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Barriers to Sustainable Construction in Tier-2 Indian Cities: A Case Study of Gwalior

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Abstract: Sustainable construction is essential for reducing the environmental impact of urban growth in India. While Tier-1 cities have seen growing adoption of green practices, Tier-2 cities such as Gwalior lag behind due to context-specific challenges. This study investigates the barriers to sustainable construction in Gwalior using quantitative data collected from 123 stakeholders in the construction sector. Five major categories—awareness, regulatory support, material availability, cost perception, and training—were assessed. Regression analysis reveals that training and education (β = 0.301) and awareness (β = 0.263) significantly influence adoption, while cost perception (β = –0.141) negatively impacts it. The findings provide evidence for targeted interventions aimed at improving policy enforcement, professional training, and green supply chain infrastructure in mid-sized cities.
Keywords: Sustainable construction, Tier-2 cities, stakeholder perception, construction barriers, Gwalior

I. INTRODUCTION

The construction industry plays a critical role in shaping sustainable urban development, especially in rapidly urbanizing nations like India. Globally, the sector is responsible for over 40% of extracted raw materials, approximately 30% of greenhouse gas emissions, and substantial solid waste generation (UNEP, 2021). This environmental burden has led to a growing global emphasis on sustainable construction—defined as the practice of designing, constructing, and maintaining buildings in an environmentally responsible and resource-efficient manner throughout their lifecycle (Kibert, 2016). Sustainable construction not only seeks to reduce the ecological footprint of buildings but also aims to promote social well-being and economic resilience through better energy efficiency, improved indoor air quality, and reduced long-term operational costs.

In response to these challenges, many countries have adopted regulatory frameworks and market-driven certification systems such as LEED (Leadership in Energy and Environmental Design), BREEAM (Building Research Establishment Environmental Assessment Method), and Green Star, which have significantly advanced the mainstreaming of sustainable building practices. India, too, has developed its own national standards and rating systems—most notably the Energy Conservation Building Code (ECBC) and the Green Rating for Integrated Habitat Assessment (GRIHA)—to encourage the adoption of green construction (BEE, 2018; TERI, 2020). Organizations like the Indian Green Building Council (IGBC) have further strengthened the institutional ecosystem by offering voluntary certification tools adapted to Indian conditions.

However, the adoption of sustainable construction practices remains uneven across India. While Tier-1 metropolitan cities such as Delhi, Mumbai, and Bengaluru have witnessed notable advancements in green-certified buildings, Tier-2 cities—characterized by moderate infrastructure, growing populations, and emerging economic activity—continue to lag behind (MoHUA, 2020). These mid-sized urban centers face unique challenges such as limited technical expertise, weak regulatory enforcement, cost-sensitive market behavior, and insufficient access to eco-friendly materials (Gupta & Choudhury, 2019; Sharma & Narayan, 2020). Moreover, there is a widespread perception among stakeholders that sustainable construction is prohibitively expensive and complex, further reducing its appeal in cost-conscious environments (Darko & Chan, 2016).

Gwalior, a Tier-2 city located in central India, exemplifies this implementation gap. Despite being included in national missions like the Smart Cities Mission and AMRUT, the practical uptake of green construction in the city remains minimal. Local developers, contractors, and even regulatory bodies often lack the training, incentives, or material supply chains necessary to execute sustainable practices effectively (Reddy & Thomas, 2021). This reflects a broader pattern observed in secondary cities across India, where the absence of contextualized implementation frameworks impedes progress toward sustainability goals.

Given India's commitment to the Sustainable Development Goals (SDGs) and the Paris Agreement, promoting sustainable construction in Tier-2 cities is both a necessity and an opportunity. These cities are projected to absorb a significant share of future urban growth and therefore represent strategic sites for intervention. However, achieving meaningful change requires a clear understanding of the localized barriers impeding adoption.

This study addresses this gap by empirically analyzing the awareness levels, cost perceptions, regulatory challenges, material availability, and educational deficits influencing sustainable construction in Gwalior. By capturing stakeholder perspectives and quantifying the relative influence of each barrier, the research aims to inform evidence-based policy and practice tailored to India's evolving urban landscape.

II. LITERATURE REVIEW

Sustainable construction, also known as green or eco-friendly building, refers to the practice of designing, constructing, operating, and deconstructing buildings in ways that minimize environmental impact while maximizing economic and social benefits (Kibert, 2016). The concept emerged in the 1970s amid growing global concerns about climate change, urban sprawl, and resource depletion. Landmark events such as the 1987 Brundtland Report, which defined sustainable development as meeting present needs without compromising the future, laid the theoretical foundation for integrating environmental responsibility into building practices (WCED, 1987). Over time, sustainable construction has evolved from a fringe environmental ideal into a measurable and market-driven domain supported by regulatory codes and rating systems.

Globally, several countries have institutionalized sustainability through frameworks like LEED (United States), BREEAM (United Kingdom), and Green Star (Australia), all of which provide benchmarks for resource efficiency, carbon reduction, and occupant health (USGBC, 2019; WorldGBC, 2020). These systems have been supported by policies offering tax incentives, fast-track approvals, or mandatory compliance for certain building categories. For example, Germany's EnEV mandates energy-efficient design standards, while the UK integrates green retrofitting into national housing strategies. Even emerging economies like China and South Africa have implemented their own context-specific rating systems, reflecting a global shift toward mandatory sustainability practices (Zhang et al., 2017; Alyami et al., 2013).

In India, the policy framework for sustainable construction has seen considerable expansion in recent years. The Bureau of Energy Efficiency introduced the Energy Conservation Building Code (ECBC) in 2007, mandating minimum energy performance standards for commercial buildings (BEE, 2018). Additionally, the Green Rating for Integrated Habitat Assessment (GRIHA), developed by The Energy and Resources Institute (TERI), has been positioned as the national rating system with greater sensitivity to local climatic and socio-economic contexts (TERI, 2020). The Indian Green Building Council (IGBC) also promotes voluntary certification across different building types. Complementing these initiatives are urban development missions like Smart Cities Mission and AMRUT, which aim to embed sustainability principles into broader infrastructural reforms (MoHUA, 2020).

Despite these advances, implementation remains inconsistent—especially in Tier-2 and Tier-3 cities. Studies show that barriers in these regions are often structural and systemic. Zuo and Zhao (2014) highlight the general lack of awareness and practical knowledge among stakeholders in developing economies. Similarly, Sharma and Narayan (2020) report that in smaller Indian cities, most construction professionals are unfamiliar with green rating systems and often associate sustainable construction with high costs and impractical complexity. This knowledge gap is further compounded by fragmented supply chains, inadequate training programs, and limited local incentives (Jain & Garg, 2020; Reddy & Thomas, 2021).

Regulatory and institutional barriers are also prominent. While codes like ECBC exist, their enforcement at the municipal level is weak, particularly outside Tier-1 cities. Gupta and Choudhury (2019) found that local governments often lack the technical capacity to implement or monitor green building guidelines effectively. Moreover, there is often jurisdictional overlap between state and municipal authorities, leading to confusion and non-compliance. Studies such as those by Gou and Xie (2017) argue that India's decentralized approach to policy enforcement undermines national sustainability goals, in contrast to more centralized models like China's.

Material availability remains another critical bottleneck. In cities like Gwalior, sourcing certified green materials—such as fly ash bricks, recycled aggregates, or low-VOC paints—is difficult due to limited supplier networks and low demand (Reddy & Thomas, 2021). Jain and Garg (2020) emphasize that vendors are often unaware of green product specifications or unwilling to stock them due to poor market readiness. Without access to reliable materials, even willing stakeholders are unable to implement sustainable practices effectively.

Economic constraints and cost perceptions further inhibit adoption. Although green buildings often offer lifecycle cost savings, stakeholders—especially in mid-sized cities—prioritize initial construction costs over long-term benefits (Darko & Chan, 2016; Kumar et al., 2019). Vyas and Shah (2022) found that the absence of green financing models—such as targeted loans or subsidies—makes it harder for developers to justify sustainable alternatives, especially when client awareness is low.

The role of education and training is another widely acknowledged gap. Agarwal et al. (2021) argue that Indian engineering and architecture programs often treat sustainability as an elective rather than an integrated design principle.

This results in a workforce that is underprepared to execute green projects. Desai and Vora (2024) further note that universities seldom collaborate with industry or regulatory bodies, limiting students' exposure to practical sustainability tools like GRIHA or IGBC. Without proper training, both professionals and laborers struggle to implement or even recognize sustainable construction standards.

In conclusion, the literature identifies five major barriers to sustainable construction adoption in India's Tier-2 cities: limited awareness, weak regulatory enforcement, poor material access, high cost perception, and lack of formal training. However, most existing studies focus on metropolitan areas, with little empirical research dedicated to understanding these challenges in mid-sized urban centers like Gwalior. This research aims to fill that gap by quantifying the impact of these five barriers and offering a stakeholder-informed framework for sustainable construction in Tier-2 cities.

III. METHODOLOGY

A. Research Design

This study utilizes a quantitative cross-sectional research design to investigate the barriers to sustainable construction in Gwalior, a Tier-2 Indian city. The cross-sectional approach allows for the collection of data from multiple stakeholders at a single point in time, enabling a snapshot of current perceptions and practices. The design is particularly suitable for identifying and comparing the influence of key variables such as awareness, cost perception, regulatory support, and training on sustainability adoption (Creswell, 2014).

B. Study Area and Target Population

Gwalior was selected as the study location due to its status as a growing Tier-2 city with active participation in national urban development programs like the Smart Cities Mission. The target population consisted of professionals directly involved in the construction sector, including civil engineers, architects, contractors, developers, consultants, and government officials. These stakeholders were chosen because of their direct or indirect influence on construction decisions and sustainability outcomes.

C. Sampling Technique and Sample Size

Given constraints such as limited access to an exhaustive sampling frame and logistical challenges, a non-probability convenience sampling method was employed. This approach, while not statistically random, is commonly used in exploratory research and allowed access to a broad, willing set of participants. A total of 123 valid responses were obtained, providing an adequate sample size for statistical reliability and multiple regression analysis.

D. Research Instrument and Variables

Data were collected using a structured questionnaire divided into two sections:

- Section A: Captured demographic data (designation, years of experience, project type).
- Section B: Included 24 Likert-scale items (1 = Strongly Disagree to 5 = Strongly Agree) grouped into six key constructs:
    - Awareness of Sustainable Practices
    - Regulatory Support
    - Material Availability
    - Cost Perception
    - Training and Education
    - Adoption of Sustainable Practices (dependent variable)

These constructs were selected based on a comprehensive review of existing literature and adapted to reflect the regional context of Gwalior.

E. Reliability and Validity

To assess the internal consistency of the constructs, Cronbach's Alpha was calculated for each. All six constructs demonstrated α values above 0.75, indicating acceptable to very good reliability (Nunnally & Bernstein, 1994). The questionnaire was also pilot tested among a small group of professionals to ensure clarity and content validity.

F. Data Analysis Techniques

Data were analyzed using SPSS software. The analysis involved:

- Descriptive statistics to identify trends in stakeholder perceptions.
- Reliability testing (Cronbach's Alpha) to validate internal consistency.
- Multiple linear regression to evaluate the influence of each independent variable (barrier) on the dependent variable (adoption of sustainable construction).

  The model's explanatory power was assessed using R^2 and adjusted R^2 values, while p-values determined the statistical significance of each predictor.

G. Research Objectives and Hypotheses

The methodological framework was aligned with the following objectives:

- To assess awareness levels of sustainable construction.
- To identify key regulatory, material, economic, and educational barriers.
- To evaluate the influence of these barriers on adoption.
- To propose recommendations based on empirical findings.

Accordingly, five hypotheses (H1–H5) were formulated to test the significance of each construct's influence on the adoption of sustainable construction.

IV. RESULTS AND ANALYSIS

This section presents the empirical findings from the structured questionnaire administered to construction professionals in Gwalior. The analysis covers respondent demographics, reliability of survey constructs, descriptive statistics of perceived barriers, multiple regression results, and hypothesis testing to evaluate the impact of these barriers on the adoption of sustainable construction practices.

A. Demographic Profile of Respondents

Table 1 presents the distribution of respondents based on designation, years of experience, and types of projects handled. Among the 123 professionals surveyed, civil engineers comprised the largest group (28.5%), followed by contractors (22.7%) and architects (17.9%). The diversity of roles ensures broad representation across planning, execution, and regulatory aspects of construction.

Experience-wise, most respondents had between 5 to 10 years of experience (34.1%), which reflects a balanced input from both early-career and mid-career professionals. The remaining participants were distributed across less than 5 years (24.4%), 11–15 years (22.8%), and over 15 years (18.7%).

Regarding project type, residential projects were the most common (40.7%), which is consistent with the growth of housing demand in Tier-2 cities. Other segments like commercial (20.3%), infrastructure (14.6%), institutional (12.2%), and mixed-use (12.2%) were also represented, reflecting a diverse project landscape in Gwalior.

Table 1: Respondent Demographics

Demographic Variable	Category	Frequency (n)	Percentage (%)
Designation	Civil Engineer	35	28.5%
	Contractor	28	22.7%
	Architect	22	17.9%
	Developer	16	13.0%
	Consultant	12	9.8%
	Government Official	10	8.1%
Experience	<5 years	30	24.4%
	5–10 years	42	34.1%
	11–15 years	28	22.8%
	>15 years	23	18.7%
Project Type	Residential	50	40.7%
	Commercial	25	20.3%
	Infrastructure	18	14.6%
	Institutional	15	12.2%
	Mixed-Use	15	12.2%

B. Reliability Analysis

As shown in Table 2, the Cronbach's Alpha was used to assess the internal consistency of each construct in the questionnaire. All constructs exceeded the acceptable threshold of 0.70, indicating reliable and coherent item groupings.

- Adoption (α = 0.867) and Training & Education (α = 0.841) showed the highest reliability.
- Material Availability had the lowest, but still acceptable, alpha value (0.754).

This confirms that the items used to measure each barrier and outcome were statistically consistent, strengthening the validity of subsequent analyses.

Table 2: Cronbach Alpha Values

Construct	Number of Items	Cronbach's Alpha (α)	Reliability Level
Awareness	4	0.821	Good
Regulatory Support	4	0.788	Acceptable
Material Availability	4	0.754	Acceptable
Cost Perception	4	0.812	Good
Training & Education	4	0.841	Good
Adoption (Dependent Var.)	4	0.867	Very Good

C. Descriptive Statistics of Constructs

Table 3 summarizes the mean and standard deviation of each construct.This table summarizes the average perceptions (mean) and variability (standard deviation) for each construct.

- Awareness had the highest mean (3.89), indicating that respondents are generally familiar with the concept of sustainable construction.
- Cost Perception followed closely (mean = 3.97), suggesting that stakeholders strongly believe sustainable construction is costly.
- Material Availability (3.07) and Training & Education (3.11) received the lowest scores, pointing to practical implementation gaps in supply and skill development.

These insights reveal that while sustainability awareness is high, execution barriers remain in material sourcing and professional training.

Table 3: Descriptive Statistics of Barrier Constructs

Construct	Mean	Standard Deviation
Awareness	3.89	0.61
Regulatory Support	3.20	0.73
Material Availability	3.07	0.69
Cost Perception	3.97	0.56
Training & Education	3.11	0.81
Adoption of Practices	3.58	0.62

D. Regression Analysis

Table 4 presents the overall fitness of the regression model. With an R^2 value of 0.549, the model explains approximately 54.9% of the variance in sustainable construction adoption. This indicates a strong and meaningful relationship between the independent variables (barriers) and the dependent variable (adoption).

Table 4: Model Summary

Model	R	R^2	Adjusted R^2	Std. Error
1	0.741	0.549	0.530	0.524

As shown in Table 5, the analysis of variance (ANOVA) confirms that the regression model is statistically significant ($F = 27.571$, $p < 0.01$). This validates that the combined set of independent variables reliably predicts the dependent variable.

Table 5: ANOVA Summary

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	37.941	5	7.588	27.571	0.000**
Residual	31.241	117	0.267		
Total	69.182	122			

Table 6presents the individual influence of each barrier on the adoption of sustainable construction practices. Among the predictors, Training & Education demonstrated the strongest positive effect (β = 0.301, p = 0.000), highlighting the critical role of professional skill development and formal instruction in enabling sustainable practices. Awareness followed as the second most influential factor (β = 0.263, p = 0.004), indicating that better-informed stakeholders are more likely to support and implement sustainable methods. In contrast, Cost Perception was the only significant negative predictor (β = –0.141, p = 0.044), confirming that perceived high costs act as a deterrent. Regulatory Support (β = 0.179) and Material Availability (β = 0.166) also showed statistically significant positive effects, albeit with lower beta values, suggesting that while these factors influence adoption, their impact is less pronounced. Collectively, the regression results confirm that all five barriers meaningfully shape the landscape of sustainable construction adoption in Gwalior.

Table 6: Regression Coefficients

Predictor	Unstandardized B	Standard Error	Standardized Beta (β)	t	Sig. (p)
Constant	0.613	0.241	—	2.545	0.012
Awareness	0.234	0.079	0.263	2.962	0.004 **
Regulatory Support	0.196	0.088	0.179	2.227	0.028 *
Material Availability	0.182	0.085	0.166	2.144	0.034 *
Cost Perception	–0.148	0.073	–0.141	–2.033	0.044 *
Training & Education	0.291	0.076	0.301	3.842	0.000 **

Note: *p < 0.05, **p < 0.01

E. *Hypothesis Testing*

Table 7confirms that all five proposed hypotheses were statistically supported. H5, which posits that a lack of formal training and education hinders the implementation of sustainable construction, emerged as the strongest predictor (β = 0.301, p = 0.000), highlighting the critical importance of professional capacity building. H1 was also validated (β = 0.263, p = 0.004), indicating that limited awareness significantly contributes to poor adoption. H2 and H3, concerning inadequate regulatory support (β = 0.179, p = 0.028) and limited material availability (β = 0.166, p = 0.034), were both found to be significant barriers, though with comparatively lower influence. H4 was the only hypothesis with a negative beta (β = –0.141, p = 0.044), confirming that high cost perception reduces stakeholders' willingness to embrace sustainable practices. Collectively, these results validate the conceptual framework and demonstrate that all five barriers play meaningful roles in shaping sustainable construction adoption in Gwalior.

Table 7: Summary of Hypothesis Testing

Hypothesis Code	Statement	Standardized Beta (β)	p-value	Result
H1	Low awareness significantly contributes to poor adoption of sustainable construction practices.	0.263	0.004	Accepted
H2	Inadequate regulatory support is a significant barrier to sustainable construction.	0.179	0.028	Accepted
H3	Limited availability of eco-friendly construction materials negatively affects adoption.	0.166	0.034	Accepted
H4	High cost perception significantly reduces the willingness to adopt sustainable practices.	–0.141	0.044	Accepted
H5	Lack of formal training and education hinders implementation of sustainable construction.	0.301	0.000	Accepted (Strongest)

V. CONCLUSION

This study examined the key barriers influencing the adoption of sustainable construction practices in Gwalior, a representative Tier-2 city in India. Through quantitative analysis of responses from 123 construction professionals—including architects, engineers, contractors, and officials—the research identified five critical factors affecting adoption: awareness, regulatory support, material availability, cost perception, and training and education.

The findings reveal that while awareness of sustainable construction concepts is relatively high among stakeholders, actual implementation remains limited due to practical and systemic constraints. Among all factors analyzed, lack of training and education emerged as the most significant barrier, highlighting the need for structured capacity-building programs and curriculum integration at professional and academic levels. Awareness was also found to positively influence adoption, suggesting that continued efforts in information dissemination and stakeholder engagement are essential.

Conversely, cost perception was the only negative predictor, confirming that the belief that sustainable construction is expensive deters its acceptance, particularly in price-sensitive Tier-2 markets. Inadequate regulatory support and poor material availability further exacerbate the issue, although their influence was found to be comparatively moderate.

Overall, the study concludes that overcoming these barriers requires a multi-pronged strategy: enhancing education and training programs, improving regulatory enforcement and incentives, strengthening green material supply chains, and addressing financial misconceptions through awareness campaigns and policy interventions. By tackling these interconnected challenges, cities like Gwalior can significantly accelerate their transition toward environmentally responsible and economically viable construction practices.

The framework developed through this research offers a replicable model for assessing and addressing sustainable construction barriers in other Tier-2 and Tier-3 cities across India, contributing to broader national and global sustainability goals.

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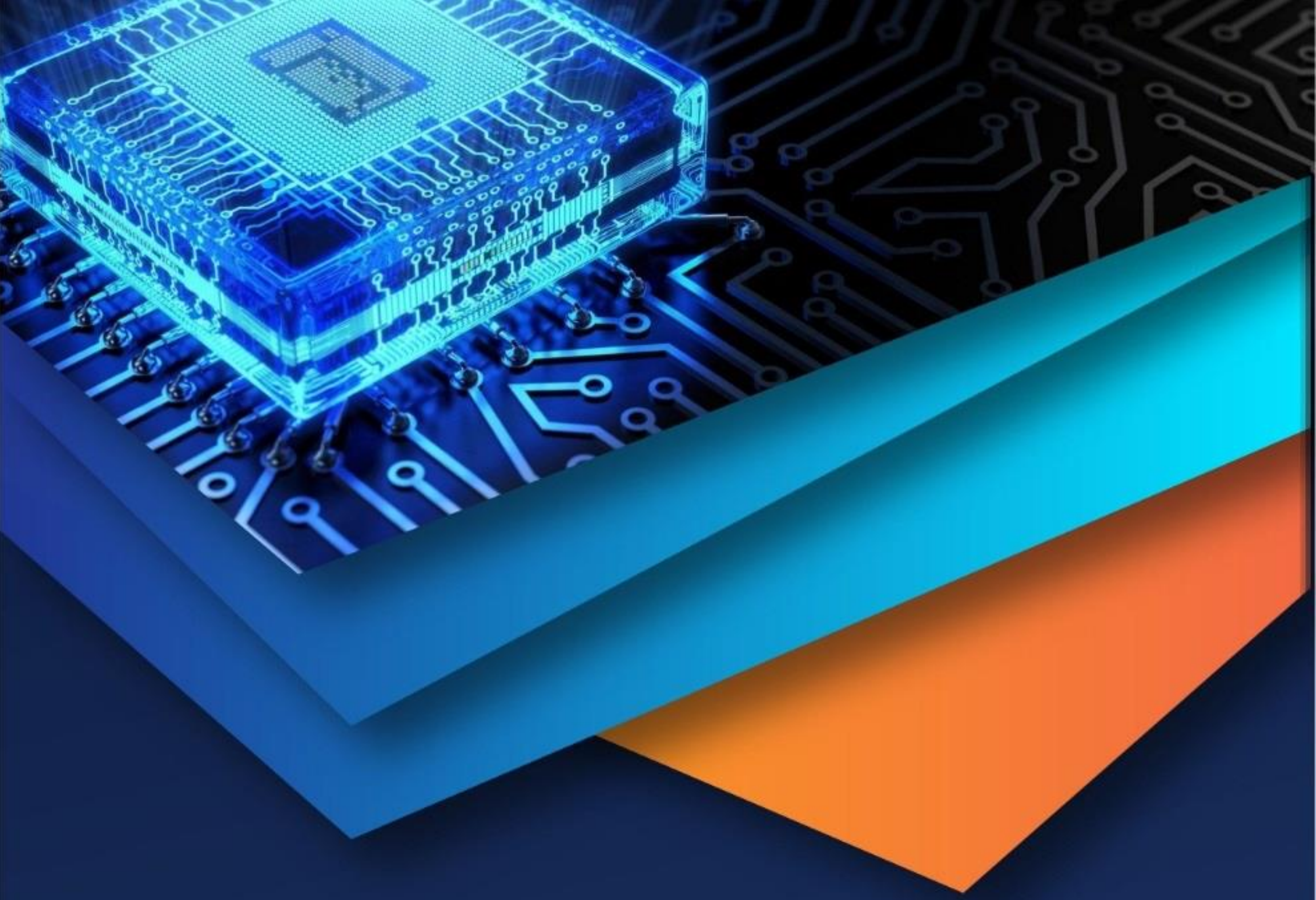

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