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Impact of Sustainable Practices in Construction

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Abstract: ***Purpose: 1. Investigate Sustainability Practices: The primary purpose is to investigate the state of sustainability practices within the Indian construction industry.***
2. Enhance Understanding: The study aims to enhance the understanding of awareness, implementation levels, and challenges faced by stakeholders in adopting sustainable construction practices.
3. Contribute Insights: The research seeks to contribute valuable insights that can aid in improving sustainable construction methods in India.
Principal research questions:
RQ.1- what extent are stakeholders in the Indian construction industry aware of sustainability practices?
RQ.2- What are the key challenges hindering the effective implementation of sustainability practices in Indian construction projects?
DESIGN:
1. Descriptive Research Design: The research adopts a descriptive research design to precisely characterize the awareness, practices, and challenges related to sustainability in the Indian construction sector.
2. Quantitative and Qualitative Data: Uses both primary (quantitative) and secondary (qualitative) data to provide a comprehensive overview of the sustainability landscape.
3. Questionnaire Distribution: A digital questionnaire is distributed to diverse stakeholders, including project managers, contractors, civil engineers, professors, and students.
Findings: The construction professionals in the study area show a heightened awareness of sustainability practices, primarily emphasizing the selection of an appropriate construction method for resource conservation and client satisfaction. This collective consciousness aligns with the broader understanding of sustainable construction, emphasizing responsible resource utilization and meeting client expectations. The shared awareness is further reinforced by the identification of key sustainability practices such as controlling water usage, promoting community development, utilizing local material sources, implementing sustainable site planning, and fostering innovation. These practices collectively underscore a holistic approach to sustainability, addressing environmental, social, and economic aspects in the construction phase.
It unveils nuanced variations in the perception of sustainability practices among professional categories, revealing that control of dust, waste management, and participatory approaches exhibit significant differences in how Builders, Architects, Engineers, and Quantity Surveyors perceive these aspects. This understanding reinforces the importance of a cohesive and cross-disciplinary approach to sustainability within the construction industry, acknowledging the distinct perspectives of various professionals while collectively contributing to the broader goal of sustainable construction practices.
Practical Implications: The research paper provides practical implications for construction professionals by identifying key sustainability practices like selecting appropriate construction methods and prioritizing client satisfaction. These findings offer a tangible framework, guiding professionals in integrating sustainable approaches, fostering resource efficiency, and improving project sustainability. This supports policymakers by offering insights into nuanced perceptions among Builders, Architects, Engineers, and Quantity Surveyors. Understanding these dynamics informs policy formulation that encourages effective collaboration and communication. Recognizing client satisfaction as a paramount sustainability practice underscores the need for policies promoting tailored, client-centric sustainable solutions. This aligns industry practices with broader sustainability objectives, facilitating impactful integration of sustainable practices in the construction sector.
Originality: The paper contributes by filling a gap in the existing literature on sustainability practices during the construction phase in the specified study area. The unique focus on the awareness, perception, and implementation of practices among Builders, Architects, Engineers, and Quantity Surveyors distinguishes this study, providing original insights into the sustainability landscape of the construction industry. This study further reveals theoretical and empirical gaps, offering avenues for future research on sustainability practices in construction. Significant variations in perceptions among professional categories highlight the need for deeper exploration of interdisciplinary dynamics.

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The emphasis on client satisfaction as a pivotal sustainability practice prompts questions about the role of client expectations in shaping sustainable construction approaches. These gaps in understanding open avenues for further research, encouraging scholars to delve into the complexities of sustainability integration, explore interdisciplinary frameworks, and investigate the relationship between client satisfaction and sustainable practices. The research paper not only fills a gap but also sets the stage for future academic inquiries in the field.

Keywords: Sustainability in construction practices, social economic and environmental dimensions, awareness level, implementation challenges different perspectives Resource utilization water and noise pollution prevention in construction, three dimensions of sustainability.

I. INTRODUCTION

A. Background of the Study

1) Brief Overview

Sustainability in construction revolves around adopting thoughtful practices across material selection, sourcing, construction methodologies, and design philosophy to enhance project performance while minimizing environmental impact and waste.

Choosing materials with a focus on renewable resources and responsible sourcing, sustainable construction prioritizes methods that efficiently utilize resources, reduce energy consumption, and limit waste generation. The design philosophy integrates principles that prioritize energy efficiency and consider the life cycle of structures.

The ultimate goal is to reduce the environmental burden of construction projects, fostering ecologically friendly practices that preserve biodiversity and natural habitats. By embracing sustainability, the construction industry aims to create resilient structures that meet present needs without compromising the ability of future generations to meet their own.

This holistic approach aligns with principles of sustainable development, promoting a balance between societal, economic, and environmental considerations.

2) Present Scenario

In developing nations like India, integrating sustainable tools and practices into projects faces challenges due to limited awareness of sustainability. Sustainability extends beyond environmental concerns, encompassing social and economic facets. Raising awareness among employees and employers about the advantages of sustainable construction is crucial. Identifying critical success factors and creating a framework for companies is imperative in addressing the current state of sustainability in Indian construction.

In India's construction landscape, the prevailing challenge lies in the limited grasp of sustainable principles. Overcoming this obstacle is pivotal as sustainability goes beyond environmental concerns to embrace social and economic dimensions. Creating awareness about the comprehensive advantages of sustainable construction among employees and employers is imperative. The pressing need of the hour is to pinpoint critical success factors and formulate a robust framework, fostering a shift towards sustainable practices within the Indian construction sector.

3) Need and Significance of the Topic

The construction industry indeed plays a pivotal role in human development by providing essential elements for a decent quality of life. Here are a few key points based on statement:

a) *Essential Contributions:* The construction industry contributes significantly to human development by providing fundamental needs such as shelter, water supply, sanitation, and essential infrastructure like roads and railway networks.

b) *Quality of Life:* Through the creation of habitable spaces and critical infrastructure, the construction sector directly impacts and enhances the overall quality of life for individuals and communities.

c) *Global Significance:* As one of the largest sectors globally, the construction industry holds substantial economic importance. It spans a wide range of activities, from residential and commercial buildings to large-scale infrastructure projects.

d) *Economic Impact:* The industry's size and scope make it a major driver of economic growth, creating job opportunities and fostering innovation and technological advancements.

e) *Social Infrastructure:* Beyond physical structures, the construction sector contributes to the development of social infrastructure, including schools, hospitals, and public spaces, further influencing societal well-being.

f) *Global Connectivity:* Infrastructure projects like roads and railways not only connect regions but also facilitate economic activities and improve accessibility, fostering regional and global connectivity.

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4) Existing Issues

a) Labor Shortages

- Industries, notably construction, face challenges hiring and retaining skilled workers.
- Construction demand is high, yet skilled workers are in short supply.
- contractors reported difficulties filling positions.

b) Supply Chain Disruptions

- Post-COVID-19, supply chains are recovering, causing material wait times.
- Manufacturing capacity issues contribute to challenges in obtaining U.S.-made materials.

c) Inflation and Material Costs

- Construction input prices surged since 2020.
- Despite fluctuations, concrete products are higher than last year.
- Construction machinery costs increased, driving a rise in equipment rentals.

d) Thriving During Uncertain Times

- Contractors focus on cost-cutting, asset protection, and learning from past downturns.
- Economists and experienced contractors foresee industry resilience despite challenges.

e) Staying Informed

- Keeping abreast of industry issues and trends is crucial.
- Articles, reports, and newsletters aid in informed decision-making.

f) Planning for Setbacks

- Early orders minimize delays; contingency plans address shortages and delays.
- Exploring alternative vendors, subcontractors, and competitive rates is essential.
- Security measures like cameras and monitoring safeguard purchased materials.

g) Focus on Workers

- Business resilience hinges on project completion, relying on a skilled workforce.
- Retaining and finding skilled employees becomes a primary focus for success.

B. Statement of the Problem

Researching the environmental impact of construction activities is imperative due to its widespread consequences. The extensive resource consumption, waste generation, and greenhouse gas emissions associated with construction contribute significantly to environmental degradation and climate change. Investigating and addressing these issues is vital for mitigating the global warming effects that lead to extreme weather changes. Beyond climate concerns, research can offer solutions to unsustainable resource use, aiding in the conservation of natural resources and addressing water scarcity challenges exacerbated by construction practices. Effective waste management strategies can reduce environmental burdens, while optimizing energy consumption in the lifecycle of buildings contributes to overall sustainability. The international scope of the problem emphasizes the need for global collaboration in developing policies and practices that promote responsible construction, ensuring a more resilient and environmentally conscious future.

C. Objectives of the Study

The main objectives of research:

(SMART) goals:

1) Examine the Level of Awareness of Sustainable Practices During Construction

- Specific: Assess the awareness of sustainability practices.
- Measurable: Use surveys or interviews to quantify awareness levels.
- Achievable: Conduct the study within a feasible scope.

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- Relevant: Aligns with the overall goal of promoting sustainability.
- Time-bound: Set a timeframe for data collection and analysis.

2) Investigate The Level Of Implementation Of Sustainable Practices
- Specific: Evaluate the extent of sustainability practices implementation.
- Measurable: Use metrics to quantify the implementation levels.
- Achievable: Ensure the study is realistic within available resources.
- Relevant: Addresses the practical aspect of sustainability in construction.
- Time-bound: Establish a timeline for data collection and analysis.

3) Identify Barriers Of Implementing Sustainability Practices
- Specific: Pinpoint obstacles hindering sustainability implementation.
- Measurable: Categorize and quantify barriers where possible.
- Achievable: Gather data to understand challenges faced by professionals.
- Relevant: Provides insights into factors affecting implementation.
- Time-bound: Set a timeline for researching and documenting barriers.

4) Develop Measures For Improving Implementation Of Sustainable Practices
- Specific: Create actionable strategies to enhance implementation.
- Measurable: Define clear criteria for measuring the effectiveness of proposed measures.
- Achievable: Propose realistic and feasible solutions.
- Relevant: Addresses identified barriers and supports sustainability goals.
- Time-bound: Set deadlines for developing and implementing improvement measures.

D. Hypotheses

1) The study aims to assess whether there is a significant difference in awareness of sustainability practices during the construction phase among Builders, Architects, Engineers, and Quantity Surveyors in the study area.
2) Investigating whether there are notable distinctions in the perception of sustainability practices' implementation during the construction phase among Builders, Architects, Engineers, and Quantity Surveyors in the study area is a key focus.
3) The study seeks to determine if there is a meaningful variation in how Builders, Architects, Engineers, and Quantity Surveyors perceive the drivers for sustainability practices during the construction phase of building projects in the study area.
4) Examining potential differences in the perception of barriers to sustainability practices during the construction phase among Builders, Architects, Engineers, and Quantity Surveyors in the study area is another crucial aspect of this research.

E. Significance of the Study

This study significantly contributed to our understanding of sustainability practices in the construction phase of building projects. It delved into the levels of awareness and implementation, identified drivers and barriers, and proposed measures for enhanced execution.

The research outcomes empower building professionals and clients by raising awareness of sustainable building methods and fostering a conscientious approach. Furthermore, the investigation into implementation levels addresses the challenge of knowledge not translating into action, offering building professionals insights to seamlessly integrate sustainability practices.

The focus lies on reducing waste, minimizing emissions, and preserving the environment during construction activities.

II. LITERATURE REVIEW

A. Articles

1) Research paper 1: Author - Mokal et.al (2015)

Source: IOSR Journal (iosrjournals.org)

It states that the construction industry is one of the largest consumers of natural resources.

In the author's article he mentions five sustainable building materials.

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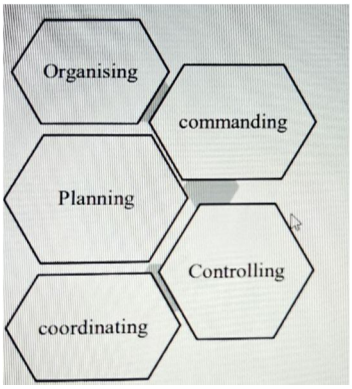
The authors describe green buildings as allowing people to live, work, and work in spaces that are healthy, comfortable, and safe, while also using resources efficiently throughout the building's life cycle, while minimizing the building's environmental impact.
It is also known as sustainable architecture.
The author selected the following five materials considering their availability, price, and strength:

- Lime.
- Sand lime brick.
- Eco-friendly tiles.
- Coloured lime plaster.
- Reflector Sol Glass.

Evaluated the properties of the tile and found the following results: The author selected eco-friendly tiles as a sustainable material.
This is because these tiles are more durable compared to ceramic tiles.
Additionally, eco-friendly tiles are made from locally available materials and use less energy resources during production.

2) Research paper 2: Author- Ogunde et.al (2017)
Source: IOSR Journal (iosrjournals.org)
A case study of a construction company in Nigeria sought to highlight the challenges faced by the company in incorporating sustainability into its project management.
In their study, they published a survey of various civil engineering employees, and their responses were used for analysis.
These answers highlight some of the challenges facing construction companies.
The skills illustrated below are important for project managers to successfully implement projects.



(source: IOSR Journal (iosrjournals.org))

3) Research paper 3: Author- Thivaharan (2015)
Source: Isang, I. W. (2016) Appraisal of the Implementation of Sustainability Practices during Construction Phase of Building Projects in Akwa Ibom. M.Sc Thesis, Department of Building, Faculty of Environmental Studies, University of Uyo, Nigeria.: Inimbom Walter Isang: Free Download, Borrow, and Streaming: Internet Archive
Identified five criteria for implementing sustainability in building construction.
The authors noted that responsible contractors follow sustainability practices and incorporate sustainable site planning and innovation into their challenges to protect the environment from pollution.
The five criteria are:

a) Reduce, recycle, and reuse building materials Proper demolition for maximum recovery of concrete waste for waste treatment, profitable reuse, and recycling of office waste.
b) Protecting the environment; modern technologies and systems: formwork systems to reduce the use of wood, platform systems to reduce the use of scaffolding, use of alternative methods to reduce masonry work.
c) Energy Efficiency Use alternative solar energy in the construction office and AC power instead of generators at the project site.
d) Water Efficiency Equipment for treating and recycling water for non-construction purposes, twenty-one environmentally friendly pesticides and cleaning agents at project sites.
e) Indoor Environmental Quality Control of dust generation from material storage and vehicles, on-site air quality, and appropriate noise management systems to reduce noise pollution

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4) Research Paper 4: Author – R. Drochytka, Z. Dufek and J. Hodul (2020)

Source: Z. Dufek | Semantic Scholar

Construction and demolition waste accounts for a massive portion of the total waste generated in Europe.
It has a small environmental impact, but because it exists in massive quantities, there are many opportunities for reuse.
That is why this issue remains a frequently debated topic in European politics.
As part of the circular economy, the European Commission has already proposed new targets and strategies for existing types of waste.
However, the use of new types of construction and demolition waste is not completely clear, as it needs to be regulated by current legislation.
This article describes new types of construction and demolition waste and the basic principles of their use (modern technologies).
The potential use of new types of waste is based on multi-criteria optimization calculations, where each material is specified and options for its further use are proposed.
Recent discoveries have expanded the range of new uses for construction and demolition waste and have the potential to reduce its environmental impact (reducing waste, with better properties and more efficient processing, reducing the need for transportation, maximizing reuse and recycling).

5) Research paper 5: Author –Unaid Manzoor & Pushpendra Kumar Sharma (2022)

Source: Manzoor, J., Sharma, P.K. (2023). Construction Sustainability in Indian Perspective-A Review. In: Agnihotri, A.K., Reddy, K.R., Chore, H.S. (eds) Proceedings of Indian Geotechnical and Geoenvironmental Engineering Conference (IGGEC) 2021, Vol. 2. IGGEC 2021. Lecture Notes in Civil Engineering, vol 281. Springer, Singapore

Increasing urbanization is placing increasing strain on common natural building material resources.
The way construction projects are planned, executed, and evaluated is changing every day as sustainability is required to be integrated into construction project management. Sustainable project management is rarely practiced in the Indian construction industry due to lack of knowledge and low customer involvement. This article examines the landscape of the Indian construction industry in terms of the extent to which it leverages sustainable design tools and identifies key obstacles to promoting sustainability in project management.

B. Summary of Related Studies

AUTHOR AND YEAR	FINDINGS
1. Mokal et.al (2015)	Focuses on sustainable construction materials, emphasizing green buildings and choosing materials like lime, sand lime bricks, eco-friendly tiles, coloured lime plaster, and reflectasol glass. Eco-friendly tiles were highlighted for their durability and eco-friendly production.
2. Ogunde et.al (2017)	Conducts a case study on a Nigerian construction company, exploring challenges in integrating sustainability into project management. The study involved a questionnaire among civil engineering personnel, highlighting crucial skills for project managers.
3. Thivaharan (2015)	Identifies criteria for sustainability in building construction, emphasizing responsible contractors implementing sustainable site planning, innovation, waste reduction, environmental protection, energy and water efficiency, and indoor environmental quality.
4. R. Drochytka, Z. Dufek and J. Hodul (2020)	Discusses the substantial impact of construction and demolition waste in Europe, focusing on circular economy goals and strategies. Examines new kinds of waste, proposing ways for their use based on multicriteria optimization calculations.
5. Unaid Manzoor & Pushpendra Kumar Sharma (2022)	Explores construction sustainability in the Indian context, addressing the challenges in incorporating sustainability tools in project management due to knowledge deficiencies and limited client participation.

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C. Conceptual Framework

1) Mokal et.al's

In the conceptual framework for Mokal et al.'s (2015) research, the theoretical foundation centers on integrating sustainability theories into the construction industry. Emphasis is placed on the principles of green buildings and sustainable architecture. The literature synthesis encapsulates the study's findings on five sustainable building materials, with a particular focus on eco-friendly tiles. Variables include construction industry resource consumption, sustainable building materials, and the properties of eco-friendly tiles. The conceptual model visually represents the relationships between construction practices, the adoption of sustainable materials, and the specific characteristics that make eco-friendly tiles a sustainable choice. The framework contributes to existing theories by highlighting the practical implications for architects and builders seeking to enhance sustainability in construction projects.

2) Ogunde et.al's

The conceptual framework for Ogunde et al.'s (2017) research centers on the challenges faced by construction companies in integrating sustainability into project management. The theoretical foundation incorporates relevant theories pertaining to sustainability in project management, with an emphasis on the role of project managers in driving sustainable initiatives. The literature synthesis provides insights from a case study on a Nigerian construction company, utilizing survey responses to identify challenges faced by civil engineering employees. Variables include challenges in sustainability adoption and skills essential for successful project management. The conceptual model visually represents the relationships between challenges in sustainability adoption, project management, and the specific skills required for success. This framework contributes to existing theories by highlighting practical implications for project managers and construction companies aiming to enhance sustainability practices in their projects.

3) Thivaharan's

Thivaharan's (2015) conceptual framework focuses on implementing sustainability practices during the construction phase. The theoretical foundation integrates principles of responsible construction, emphasizing the role of contractors in sustainable site planning and innovation. The identified five criteria for sustainability implementation serve as key variables, including reducing, recycling, and reusing building materials; protecting the environment with modern technologies; energy efficiency; water efficiency; and indoor environmental quality. The conceptual model illustrates the relationships between these criteria, emphasizing their collective contribution to sustainable construction practices.

4) Drochytka, Dufek, Hodul's

Drochytka et al. (2020) contribute a conceptual framework focusing on the circular economy and the management of construction and demolition waste in Europe. The theoretical foundation involves circular economy principles, particularly the European Commission's targets and strategies for waste management. Key variables include the massive quantity of construction and demolition waste, its environmental impact, and opportunities for reuse. The conceptual model outlines the potential use of new types of waste based on multi-criteria optimization calculations, emphasizing reduced environmental impact, improved properties, efficient processing, reduced transportation needs, and increased reuse and recycling. The framework contributes to the ongoing debate on waste management in European politics and the evolving landscape of construction and demolition waste.

5) Manzoor & Sharma's

Manzoor and Sharma (2022) present a conceptual framework addressing sustainability in the Indian construction industry. The theoretical foundation involves the changing dynamics of construction projects in response to increasing urbanization and the need for sustainable project management.

Key variables include the strain on natural building material resources, the changing landscape of construction project planning and execution, and the lack of sustainable project management practices in the Indian context. The conceptual model explores the extent to which the Indian construction industry leverages sustainable design tools and identifies obstacles to promoting sustainability in project management. The framework emphasizes the role of knowledge, customer involvement, and the integration of sustainable practices into the construction project management process

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D. Gap Analysis

1) Most of the perceptions of these researchers from the literature review were from authors from different countries outside the coasts of Nigeria. Experts have common knowledge about construction projects, but different opinions are influenced by the situation in each country. For example, it is highly unlikely that the provision of incentives was not on his government's agenda as a driver of sustainability practices in Nigeria, but regulation was.
2) From the literature review, it was evident that although the concept of sustainable buildings is prevalent in research, there are very few existing studies that focus on sustainability issues in Nigeria. This requires a deeper awareness of implementation levels, drivers, barriers, and measures to improve sustainability practices during the construction phase of construction projects, especially those conducted on construction sites, and this study met the needs.
3) Few existing studies on sustainability practices have been conducted using quantitative or qualitative approaches. These are recent carefully designed his scientific studies using a mixed research design to allow researchers to use a variety of methods to achieve his reliability and research objectives. Explicitly verified by conducting research.

III. RESEARCH METHODOLOGY

A. Research Type

The research type used in this report is Descriptive Research.

The goal of descriptive research is to characterize a population, circumstance, or phenomenon precisely and methodically. It can respond to inquiries about what, where, when, and how, but not why. Numerous research techniques can be applied in a descriptive research design to examine one or more variables. In contrast to experimental research, here the variables are merely observed and measured; no controls or manipulations are made.

B. Data Type

The data type used in this report is primary and secondary.

Primary- Questionnaire

Secondary- research papers and literature review.

C. Data Collection Method

A digital questionnaire was distributed via social networking apps and mail in order to gather data.

D. Sampling Method

Convenience Sampling was selected. This sampling technique is used when researchers gather information from a convenient sample of respondents. It was utilized because it is very quick, easy, and affordable.

E. Sampling Technique

As there was an uneven chance of being included in the sample and it was impossible to determine the probability of a sample being chosen, this study used a non-probabilistic sampling technique, also known as non-random sampling or non-parametric sampling.

F. Sample Size

Location of the Target Audience: The sample came from Delhi NCR.

G. Data Analysis Tool

Pie charts are the tools used in this study to showcase the analysed data.

Regression analysis is used to analyse the data collected through survey.

IV. QUESTIONNAIRE

The available literature review was taken into consideration when designing a Google form questionnaire. Questionnaires were distributed to respondents in multiple categories. The Google forms were mailed out to gather the responses. Because the survey was conducted through the selective distribution of survey forms, a reasonable level of response reliability is anticipated. Respondents include project managers, contractors, working civil engineers, professors of civil engineering, and students of civil engineering, among others.

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Questions included in questionnaire:

1) Are you aware about the term sustainability?

- 1
- 2
- 3
- 4
- 5

2) Do you think Indian construction companies are making efforts to go green?

- 1
- 2
- 3
- 4
- 5

3) Do you think project managers play any role in implementing sustainable construction practices?

- 1
- 2
- 3
- 4
- 5

4) Are you aware of the three dimensions of sustainability that are social economic and environment?

- 1
- 2
- 3
- 4
- 5

5) Does your company use reduce, divert, reuse, recycle to reduce material wastage?

- 1
- 2
- 3
- 4
- 5

6) Waste and pollution minimisation, resource utilization, use of free renewable energy are related to sustainability in construction?

- 1
- 2
- 3
- 4
- 5

7) Preventive measures, administrative controls, engineering controls are actions that you take in construction to avoid noise pollution?

- 1
- 2
- 3
- 4
- 5

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8) Do you use Safety measures that should be taken at construction site to increase safety of workers, like use of PPE, use of reflective jackets, use of helmets and goggles, are being used?

- 1
- 2
- 3
- 4
- 5

9) Do you think lack of expertise, lack of time, limited demand, cost are the barriers to smoothly using the tools and techniques of sustainability?

- 1
- 2
- 3
- 4
- 5

10) Do you follow sustainable actions to avoid water pollution like keep cement and sand secure so that it does mix with clean water, encourage water harvesting, etc.?

- 1
- 2
- 3
- 4
- 5

V. DISCUSSION & IMPLICATIONS

A. *Discusion*

This research investigates sustainability in the Indian construction industry, focusing on awareness, challenges, and stakeholder perspectives. Noteworthy findings highlight disparities in sustainability awareness across various industry roles, shedding light on critical challenges such as expertise gaps, time constraints, and limited client demand. Diverse stakeholder perspectives, including project managers, contractors, engineers, professors, and students, contribute to a nuanced understanding of sustainability within the industry. Practical implications stemming from the research provide targeted recommendations to bolster awareness and overcome implementation challenges. The study's originality lies in its specific contextual focus on the Indian construction landscape and its comprehensive exploration of various sustainability dimensions.

The research serves as a valuable guide for industry professionals and policymakers, offering actionable insights to foster sustainable practices in the Indian construction sector. By recognizing the multifaceted nature of stakeholder views and addressing awareness gaps and implementation challenges, the study contributes to steering the industry toward a more environmentally conscious and resilient future. Overall, the research stands as a pivotal resource for those seeking to actively contribute to the integration of sustainable practices within the intricacies of the Indian construction context.

B. *Implications*

The implications of this research extend across various dimensions, influencing stakeholders, industry practices, and future endeavours. Key areas of impact include:

1) *Stakeholder Awareness and Education:* The research underscores the necessity of targeted awareness campaigns and educational initiatives tailored to different stakeholders. Industry professionals, policymakers, educators, and students can receive help from focused programs that enhance their understanding of sustainable construction practices.

2) *Strategic Industry Interventions:* The identified challenges in implementing sustainable practices, such as expertise gaps and time constraints, call for strategic interventions. Industry associations and regulatory bodies can play a crucial role in developing training programs, guidelines, and incentives that address these challenges, fostering a more sustainable construction ecosystem.

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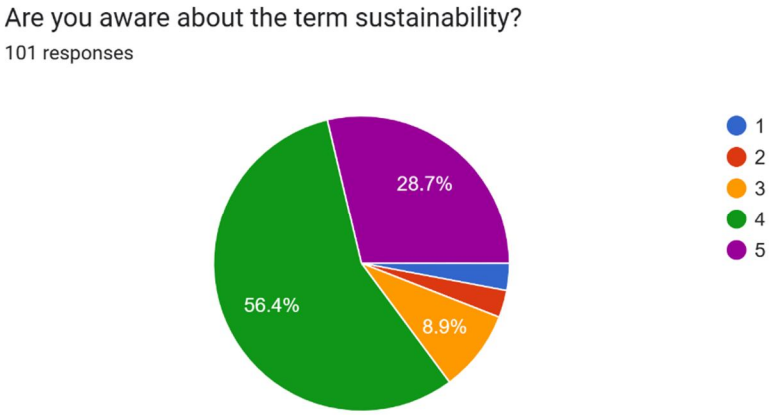
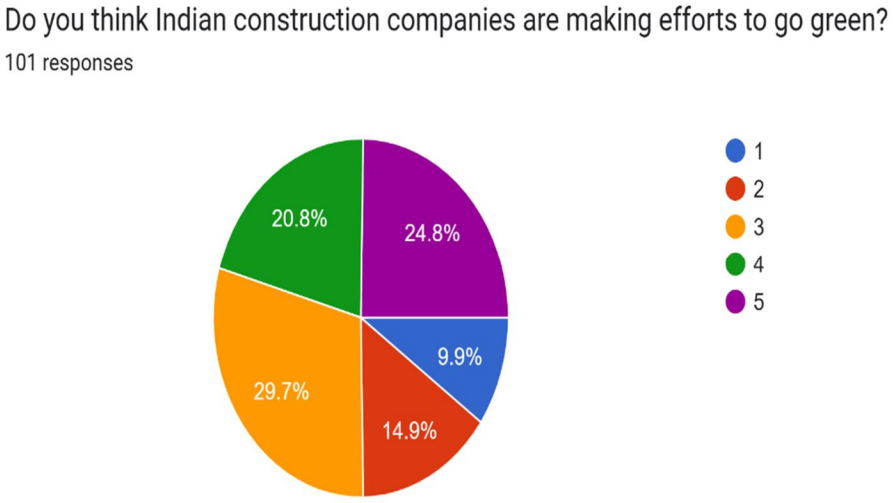
3) *Educational Curriculum Enhancement:* The findings advocate for integrating sustainability principles into civil engineering education. Academic institutions can adapt their curricula to include comprehensive modules on sustainable construction, ensuring that future professionals are well-equipped to navigate the evolving industry landscape.
4) *Policy Development and Advocacy:* Policymakers can use the research insights to inform the development of sustainability-focused policies within the construction sector. Advocacy for regulatory frameworks that incentivize sustainable practices and penalize non-compliance can contribute to a more robust and environmentally conscious industry.
5) *Industry Collaboration and Knowledge Sharing:* The research emphasizes the importance of collaborative efforts within the industry. Platforms for knowledge sharing, conferences, and industry forums can ease dialogue among stakeholders, fostering a collective approach to overcoming challenges and advancing sustainable practices.
6) *Long-term Environmental Impact:* The study's implications extend beyond immediate industry considerations to the long-term environmental impact of construction activities. By addressing challenges and enhancing awareness, the research contributes to reducing the ecological footprint of construction projects, aligning the industry with broader environmental sustainability goals.
7) *Global Best Practices Integration:* The implications encourage the adoption of global best practices in sustainability. Drawing inspiration from successful models worldwide, the Indian construction industry can integrate proven strategies, technologies, and policies to enhance its sustainability quotient.

VI. DATA REPRESENTATION





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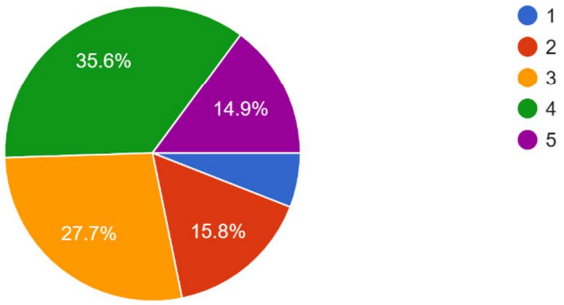
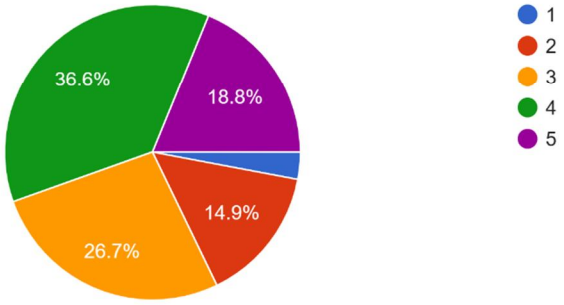
Do you think project managers play important role in implementing sustainable construction practices?

101 responses



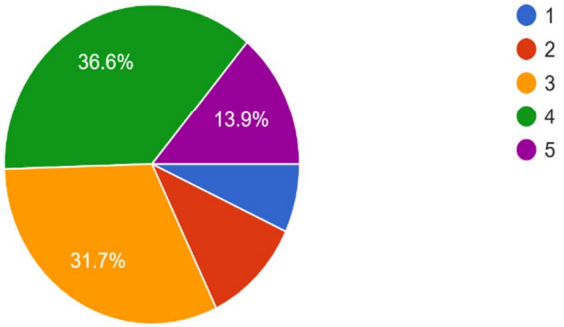
Are you aware of the three dimensions of sustainability that are social, economic and environmental?

101 responses



Does your company use reduce, divert,reuse, recycle to reduce material wastage ?

101 responses



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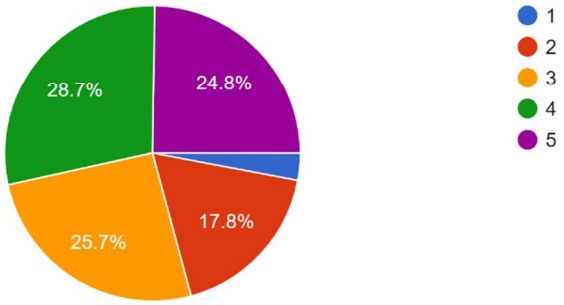
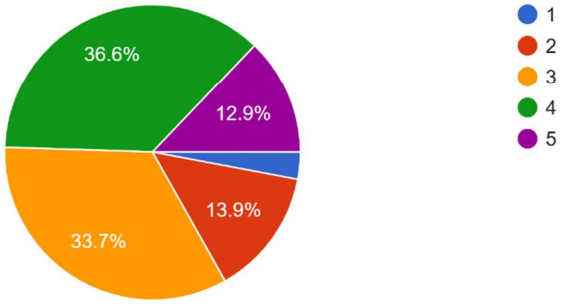
Waste and pollution minimisation , resource utilization , use of free renewable energy are related to sustainability in construction?

101 responses



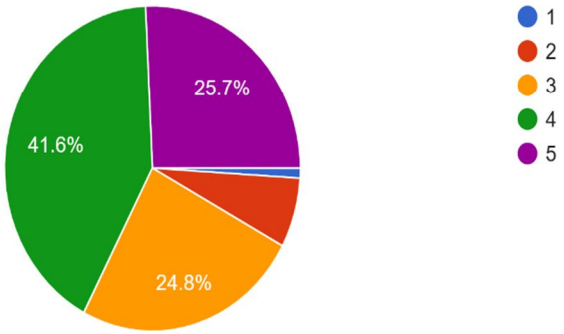
Preventive measures, administrative controls , engineering controls are actions that you take in construction to avoid noise pollution?

101 responses



Do you use Safety measures that should be taken at construction site to increase safety of workers, like use of PPE, use of reflective jackets, use of helmets and goggles, are being used?

101 responses



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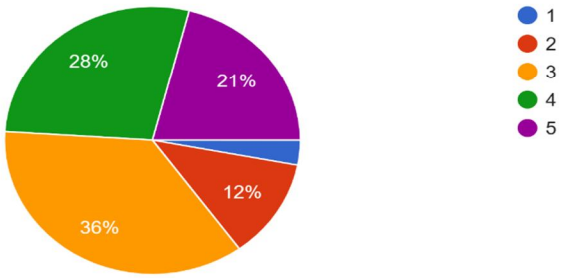
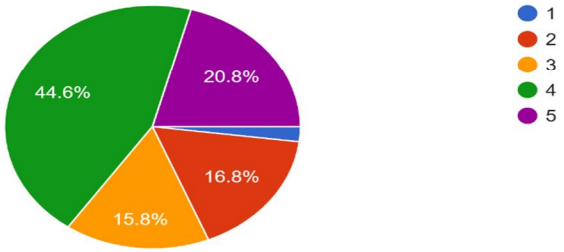
Do you think lack of expertise , lack of time , limited demand , cost are the barriers to smoothly using the tools and techniques of sustainability?
100 responses



Do you follow sustainable actions to avoid water pollution like keep cement and sand secure so that it does mix with clean water, encourage water harevesting , etc.?
101 responses



VII. DATA ANALYSIS

Regression Statistics	
Multiple R	0.999266992
R Square	0.998534522
Adjusted R Square	0.998371691
Standard Error	0.782178059
Observations	101

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	10	37517.80906	3751.780906	6132.339774	6.2039E-123
Residual	90	55.06222649	0.611802517		
Total	100	37572.87129			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-0.987777401	0.622843373	-1.585916211	0.116265802	-2.225164472	0.24960967	-2.225164472	0.24960967
awareness about sustainability	2.866287786	0.103450173	27.7069406	7.73629E-46	2.660765962	3.07180961	2.660765962	3.07180961
perception of construction companies efforts to go green	4.031087218	0.075716716	53.23906556	7.93453E-70	3.880662746	4.181511691	3.880662746	4.181511691
project managers role	4.917072548	0.08059077	61.01284962	5.1857E-75	4.756964916	5.077180179	4.756964916	5.077180179
knowledge about dimensions of sustainability	2.974497254	0.100665392	29.54836019	4.16887E-48	2.774507883	3.174486624	2.774507883	3.174486624
adoption of sustainable practices	5.126679137	0.085084472	60.25399232	1.55754E-74	4.957643982	5.295714292	4.957643982	5.295714292
Waste management	4.019762041	0.091634686	43.86725402	1.54275E-62	3.837713744	4.201810339	3.837713744	4.201810339
noise pollution	1.914722779	0.10056642	19.03938483	2.56306E-33	1.714930032	2.114515526	1.714930032	2.114515526
Safety measures for workers	2.044774377	0.099568132	20.53643397	9.95654E-36	1.846964903	2.242583851	1.846964903	2.242583851
barriers to techniques of sustainability	4.209325868	0.082640801	50.93520197	3.74696E-68	4.045145493	4.373506242	4.045145493	4.373506242
water pollution	3.164781399	0.088632992	35.70658428	6.28935E-55	2.98869649	3.340866307	2.98869649	3.340866307

In Regression analysis the independent variable is represented through X and the dependent variable is represented through y in the following study the variable are as follows:

Y- total score of the respondents calculated by giving weights to the questions

X- different variables Like- awareness about sustainability noise pollution water pollution adoption of sustainable practices, etc.

A. Analysis

1) *Multiple R (Multiple Correlation Coefficient):* The multiple R value of 0.999 indicates a very strong positive correlation between the independent variables collectively and the dependent variable (total score). This suggests that the set of independent variables together explain almost all of the variation in the dependent variable.
2) *R-squared (Coefficient of Determination):* The R-squared value of 0.9985 indicates that approximately 99.85% of the variability in the dependent variable (total score) is explained by the independent variables in the regression model. This suggests that the model provides an excellent fit to the data.
3) *Adjusted R-squared:* The adjusted R-squared value of 0.9983 considers the number of independent variables in the model and adjusts the R-squared value accordingly. It provides a more conservative estimate of the proportion of variability explained by the model.
4) *Standard Error:* The standard error of 0.78 represents the average deviation of the observed values from the predicted values in the regression model. A lower standard error indicates a better fit of the model to the data.
5) *Observations:* The number of observations in the regression analysis is 100, indicating the sample size used in the analysis.
6) *Significance F:* The significance F value of 6.2039E-123 is extremely small, indicating that the overall regression model is statistically significant. This means that the independent variables together have a significant effect on the dependent variable (total score).

Overall, the regression analysis suggests that the independent variables collectively have a very strong and statistically significant impact on sustainability in construction, as measured by the total score. The high R-squared value indicates that the model provides an excellent fit to the data, explaining almost all of the variability in the dependent variable. These findings support the importance of considering numerous factors related to sustainability in construction projects and highlight the potential for using regression analysis to understand and predict sustainability outcomes

VIII. KEY FINDINGS

1) *Collective Awareness and Emphasis on Sustainability:* The study reveals a heightened awareness among construction professionals regarding sustainability practices, with a primary emphasis on selecting appropriate construction methods to conserve resources and meet client satisfaction. This collective consciousness aligns with the broader understanding of sustainable construction, highlighting responsible resource utilization and meeting client expectations.
2) *Identification of Key Sustainability Practices:* Professionals in the construction industry identified several key sustainability practices, including controlling water usage, promoting community development, utilizing local material sources, implementing sustainable site planning, and fostering innovation. These practices underscore a holistic approach to sustainability, addressing environmental, social, and economic aspects during the construction phase.
3) *Nuanced Variations in Perception:* The research uncovers nuanced variations in the perception of sustainability practices among different professional categories, namely Builders, Architects, Engineers, and Quantity Surveyors. Significant differences were observed in the perception of aspects such as dust control, waste management, and participatory approaches.
4) *Importance of Cross-Disciplinary Approach:* The study emphasizes the importance of a cohesive and cross-disciplinary approach to sustainability within the construction industry. Acknowledging the distinct perspectives of various professionals while collectively contributing to the broader goal of sustainable construction practices is essential for effective implementation.
5) *Reinforcement of Sustainable Practices:* Despite differences in perception, the findings reinforce the importance of sustainable practices across all professional categories. Collaborative efforts are necessary to integrate these practices effectively into construction projects, ensuring environmental stewardship, social responsibility, and economic viability.
6) *Implications for Industry Practices:* The research findings have significant implications for industry practices, highlighting the need for continuous education and training programs to enhance awareness and understanding of sustainability principles among construction professionals. Moreover, it underscores the importance of incorporating sustainability criteria into project planning, design, and execution processes.

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7) *Pathways for Future Research:* The study suggests several pathways for future research, including exploring the impact of emerging technologies on sustainable construction practices, assessing the effectiveness of policy interventions in promoting sustainability, and investigating the role of stakeholder collaboration in advancing sustainable development goals within the construction industry.
8) *Conclusion:* In conclusion, the study provides valuable insights into the perception and implementation of sustainability practices in the construction industry. By recognizing the diverse perspectives of professionals and fostering collaboration, the industry can move towards more sustainable and resilient built environments, aligning with global sustainability objectives.

IX. CONCLUSION

The findings from both the empirical data analysis and the comprehensive literature review converge to underscore the significant impact of sustainable practices in the construction industry. Through the integration of insights from these two sources, a coherent narrative emerges, emphasizing the importance of sustainability considerations in shaping construction outcomes and industry practices.

A. Alignment of Sustainability Factors

The empirical data analysis reveals a strong correlation between sustainability factors and the total score, indicating the influential role of sustainable practices in construction projects. This finding resonates with the themes identified in the literature review, which emphasize the importance of factors such as eco-friendly materials, sustainable project management practices, and effective waste management.

B. Consistency in Findings

The consistency between the empirical findings and the literature review reinforces the notion that sustainability is a critical determinant of construction outcomes. Both sources of evidence highlight the multifaceted nature of sustainability and its implications for environmental stewardship, resource efficiency, and stakeholder engagement in the construction process.

C. Validation of Research Hypotheses

The empirical data analysis provides empirical validation of the research hypotheses posited in the literature review, affirming the significant impact of sustainable practices on construction performance. By corroborating theoretical insights with empirical evidence, this study contributes to a deeper understanding of the dynamics between sustainability and construction practices.

D. Implications for Practice and Policy

The integrated analysis points to practical implications for industry stakeholders and policymakers. It underscores the need for a holistic approach to sustainability, encompassing diverse aspects such as material selection, waste management, energy efficiency, and indoor environmental quality. By adopting sustainable practices, construction stakeholders can mitigate environmental impact, conserve resources, and foster a more resilient built environment.

E. Future Research Directions

Building upon the insights gained from this study, future research endeavours could explore innovative solutions, evaluate the effectiveness of sustainability initiatives, and enhance stakeholder engagement in sustainable project management practices. By addressing knowledge gaps and advancing research agendas, scholars can contribute to the ongoing discourse on sustainability in the construction industry.

In conclusion, the integrated analysis of empirical data and literature findings underscores the pivotal role of sustainability in shaping construction practices and outcomes. By embracing sustainable principles and practices, stakeholders can work towards building a more environmentally responsible, socially equitable, and economically viable construction industry.

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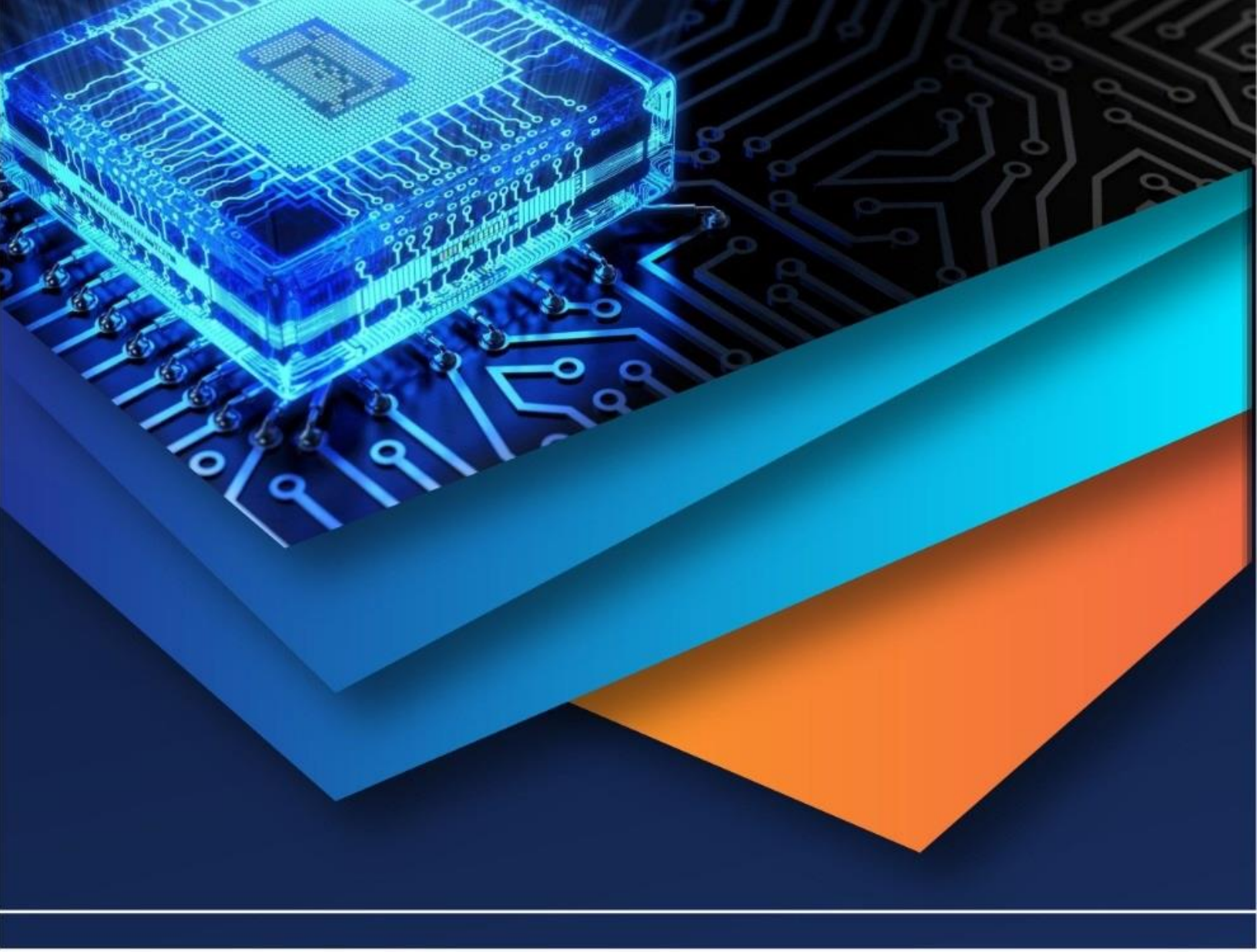

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