for the classroom. The noise levels in the afternoon hours are noisier than the noise levels of the morning hours. The increased noise levels is found to be one of the cause for the deterioration of the students performance in the school, hence a focused attention is needed to create a good acoustic environment in a school building and the surroundings to reduce the noise levels.

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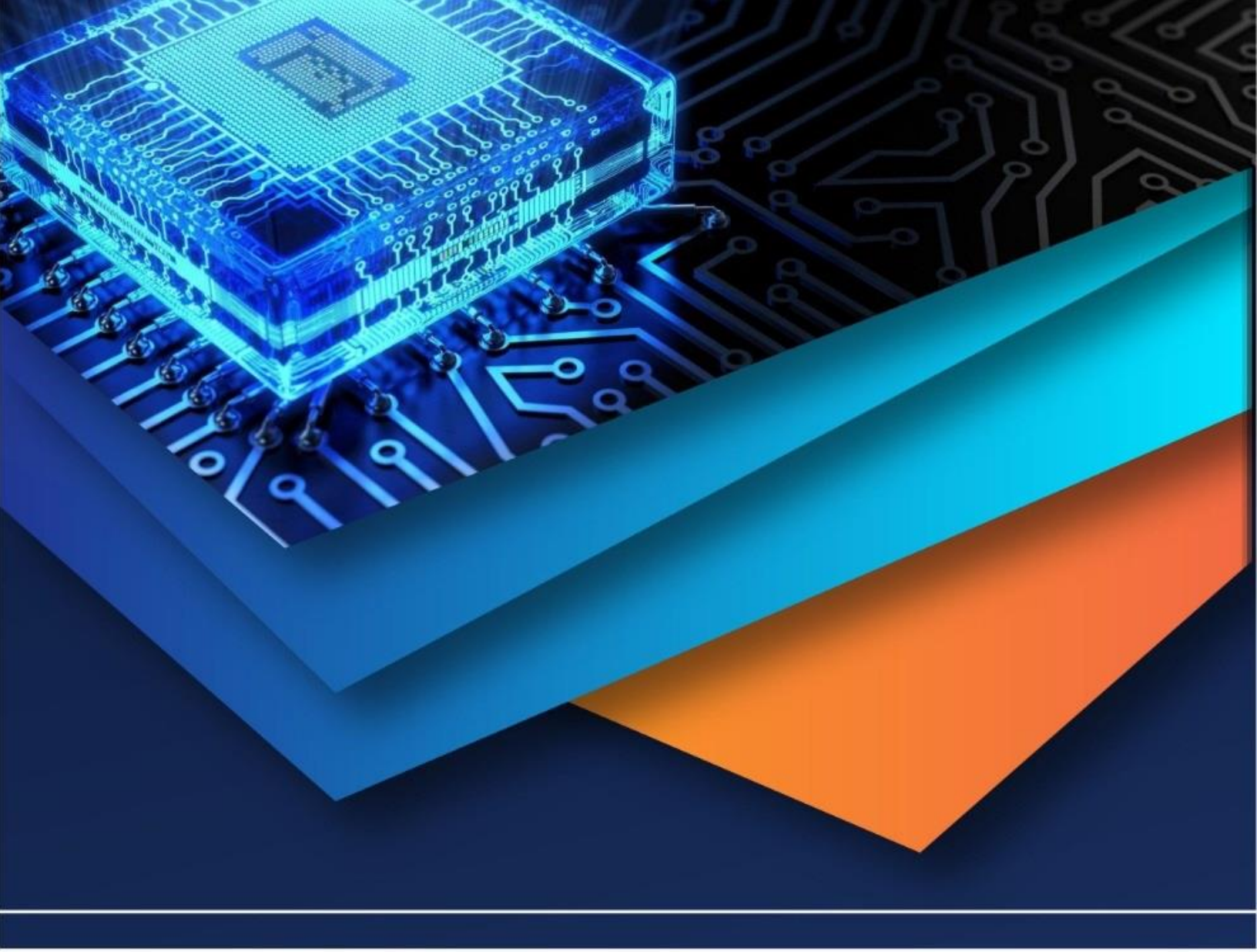

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