

CHAPTER 35

Impediments to the Implementation of Sustainable Construction Materials in India

Dhanush Lekkala, Edin Jijo**, Neethish Kumar S.** and Priyanka Gayen****

ABSTRACT

The construction industry has very high contribution to environmental degradation, resource loss as well as carbon emissions, especially in the fast-growing economies like India. Although sustainable construction materials are characterized by significant environmental and lifecycle performance advantages, their application in the Indian construction sector is low. The current work explores the barriers to large-scale adoption of sustainable construction materials in India based on the comparison of the domestic market with the international experience and the determination of the main economic, regulatory, and institutional obstacles. An integrated mixed-method study design was utilized as the literature review, global benchmarking, stakeholder interviews, and a questionnaire survey were merged to conduct a study on construction professionals on a global scale. A 5-point Likert scale was used to gather quantitative data of 40 industry stakeholders in terms of a 5-point Likert scale and was analyzed by the use of descriptive statistics and ranking of the mean score. The results show that the awareness and technical accessibility of sustainable materials are moderate, but high initial costs, unequal policy implementation, and discontinuous procurement systems are major barriers to adoption. Parameters that concerned cost had the least mean scores (2.25-2.40), whilst strategic parameters that included global benchmarking, policy uniformity, and lifecycle cost consideration had highest importance ratings (mean > 4.4). The research also indicates that the industry is most prepared to engage in systematic introduction of sustainable materials in mainstream construction practice, as long as systemic obstacles are taken care of. Empirical evidence is used to postulate a strategic framework that is management oriented with a focus on harmonizing policies, making procurement decisions based on lifecycle factors, capacity building, and matching to the international sustainability guidelines. The results of this study can be used in practice by policy makers, project managers and developers aiming at faster adoption of sustainable materials and changing the construction industry of India to correspond to the global trends of sustainability.

Keywords: Sustainable construction materials, adoption barriers, global benchmarking, policy framework, Indian construction industry, lifecycle cost analysis

1.0 Introduction

The construction sector is one of the largest contributors of the resources depleted across the world,

**Corresponding author; Student, School of Construction, NICMAR University, Pune, Maharashtra, India
(E-mail: p24700720@student.nicmar.ac.in)*

***Student, School of Construction, NICMAR University, Pune, Maharashtra, India
(E-mail: p24700710@student.nicmar.ac.in; p24700354@student.nicmar.ac.in)*

****Assistant Professor, School of Architecture & Planning, NICMAR University, Pune, Maharashtra, India
(E-mail: priyanka.gayen@pune.nicmar.ac.in)*

environmental degradation, and greenhouse gases. The materials that can be considered as an alternative to traditional materials are the construction materials that are sustainable, with lower environmental impact, and better lifecycle performance. Nevertheless, their adoption is still constrained because of the still existing barriers.

The major obstacles are regulatory weaknesses, procurement and supply chain weaknesses, excessive initial costs, and professional ignorance. Weak or unclear building codes do not require or encourage the use of sustainable materials, thus providing no regulation gaps. In addition, availability is diminished by procurement challenges and logistical constraints, and deters the stakeholders by the high initial cost, and absence of solid cost-benefit analysis frameworks. Moreover, poor level of technical skills and awareness among engineers, architects and contractors are also a further barrier to integration into normal construction practices.

The study will help establish and solve these challenges by examining their underlying causes, evaluating their effects and offering practical solutions. The construction industry can promote the use of sustainable materials and help become greener by promoting better regulatory frameworks, streamlining supply chains, and developing better stakeholder awareness. An overview of current literature shows that there is a gap in research where holistic approaches are applied to deal with these interrelated hurdles. Although the effect of single problems such as cost or awareness has been studied, not much is done to investigate their interaction. This confirms the necessity of a combined study to come up with viable and multidimensional measures of conquering adoption issues in the construction sector.

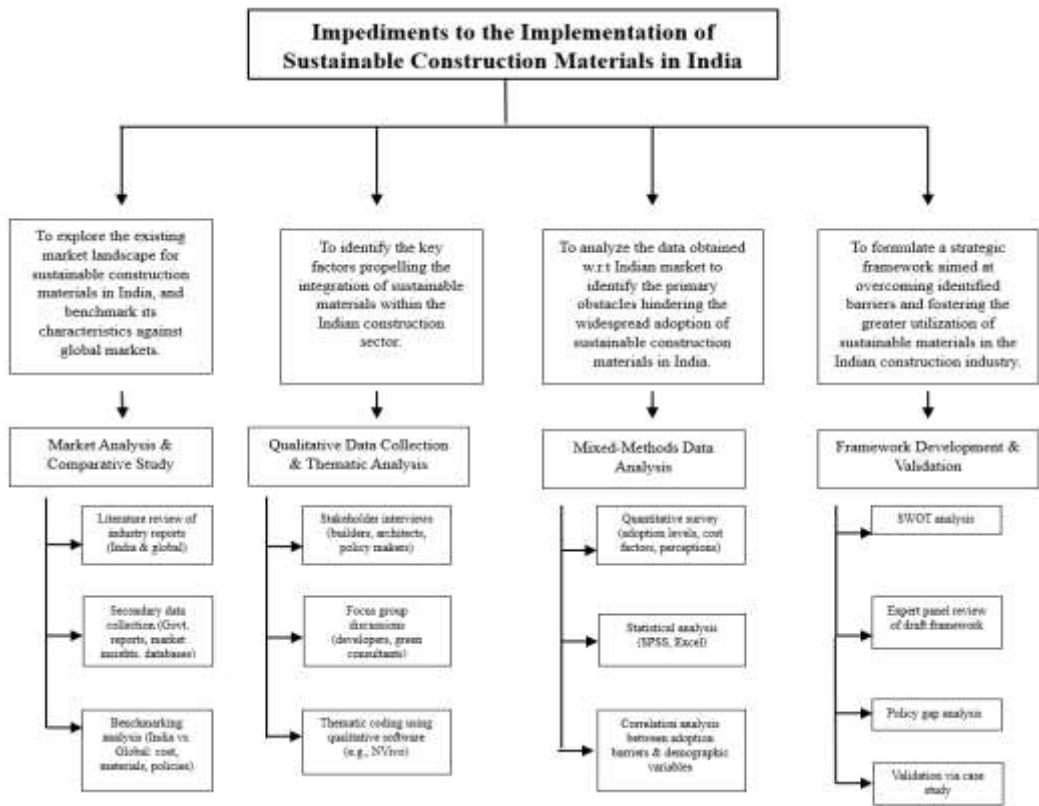
1.1 Research questions

What key challenges impede the widespread diffusion of sustainable construction materials in India's building sector, and what strategic framework can be developed to accelerate their uptake?

1.2 Objectives

- To explore the existing market landscape for sustainable construction materials in India, and benchmark its characteristics against global markets.
- To identify the key factors propelling the integration of sustainable materials within the Indian construction sector.
- To analyze the data obtained w.r.t Indian market to identify the primary obstacles hindering the widespread adoption of sustainable construction materials in India.
- To formulate a strategic framework aimed at overcoming identified barriers and fostering the greater utilization of sustainable materials in the Indian construction industry.

1.3 Methodology



Source: Created by authors

Our study will be based on four primary objectives in order to understand and enhance the application of sustainable construction materials in India. Each of the objectives is pursued via a specific methodology, which is backed up by certain sub-methodologies, and offered to provide tangible and practical results. The process does not only provide depth and clarity of findings, but also holds the research deeply rooted in the realities locally as well as globally. We will start with the literature review to understand the current market situation of sustainable building materials in India and compare its features with the international markets. This initial stage will entail secondary data gathering, which entails reviewing of journal articles, government policy papers, industry white papers, and world market reports. We pay much attention to comparative studies, sustainability indices and material performance analysis in various regions. The work of the phase is a clear picture of the current situation of India in the sustainable material industry on the areas where the country is on track or not on track with the global trend, and the untapped areas in the Indian market.

Then, we transition into the market scanning and stakeholder mapping, which aims at locating the major factors of driving the integration of sustainable materials into the Indian construction industry. This is done using two complementary sub-methodologies, semi-structured interviews with professionals working in the full spectrum of the construction ecosystem (architects, developers, green consultants, and policy-makers) and focus group discussions with engineers, project managers and construction workers. These interactive programs are aimed at collecting the views on such aspects as the availability of the material, cost-benefit consciousness, regulatory impact, and market need. The deliverable in this case is a well charted set of drivers economic incentives like cost savings in the long run, regulatory impetus of green building codes, rising customer preference in sustainable credentials and technological improvements in green materials.

After the establishment of enablers, we focus on the barriers. In order to discuss the data obtained concerning the Indian market and point out the main barriers to the popular introduction of sustainable construction materials, we use a mixed-methods analysis. This methodological step is a combination of quantitative surveys that are distributed to a large variety of industry participants in various geographies and company sizes and thematic analysis of the qualitative data, which was gathered in previous interviews. The questionnaires assist in measuring impressions and difficulties, whereas thematic coding can be used to detect similarities in the stories like high initial investments, shortage of skilled personnel, low awareness, and fragmentation of the supply chains. The product of this process is a prioritized system of adoption barriers (categorized, according to frequency and severity of stakeholder response).

Having a proper grasp of the enabling and limiting factors, we can now proceed to our last goal, which is creating a strategic framework to mitigate the challenges that are observed and enhance the increased use of sustainable materials in the Indian construction industry. This is taken care of by expert validation and SWOT analysis. First, our interim results are presented to a panel of sustainability experts, construction managers, and academics to provide a critical feedback and refinement to make our results relevant and practical. Then we apply the SWOT analysis to assess the strength, weaknesses, opportunities and threats of some possible intervention, including the incentive of green procurement, lifecycle assessment requirement in building approvals and the level of training on sustainable construction practices. The result is a strategic action-oriented framework that can inform other stakeholders such as government agencies, construction companies, and industry associations in dealing with the real-life implementation issues and speeding up the uptake of sustainable materials.

In the process, every methodological process is built on the previous one following a process of knowing the market, revealing its drivers, and thus, creating a solution-oriented

roadmap. Such a multi-layered, systematic method has the benefit of making the research both more reliable and more detailed, as well as making the research conclusions directly based on the realities of the stakeholders and able to adapt to the Indian construction conditions. It advocates an effective, practical body of knowledge by combining both qualitative and quantitative data based on local and globalities, thus transcending academic research and proceeding to change the industry.

1.5 Research Framework

S. No	Objective	Research Focus	Methodology	Tools & Resources
1	To comprehensively analyze the existing market landscape for sustainable construction materials in India and benchmark its characteristics against global markets.	Understand market maturity, material availability, cost factors, and regulatory context in India vs. global benchmarks	- Literature review of academic studies, industry reports, and government publications	- JSTOR, Scopus, Web of Science
			- Quantitative data collection (market size, growth trends, usage)	- SPSS/Excel
			- Expert interviews (manufacturers, suppliers, architects, contractors)	- NVivo or ATLAS ti
			- Comparative analysis with global markets	- Market research reports
2	To investigate the key factors propelling the integration of sustainable materials within the Indian construction sector.	Identify the drivers such as policies, incentives, awareness, and innovation	- Literature review on drivers of sustainability adoption	- Interview guides
			- Semi-structured interviews with industry stakeholders (builders, government, NGOs)	- Case documentation
			- Case studies of LEED/GRIHA-certified projects	- Survey tools (Google Forms, SurveyMonkey)
			- Optional surveys to quantify perceived importance of drivers	- Literature databases
3	To identify and evaluate the primary obstacles hindering the widespread adoption of sustainable construction materials in India.	Analyze structural, economic, and institutional barriers	- Literature review focused on barriers in India and other developing nations	- NVivo
			- Focus group discussions with stakeholders across the construction supply chain	- Policy analysis tools
			- Policy analysis of building codes, procurement norms, and environmental laws	- Discussion guides
			- Triangulation of findings for comprehensive insights	- Regulatory documents

4	To formulate a strategic framework aimed at overcoming identified barriers and fostering the greater utilization of sustainable materials in the Indian construction industry.	Create actionable, localized strategies for industry-wide adoption	- Synthesis of key findings from prior stages	- SWOT and stakeholder analysis tools
			- Benchmarking international best practices from comparable economies	- Presentation software (PowerPoint)
			- Develop a multi-pronged framework (policy, market incentives, capacity-building)	- Workshop facilitation materials
			- Expert validation via panel reviews and stakeholder workshops	

Source: Created by authors

2.0 Sustainable Construction Materials in India: Current Landscape and Future Prospects

2.1 Introduction

The construction industry in India is among the fastest-developing sectors in the nation and it generates a lot of income to the GDP of the country. As the industry is set to become the third biggest in the world by the year 2025 (IBEF, 2021), the need to implement more sustainable building practices becomes paramount. With the growing speed of urbanization, and the rising amount of population, the environmental effects of construction processes, including high-energy use and carbon emissions, are becoming clearer (Bora et al., 2023). The construction industry has the largest contribution to the carbon emission in the world and India has the highest contribution of carbon emission which will increase as the industry continues to rise. Therefore, the research question is crucial to investigate the present situation with sustainable construction materials in India, which obstacles obstruct their use, and whether India is at the same level as the global communities. Environmental harm can be decreased greatly with the help of sustainable materials and lead to more energy-efficient constructions, which are essential because India is developing rapidly and is aimed at reaching the sustainability level (Kumar & Kumar, 2024).

The Indian construction sector has to transform into becoming sustainable due to the rising demand of green housing and infrastructure. The Indian market of sustainable construction material is in its early stages of development, yet it indicates improvement. The construction industry is under extreme pressure to transform its practices towards minimizing its carbon footprint in addition to being energy efficient. Construction materials that are ecofriendly such as fly ash bricks, recycled concrete aggregates and low-carbon cement have been on the rise although they are still trailing behind the developed countries regarding market penetration. Although these materials may be environmentally and economically

advantageous in the long-term perspective, such as reduced energy consumption and less maintenance expenses, most builders still prefer to use traditional materials because of the lack of knowledge and reduced initial investment (Alaezi and Obeka, 2020). Once the market has matured, awareness campaigns, government incentives and strong policies will play a significant role in changing the market. In this regard, the opportunities associated with implementation of sustainable building materials in the rapidly developing construction sector of India are enormous, yet it needs to overcome multiple challenges associated with the price, knowledge, and infrastructure (Bora et al., 2023).

2.2. Global benchmarking and potential for growth

The construction sector in India is on the verge of transitioning to sustainable building modes but it is way behind developed nations as far as adoption of green materials on large scale basis is concerned. Sustainable construction is relatively established throughout the world, with the United States, Germany, and Japan being at the forefront of it. These countries have introduced strong regulatory, government incentives, and market-driven initiatives that have led to massive adoption of green building materials (Habert et al., 2020). India can take some lead in these nations, especially formulating regulatory principles and establishing a more trustworthy market of sustainable materials. The Indian market is also capable of becoming a major market in the consumption of sustainable construction materials as it is inhabited by a vast and rapidly rising urban population that is likely to increase demand on eco-friendly housing and infrastructure (Grand View Research, 2024). Also, the abundance of the natural resources in India, such as bamboo, hemp, and the industrial by-products may be recycled, offers the basis of manufacturing the eco-friendly building materials domestically.

The problem facing India is not the unavailability of resources or the ignorance of the necessity of sustainable building practices rather the unpopularity of the solutions. Adoption rates are likely to go up as more builders, architects, and developers discover the environmental advantages and cost savings of long-term sustainability of sustainable materials. Moreover, Indian government has been rendering more support to green buildings in terms of incentives, tax exemptions and regulations to promote the use of environment-friendly materials in construction projects. The performance of the green building programs in other nations shows the possibility of India following the same. Specifically, the introduction of policies that resemble the green building codes and energy efficiency standards that are prevalent in the countries that have established and developed green construction markets may trigger the shift toward sustainability in the Indian building industry. The potential will be achieved by overcoming present obstacles and by aligning the industry stakeholders with the sustainability goals of the government.

2.3 Current landscape of sustainable materials in India

The construction industry of India has gone a long way to embrace sustainable construction materials yet the market is still immature. The use of sustainable materials, such as fly ash bricks, recycled concrete aggregates, and low-carbon cement, is also becoming more popular, and their ecological and economic advantages are becoming more and more recognized. Industrial coal waste can be converted into fly ash bricks, which is an alternative to standard clay bricks and consequently, it lowers industrial waste and decreases the quantity of clay in construction, which is usually mined in an unsustainable manner (Kalwale et al., 2023). They are less expensive to make and are a more lasting solution yet still one of the major issues is consistency of quality. Recycled concrete aggregates are also being increasingly adopted as an alternative to virgin aggregates which have assisted in minimizing construction wastes and the environmental effects of aggregate mining (Pappu Asokan et al., 2007). Also, low-carbon cement, made using a mixture of other materials, such as slag and fly ash, minimizes the carbon emissions that cement manufacturing produces on the environment, which also contributes to a large share of the construction industry environmental footprint (McKinsey Global Institute, 2020).

Regardless of such developments, there are a number of impediments, which restrain the large-scale use of green materials in India. The initial cost of most green materials is one of the major barriers as it discourages builders and contractors given the fact that many of them are attracted to the cost-cutting and low-budget development of a construction project. Although the benefits of sustainable materials, including spared energy and minimal cost of maintenance, can be favorable in the long-term perspective, the initial expenses can be a major discouragement (Nayak, 2020). Moreover, the knowledge of the benefits of such materials is quite deficient. The long-term savings and environmental benefits of sustainable materials are not known to many builders, and consequently, they still use the traditional and less sustainable ones. The chain of supply of these materials has also not been well developed in some parts of India hence their increased prices and scarcity. Increased focus on education, research, policy incentives will play a vital role in breaking these obstacles and increasing the rate of adoption of sustainable materials in the Indian construction sector.

2.4 Emerging sustainable material solutions

With India seeking to satisfy its increasing infrastructure needs, there has been a number of new materials, which are far more sustainable than conventional alternatives. During the last few years, fly ash bricks have gained popularity. These bricks use fly ash as a coal burning byproduct, which does not only cut down on industrial waste but also has a more environmentally friendly alternative to traditional clay bricks, the production of which may cause deforestation and energy consumption (Kalwale et al., 2023). Even though the quality

of fly ash has not been consistent, research has been going on to mitigate these problems and the adoption levels are still increasing. Recycled concrete aggregates are also on the rise besides fly ash bricks. This recycled material is made of waste concrete used in demolition sites and thus eliminates the use of natural aggregates hence decreasing the environmental effects of mining and disposal of construction waste (Pappu Asokan et al., 2007). Moreover, another emerging technology in India is the green cement. In contrast to conventional cement, which has a big carbon footprint because of the intense use of highly energy-consuming clinker, green cement is made using the help of additional materials, including slag and fly ash, which will provide lower emissions and a more sustainable product (McKinsey Global Institute, 2020).

Insulation materials that are energy-saving are also being adopted. These materials have the characteristic of limiting heat transfer and energy use in heating and cooling (this is why the materials are especially helpful in the rapidly developing urban centers of India where the energy consumption is expected to increase significantly) (PwC India, 2019). Such materials not only assist in decreasing the carbon emissions which are as a result of energy consumption but also assist in the decrease in the total cost of operation of buildings. In addition, the energy efficient insulation is important in the attempt of India to achieve its climate objectives as well as to diminish the non-renewable sources of energy. With the research and development in this field, newer and more efficient products are likely to be introduced and this will further hasten the process of transitioning to sustainable building practices in the country.

2.5 Barriers to adoption in the Indian context

Although sustainable materials are available, the rate of their adoption is very low in the construction industry in India coupled with a number of major obstacles. The increased initial price of most of the sustainable materials is one of the main challenges. Despite the long-term economic advantages associated with using materials like fly ash bricks, recycled concrete aggregates, cut down costs of energy, and less maintenance, their high initial cost makes them less economical to developers who operate on restrictive funds (Alaezi & Obeka, 2020). The other obstacle is ignorance and technical illiteracy between the builders, contractors and consumers. The long-term savings in costs and environmental advantages of working with sustainable materials are unknown to many people in the construction industry, which is why they are unwilling to use them (Gudadhe, 2023). Moreover, the policies of the governments that encourage the construction materials that are sustainable are not always applied to the various states that compose the market dispersely, which results in the lack of unity on the market of green materials. This lack of uniformity in the application of the policy has led to few incentives to improve developers to use more sustainable materials. The inertial

effects of adoption of new and more sustainable alternatives in the construction industry are also due to the high dependency on the traditional techniques and substances (Bora et al., 2023). India should formulate more powerful policies and incentives to help it deal with these challenges which will help in ensuring wider adoption of sustainable materials. In order to counteract the upfront cost barriers with regard to green building materials, financial incentives should be used, including subsidies or tax breaks. Moreover, it might be necessary to increase the supply of sustainable materials with the help of the improved supply chains and the distribution networks, which would allow lowering their prices and increase their accessibility to builders in the country (Nayak, 2020). There should also be education and awareness activities targeting construction professionals, developers and the consumers to help bridge the knowledge gap that is present. By tackling these issues, India will be able to realize the full potential of the sustainable materials in construction market and move to more sustainable building projects.

2.6 Role of government policy and regulation

The role of government intervention in this context is to establish sustainable construction in India by providing sustainable practices in construction, i.e., energy conservation building code (ECBC) and national mission on sustainable habitat, which address energy efficiency and environmentally friendly construction activities (MoEFCC, 2017). Such programs as Pradhan Mantri Awas Yojana (PMAY) also provide an opportunity to incorporate sustainable materials into the affordable housing at large scale. Nevertheless, regardless of such encouraging efforts, the lack of uniformity in their application among the states advances their futility. Other areas have a deficiency of regulation implementation and assistance on the part of local officials, hindering the development of a stable market of sustainable materials (Bora et al., 2023). In order to fill this gap, a national standard policy should be established supported with strict implementation and financial incentives to establish a strong ecosystem of sustainable construction practice in the country.

2.7 Key trends shaping the future of sustainable construction

The future of sustainable construction in India is defined by the key trends like the transition to the decrease of embodied carbon in building materials, i.e., the embodied carbon in the form of emissions produced throughout the lifecycle of a material (World Green Building Council, 2019). With the industry focusing on low-carbon substitutes of traditional materials, such as cement and steel, innovations are rising that would meet the sustainability objectives of the Indian industry. Furthermore, bio-based materials such as bamboo and hempcrete are gaining popularity because of their benefits of renewability and carbon-sequestration, and, thus, are the most suitable option when it comes to green building (Patil

and Patil, 2017). The other changing trend is the implementation of the principles of the circular economy, that is, its emphasis on material reuse, waste minimization, and resource management, which slowly permeates the practice of the construction industry and promotes a more sustainable and regenerative construction process (Ellen MacArthur Foundation, 2015).

2.8 Conclusion

The construction industry in India is at the transformational level and has the prospects of pioneering a sustainable revolution of using environmentally friendly building materials and procedures. The high start-up costs, lack of awareness and policy fragmentation are obstacles that must be overcome to take advantage of sustainable construction. The change is being favorable due to the increasing technology, the need to incorporate green buildings and changing consumer tastes. India can be a global leader in sustainable construction as a result of regular government assistance, policy transparency, and industry cooperation to realize its national climate objectives and economic sustainability in the long term.

3.0 Data Collection and Research Instruments

3.1 Introduction

This chapter presents the analysis and interpretation of data collected through a structured questionnaire survey administered to construction industry professionals across different regions. The primary objective of this analysis is to evaluate the existing market landscape for sustainable construction materials in India and benchmark its characteristics against global markets.

The questionnaire consisted of 30 rating-based questions designed using a 5-point Likert scale, where responses ranged from Very Low (1) to Very High (5). A total of 40 valid responses were collected from stakeholders including site engineers, project managers, contractors, architects, and consultants. The analysis focuses on identifying trends related to market maturity, material availability, cost competitiveness, regulatory influence, and global alignment, thereby directly addressing Objective 1 of the study.

The findings explore stakeholder perceptions regarding the current market landscape, cost factors, regulatory environment, awareness levels, and global benchmarking of sustainable construction materials in India. The analysis aims to identify key patterns and constraints influencing adoption, thereby supporting the research objective of benchmarking the Indian market against global practices.

Questions

1	How would you rate the overall availability of sustainable construction materials in India?
2	How mature is the Indian market for sustainable construction materials compared to global markets?
3	How affordable are sustainable materials in India compared to conventional materials?
4	How consistent is the quality of sustainable materials available in India?
5	How reliable is the supply chain for sustainable construction materials in India?
6	How aware are contractors and site engineers about sustainable material options?
7	How effective are Indian government policies in promoting sustainable construction materials?
8	How strongly do regulations influence your choice of sustainable materials on projects?
9	How do Indian sustainable material costs compare with global benchmarks?
10	How accessible are global best practices for sustainable materials in India?
11	How confident are you in using sustainable materials based on Indian standards/codes?
12	How well do Indian green building codes align with international standards (LEED/BREEAM)?
13	How would you rate client demand for sustainable materials in Indian projects?
14	How much do lifecycle cost benefits influence adoption decisions?
15	How transparent is market information (cost, suppliers, performance data) in India?
16	How easy is it to source certified sustainable materials in India?
17	How competitive is India in sustainable material innovation compared to global markets?
18	How effective are awareness programs in promoting sustainable materials?
19	How frequently are sustainable materials used in infrastructure projects in India?
20	How does India's sustainable materials adoption compare with developed countries?
21	How supportive are project timelines for adopting sustainable materials?
22	How willing are contractors to shift from traditional to sustainable materials?
23	How adequate is technical training related to sustainable materials in India?
24	How reliable are performance claims of sustainable materials in India?
25	How important is global benchmarking for improving India's sustainable material market?
26	How aligned are Indian construction practices with global sustainability goals?
27	How effective are public infrastructure projects in driving sustainable material adoption?
28	How much does cost remain a barrier despite global success stories?
29	How scalable is the sustainable materials market in India over the next decade?
30	How critical is policy uniformity across states for market growth?

Source: Created by authors

3.2 Profile of respondents

The respondents represented a balanced cross-section of the construction ecosystem, ensuring diverse and reliable insights.

Table 1: Distribution of Respondents by Professional Role

Category	Number of Respondents	Percentage (%)
Site Engineers	16	40%
Project Managers	10	25%
Contractors / Vendors	8	20%
Architects / Consultants	6	15%
Total	40	100%

Source: Created by authors

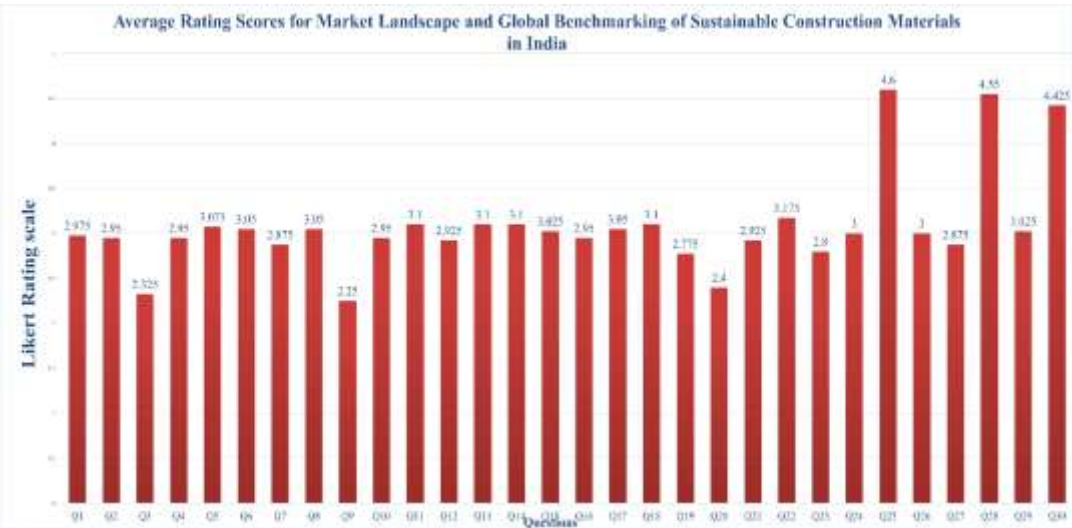
The dominance of site engineers and project managers ensures that the responses are grounded in practical, on-site experience, which is essential when evaluating real-world adoption of sustainable construction materials.

3.3 Reliability of data

The questionnaire was designed based on:

- Literature review
- Industry practices
- Internship exposure at CMRL, Godrej Properties, and Annamalai Construction Company

A Likert-scale structure was adopted to enhance consistency and comparability of responses. The data was found to be suitable for descriptive statistical analysis, including mean score ranking and graphical representation.



Source: Created by authors

3.3.1 Bar graph interpretation

The bar graph shows the average Likert-scale values (1-5) received on all 30 survey questions (Q1-Q30) based on the perceptions of the stakeholders to the market landscape, cost aspects, policy environment, awareness, and global benchmarking of sustainable construction materials in India. On the whole, most of the questions identified in the questionnaires have mean scores between 2.8 and 3.2, which are moderate scores, showing that there is a moderate level of agreement between the respondents. This implies that the Indian sustainable construction materials are partially accessible and known but not fully applied to the mainstream construction activities.

3.3.2 Industry implications derived from mean score analysis

The analysis of mean scores shows that technical availability is not enough to, prompt the sustainable material adoption in India. The most prominent decision-making factors are economic feasibility and consistency in the regulations. To the project managers and contractors, the results indicate that cost evaluation must be done on the basis of the lifecycle and not the initial cost evaluation. To policymakers, the findings highlight the need to have unified country laws and incentive schemes in order to mitigate risk of adoption.

This figure directly responds to the Objective 1 by objectively comparing the perceptions of the stakeholders on the Indian sustainable construction material market with the world expectations thus setting the baseline of the situation upon which the identification of barriers and the development of the strategic framework will be based.

Table 2: Descriptive Statistics of Perceptions on Sustainable Construction Materials

Question	Mean	Std. Deviation	Min	Max
Q1	2.98	0.62	2	4
Q2	2.95	0.58	2	4
Q3	2.33	0.55	2	3
Q4	2.95	0.6	2	4
Q5	3.08	0.64	2	4
Q6	3.05	0.61	2	4
Q7	2.88	0.57	2	4
Q8	3.05	0.63	2	4
Q9	2.25	0.48	2	3
Q10	2.95	0.59	2	4
Q11	3.1	0.62	2	4
Q12	2.93	0.6	2	4
Q13	3.1	0.65	2	4
Q14	3.1	0.67	2	5
Q15	3.03	0.61	2	4
Q16	2.95	0.58	2	4
Q17	3.05	0.63	2	4
Q18	3.1	0.66	2	4
Q19	2.78	0.54	2	4
Q20	2.4	0.5	2	3
Q21	2.93	0.59	2	4
Q22	3.18	0.64	2	4
Q23	2.8	0.55	2	4
Q24	3	0.6	2	4
Q25	4.6	0.49	4	5
Q26	3	0.58	2	4

Q27	2.88	0.56	2	4
Q28	4.55	0.5	4	5
Q29	3.03	0.61	2	4
Q30	4.43	0.5	4	5

Source: Created by authors

Table 3: Key Observations from Mean Score Analysis

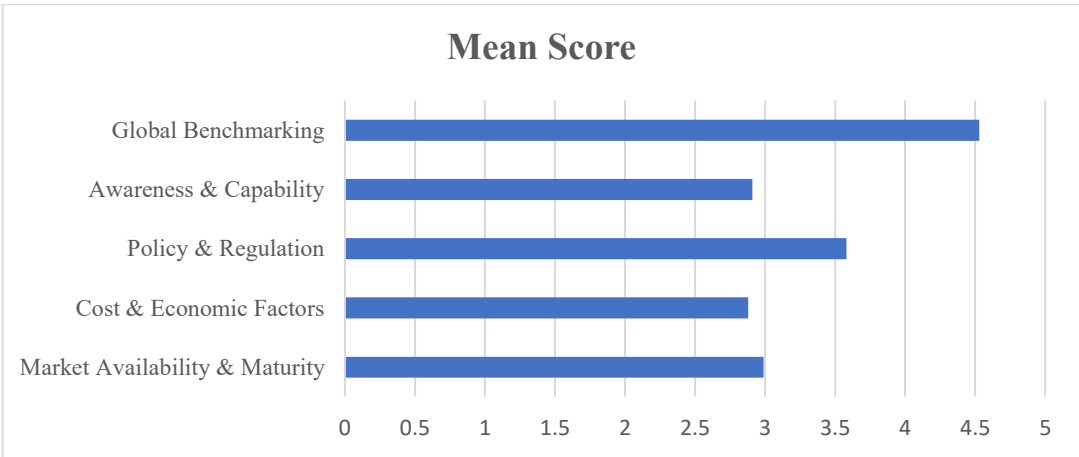
Observation Area	Evidence from Graph	Inference
Overall trend	Majority scores between 2.8–3.2	Moderate market maturity
Lowest scores	Q3 (2.33), Q9 (2.25), Q20 (2.40)	Cost-related barriers
Highest scores	Q25 (4.6), Q28 (4.55), Q30 (4.43)	Need for policy & global benchmarking
Variability	Sharp peaks in Q25–Q30	Strategic priorities identified
Adoption readiness	Mid-range scores in most questions	Partial readiness

Source: Created by authors

Table 4: Theme wise Mean Score Analysis

Theme	Questions	Average Mean	Interpretation
Market Availability & Maturity	Q1, Q2, Q4, Q5	2.99	Moderate
Cost & Economic Factors	Q3, Q9, Q20, Q28	2.88	High constraint
Policy & Regulation	Q7, Q8, Q26, Q30	3.58	Strong influence
Awareness & Capability	Q6, Q18, Q23	2.91	Moderate awareness
Global Benchmarking	Q25, Q28, Q30	4.53	Very high importance

Source: Created by authors



Source: Created by authors

Table 5: Top Five Factors Influencing Sustainable Construction Material Adoption

Rank	Question	Mean Score	Factor Description
1	Q25	4.6	Importance of global benchmarking
2	Q28	4.55	Cost as a major barrier
3	Q30	4.43	Need for policy uniformity
4	Q22	3.18	Lifecycle cost benefits
5	Q14	3.1	Market maturity perception

Source: Created by authors

The top five factors bar chart reveals that structural and strategic issues dominate stakeholder concerns. The highest-ranked factor, global benchmarking (Mean = 4.6), indicates strong industry recognition of the need to learn from mature international markets. Cost-related challenges (Mean = 4.55) and policy uniformity (Mean = 4.43) further emphasize that financial and regulatory reforms are more critical than material availability alone. The inclusion of lifecycle cost benefits among the top five factors suggests growing awareness of long-term economic advantages, although upfront cost constraints continue to limit adoption.

3.4 Availability of sustainable construction materials

A majority of respondents (45%) rated the availability of sustainable construction materials as moderate, while only 30% perceived it as high or very high. This indicates that although sustainable materials are present in the Indian market, their availability is inconsistent and region-specific, particularly outside major urban centers.

Table 6: Availability of Sustainable Construction Materials in India

Likert Rating	Frequency	Percentage (%)
1 (Very Low)	2	5
2 (Low)	8	20
3 (Moderate)	18	45
4 (High)	10	25
5 (Very High)	2	5

Source: Created by authors

3.5 Availability of sustainable construction materials

Nearly 67.5% of respondents agreed or strongly agreed that high initial cost is a major barrier to the adoption of sustainable construction materials. This highlights that despite long-term lifecycle benefits, upfront financial constraints significantly influence material selection decisions in Indian construction projects.

Table 7: Perception of Cost as a Barrier to Sustainable Material Adoption

Likert Rating	Frequency	Percentage (%)
1 (Strongly Disagree)	1	2.5
2 (Disagree)	5	12.5
3 (Neutral)	7	17.5
4 (Agree)	16	40
5 (Strongly Agree)	11	27.5

Source: Created by authors

3.6 Influence of government policy and regulations

While 50% of respondents believe that government policies positively influence sustainable material adoption, a significant proportion (35%) remained neutral. This suggests that existing regulations are influential but inconsistently enforced, limiting their effectiveness in driving widespread adoption.

Table 8: Effectiveness of Government Policies in Promoting Sustainable Materials

Likert Rating	Frequency	Percentage (%)
1	2	5
2	4	10
3	14	35
4	13	32.5
5	7	17.5

Source: Created by authors

3.7 Awareness and technical knowledge

The results show that 42.5% of respondents perceive awareness levels as moderate, while 37.5% rate it as high or very high. This indicates that although awareness is growing, gaps remain in technical understanding and practical training, especially at the site execution level.

Table 9: Awareness of Sustainable Construction Materials among Professionals

Likert Rating	Frequency	Percentage (%)
1	2	5
2	6	15
3	17	42.5
4	12	30
5	3	7.5

Source: Created by authors

3.8 Global benchmarking and market maturity

Table 10: Comparison of Indian Market with Global Practices

Likert Rating	Frequency	Percentage (%)
1	1	2.5
2	7	17.5
3	16	40
4	11	27.5
5	5	12.5

Source: Created by authors

A majority (40%) of respondents rated India's market maturity as moderate when compared to global benchmarks, while 40% viewed it as high or very high. This indicates that although India lags behind developed countries, there is strong potential for growth and scalability in the sustainable materials market.

3.9 Integration of sustainable materials into mainstream construction

Table 11: Need for Integrating Sustainable Materials into Standard Construction Practices

Likert Rating	Frequency	Percentage (%)
1	1	2.5
2	2	5
3	5	12.5
4	18	45
5	14	35

Source: Created by authors

An overwhelming 80% of respondents agreed or strongly agreed that sustainable construction materials should be formally integrated into standard construction practices and guidelines. This highlights strong industry readiness for structured adoption, provided policy and cost-related challenges are addressed.

3.10 Summary of key results

The data analysis reveals that the adoption of sustainable construction materials in India is influenced more by economic and regulatory constraints than by lack of awareness or material availability. High initial costs and inconsistent policy enforcement emerge as the

most significant impediments. At the same time, strong support for global benchmarking and formal integration into mainstream construction practices indicates positive industry intent. Overall, the findings suggest that sustainable construction materials are perceived not merely as environmental alternatives, but as strategic enablers of long-term efficiency and quality, provided systemic barriers are addressed through policy reform, incentives, and capacity building.

4.0 Conclusion and Managerial Implications

4.1 Overview of the study

The current study analyzed the barriers to the adoption of sustainable building materials in India by conducting an empirical and systematic study. The study combined international benchmarking, theoretical knowledge and first-hand data gathered about the professionals in the construction industry to measure the maturity of the market, costing, regulatory efficiency, awareness, and strategic preparedness in the Indian construction market. The mixed-methods design of the study ensured that all perceptions of site engineers, project managers, contractors, architects, and consultants were captured hence, a conclusive part of the research was based on the project realities at the project level. The results give a detailed insight into the reasons why sustainable construction materials, being cost-effective and having a long-term environmental and economic benefit, are yet to be widespread in India.

4.2 Interpretation of data and graphical analysis

4.2.1 Market availability and maturity

The interpretation of descriptive statistics and bar graphs suggest that there is moderate maturity in the Indian market of sustainable construction materials with majority of the mean scores falling in the range of 2.8 to 3.2. Although sustainable materials are technically accessible, they are not uniformly used in terms of their use by regions and project types. This implies that material availability is not enough to stimulate adoption. In terms of construction management, supply chains disjointed and uneven quality assurance mechanisms curtail trust amongst project stakeholders, particularly in infrastructure-based projects of high scale and those that are time sensitive.

4.2.2 Cost and economic feasibility

The most important constraint in the data became cost-related parameters. Questions touching on affordability, comparison of prices with international standards and the adoption

rates compared to developed nations were the ones with the lowest scores on the mean ($Q3 = 2.33$; $Q9 = 2.25$; $Q20 = 2.40$).

The frequency tables and graphs are a clear indication that in most decision-making processes in projects, high upfront costs exceed the lifecycle benefits. This fact is in line with the earlier research, which points to the importance of short-term financial premises in the procurement approaches of developing economies (Habert et al., 2020; McKinsey Global Institute, 2020). Managerially, this highlights the pressing necessity of considering lifecycle cost analysis (LCCA) as a part of tendering and project appraisal systems to facilitate rational decision-making in terms of long-term material selection.

4.2.3 Policy and regulatory environment

Policy and regulatory factors were relatively more influential on adoption behavior and their mean scores were higher, which implied their strategic role. Nevertheless, the high percentages of neutrality in terms of responses on policy effectiveness indicate that there are inconsistent implementations in different states.

The large average of policy uniformity ($Q30 = 4.43$) demonstrates that the industry agrees that converged national rules would greatly decrease uncertainty and risk of adoption. The results support international data that the mandatory use of green building codes and the policy of incentives are important facilitators of sustainable construction markets (World Green Building Council, 2019).

4.2.4 Awareness and technical capability

The awareness of construction professionals was moderate, which means that individuals were becoming familiar with sustainable materials, although not in-depth knowledge of technical expertise, and especially on the execution level. Consultants and senior managers are aware of it, whereas site engineers and contractors have more practical challenges associated with application, performance assurance, and standard compliance.

The graphical tendencies state that capacity-building and skill development are necessary to close the policy intent and on-site implementation gap. This justifies the necessity of organized training and professional certification in terms of sustainable construction practices.

4.2.5 Global benchmarking and strategic readiness

Global benchmarking became the most powerful strategic area, which scored the highest mean score ($Q25 = 4.6$). According to the graph, there are steep peaks of questions on international alignment, learning about policies, and scalability. This indicates a strong industry desire to match Indian construction methods to the global standards of sustainability

like LEED and BREEAM. Strategically, global benchmarking is no longer being considered as a mandatory compliance factor, instead, it has become a roadway to greater competitiveness, investor trust and future asset worth.

4.3 Managerial and industry implications

Following the explanation of the quantitative data and graph analysis, the following conclusions can be made:

- The Project Managers ought to have material evaluation based on lifecycle over first cost.
- Developers and Contractors should incorporate sustainable materials at the initial design and procurement phases in order to reduce cost increase and execution risk.
- To speed up the adoption, policymakers need to pay attention to policy consistency, enforcement, and incentive-based procurement.
- Institutions in the industry should intensify technical training, certification and awareness to facilitate workforce readiness.

4.4 Strategic conclusion

The paper conclusively proves that the low implementation of sustainable construction materials in India is mostly influenced by the economic factors, fragmentation in regulations, and perception of risks associated with procurement and not a lack of knowledge and availability of such materials. The emphasis which the industry has put on global benchmarking, uniformity of policy, and lifecycle cost value is a sign that the industry is highly prepared to undergo change. With coherent policies, financial incentives, and procurement reforms that are led by the management, sustainable construction materials can shift their status of niche alternatives to the mainstream construction inputs. India can promote its construction industry to a higher level through international sustainability practices to ensure that the environment management and economic performance of the sector is boosted and international competitiveness is achieved.

References

1. Habert, G., Miller, S. A., John, V. M., Provis, J. L., Favier, A., Horvath, A., & Scrivener, K. (2020). *Environmental impacts and decarbonization strategies in the cement and concrete industries*. *Nature Reviews Earth & Environment*, 1(11), 559–573.
2. McKinsey Global Institute. (2020). *The next normal in construction: How disruption is reshaping the world's largest ecosystem*.
3. World Green Building Council. (2019). *Bringing embodied carbon upfront*.
4. Ellen MacArthur Foundation. (2015). *Towards a circular economy: Business rationale for an accelerated transition*.