

Cost-Effective Construction Materials: Assessment for Sustainable Development

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Abstract - The demand for sustainable and cost-efficient construction materials is increasing as the industry seeks to address issues related to environmental sustainability, resource limitations, and financial viability. This paper examines various alternative materials that could offer economic and environmental benefits, utilizing the Relative Importance Index (RII) methodology to assess each material's effectiveness compared to traditional options like concrete and steel. Key factors such as durability, lifecycle cost, energy efficiency, and environmental impact are analyzed to evaluate the potential of locally sourced, recycled, and composite materials. By using RII for systematic analysis, the study provides valuable insights for stakeholders, including construction professionals, urban planners, and policymakers, to encourage a shift toward materials and methods that support both economic and ecological sustainability. The results emphasize the significance of adopting resource-efficient materials to promote sustainable development in construction practices.

Index Terms- Sustainable construction materials, Cost efficiency in construction, Relative Importance Index (RII), Environmental sustainability, Lifecycle cost analysis, Recycled building materials.

I. RELEVANCE AND MOTIVATION

The global economy benefits greatly from the building sector. Finding materials that are cost-effective may significantly lower building expenses, increasing the affordability and accessibility of housing and infrastructure projects. This directly affects economic planning and budgeting for projects in the public and commercial sectors. Reducing the environmental impact of construction operations requires the use of economical and sustainable building materials. Conventional materials frequently have substantial energy and carbon emission costs. Sustainable alternatives can help the worldwide effort to address climate change by lowering the carbon footprint of construction projects.

II. SCOPE OF PROJECT

The project's scope includes the identification and assessment of conventional and novel construction materials concerning their cost-effectiveness, ecological impact, and functionality. This entails a careful examination of the economics, environmental impact, and durability of materials such as composite materials, recycled concrete, and fly ash bricks.

A. Methodology

- 1) To collect the primary data by interviews with questionnaires prepared and getting filled them by stakeholder.
- 2) To interpret the primary data collected during market survey with Relative Importance Index (RII) tool.
- 3) To discuss the observation with reference to performance of cost-effective materials.
- 4) To prepare results and conclusion based on study.

III. PRIMARY DATA COLLECTION

To collect the primary data initially thoroughly literature was studied and various low- cost materials were identified through this study. In the next phase on the basis of literature study structured questionnaire was prepared.

The questionnaire is based on THREE (3) sections:

Section A: Respondent Background.

Section B: To study the scenario of the construction professionals on selection, usefulness of low-cost building material.

Section C: To investigate the barriers preventing construction professionals from selecting a variety of low-cost building materials and its methodologies.

A. Sample selection:

The selection of stakeholders was purposive sampling to ensure a diverse representation of construction industry. Different set criteria which include their experience in the construction field,

involvement in construction projects, familiarity with sustainable construction material.

B. Interview Process:

To collect the information interviews was conducted either in person or via digital platforms, depending upon stakeholders' availability and preferences. To ensure comprehensive responses to the questionnaire each interview was lasts for approximately 30 to 45 minutes.

C. Data interpretation:

After collecting all the valid responses, further processing was done in Microsoft Excel. Categorization of the collected data helps to classify the data into various forms for the further ranking of factors.

D. Relative Importance Index (RII):

Primary data collected is further analyzed using Relative Importance Index (RII) tool prioritize the various factors considered earlier based on the stakeholders' responses which insights into their relative importance and performance in sustainable development.

Mathematical equation for the calculation of Relative Importance Index (RII) as follows;

$$\text{Relative Importance Index (RII)} = \frac{\sum W}{A \times N}$$

Where,

ΣW = Sum of all relative responses

A = Highest weightage

N = Number of Respondant

IV. ANALYSIS OF DATA

Total Number of Respondents (N): 92

Highest weightage (A): 5

Section A: Respondent Background

Table No. 01: Personal information of respondent (Gender)

Q.1.	Gender		
		No of Responds	Percentage
	Female	13	14.13
	Male	79	85.87
	Total	92	100

Table No. 02: Personal information of respondent

Q.2.	Age		
		No of Responds	Percentage
	21-30 Years	62	67.39
	31-40 Years	20	21.74
	41-50 Years	8	8.70
	51-60 Years	1	1.09
	Above 60 Years	1	1.09
	Total	92	100

Q.3.	What is your position in the firm?		
		No of Responds	Percentage
	Project manager	16	17.39
	Professional Engineer/ Consultant/ Architect	56	60.87
	Contractor	14	15.22
	Construction site Manager	5	5.43
	Other	1	1.09
	Total	92	100

Table No. 03: Personal information of respondent (Designation)

Q.4.	What is the highest degree of education you are studying or have completed?		
		No of Responds	Percentage
	PhD	5	5.43
	Master Degree	28	30.43
	Bachelor Degree	38	41.30
	Diploma	21	22.83
	Total	92	100

Table No. 04: Personal information of respondent (Education)

Q.5.	What is the scope of your work?		
		No of Responds	Percentage
	Project Planning	23	25.00
	Civil Inspection/Execution Engineer	37	40.22
	Structural Consultation	16	17.39
	Environmental Consultation	5	5.43
	Geotechnical Consultation	2	2.17
	Architectural	5	5.43

Table No. 05: Personal information of respondent (Area of expertise / scope)

Q.5.	What is the scope of your work?		
		No of Responds	Percentage
	Project Planning	23	25.00
	Civil Inspection/Execution Engineer	37	40.22
	Structural Consultation	16	17.39
	Environmental Consultation	5	5.43
	Geotechnical Consultation	2	2.17
	Architectural	5	5.43

	Construction Safety	3	3.26
	Sustainability consultant	1	1.09
	Total	92	100

Table No. 06: Personal information of respondent (Work Experience)

Q.6.	Experience		
		No of Responds	Percentage
	1-5 years	35	38.04
	6-10 years	31	33.70
	11-15 years	21	22.83
	16-20 years	1	1.09
	Above 20 years	4	4.35
	Total	92	100

SECTION B: Construction Materials Selection

Table No. 07: Construction Materials Selection

Q. No.	Question		
Q.7.	How much influence do you have over the selection of Materials and construction Product on a project?		
		No of Responds	Percentage
1	Least influential	8	8.70
2	Slightly Influential	13	14.13
3	Moderately Influential	22	23.91
4	Very Influential	24	26.09
5	Most Influential	25	27.17
	Total Number of Respondent	92	100

Table No. 08: Ranking of construction professionals' responsibility for selection of construction materials.

Rank	RII	Description
1	0.598	Structural Consultant
2	0.580	Architect
3	0.578	Client
4	0.572	Civil Engineer (Inspection / Execution)
5	0.565	Project Manager
6	0.559	Environmental Consultant
7	0.559	Quantity Surveyor
8	0.543	Sustainability Consultant
9	0.535	Main/ Sub-Contractor
10	0.535	Other (Material Vendor)

Table No. 13: Ranking of respondent understanding of construction materials and products.

Rank	RII	Description
1	0.580	M-Sand (Manufactured sand)
2	0.565	Aerocon Blocks (Autoclaved, Aerated Concrete Blocks)
3	0.561	Steel with Specific Chemical Composition
4	0.557	Concrete using Construction Waste Residue and Asbestos Fiber
5	0.557	Glass Fibre Reinforced Polymer (GFRP)
6	0.557	Bamboo
7	0.550	Gypsum Area Separation Wall
8	0.537	Fly Ash Enriched Earthen Un-Burnt Bricks
9	0.528	Glass Sand
10	0.520	Concrete using Copper Slag, Phospogypsum.
11	0.520	Reclaimed Steel (Recycled)
12	0.511	Bagasse-PVC Boards.

Table No. 16: Ranking on frequency of construction materials and products.

Rank	RII	Description
1	0.600	M-Sand (Manufactured sand)
2	0.576	Aerocon Blocks (Autoclaved, Aerated Concrete Blocks)
3	0.550	Glass Fibre Reinforced Polymer (GFRP)
4	0.528	Concrete using Construction Waste Residue and Asbestos Fiber
5	0.528	Steel with Specific Chemical Composition
6	0.526	Fly Ash Enriched Earthen Un-Burnt Bricks
7	0.526	Concrete using Copper Slag, Phospogypsum.
8	0.520	Gypsum Area Separation Wall
9	0.517	Bamboo
10	0.507	Glass Sand
11	0.496	Reclaimed Steel (Recycled)
12	0.491	Bagasse-PVC Boards.

Table No. 19: Ranking on use of construction materials and products.

Rank	RII	Description
1	0.580	M-Sand (Manufactured sand)

2	0.548	Aerocon Blocks (Autoclaved, Aerated Concrete Blocks)
3	0.535	Gypsum Area Separation Wall
4	0.528	Glass Fibre Reinforced Polymer (GFRP)
5	0.513	Bamboo
6	0.511	Fly Ash Enriched Earthen Un-Burnt Bricks
7	0.511	Steel with Specific Chemical Composition
8	0.502	Reclaimed Steel (Recycled)
9	0.500	Glass Sand
10	0.496	Concrete using Construction Waste Residue and Asbestos Fiber
11	0.483	Bagasse-PVC Boards.
12	0.467	Concrete using Copper Slag, Phospogypsum.

Table No. 22: Ranking on utilization of low-cost construction materials and products its reason behind decision.

Rank	RII	Description
1	0.580	The materials more economic
2	0.578	Often looking for new technology/innovation
3	0.576	Save operation cost of construction project
4	0.567	Improved health and safety during construction progress
5	0.559	Client required it
6	0.559	Save time of construction progress
7	0.557	Desirable aesthetics
8	0.539	Architect, engineer or contractor required it
9	0.535	Regulatory requirement
10	0.528	Offered best structural performance
11	0.524	Aligns with the company's values and principles.
12	0.515	Earned points towards assessment scheme
13	0.474	Felt morally obliged to use low carbon materials

Table No. 25: Ranking on importance of developments could be in encouraging greater use of low-cost construction materials and products for sustainability.

Rank	RII	Description
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1	0.578	More environmentally conscious construction professionals
2	0.578	Training on designing with alternative materials
3	0.574	Higher value in assessment schemes
4	0.565	More information on material performance and design
5	0.557	More demonstration projects and case studies
6	0.546	Reductions in materials cost

Table No. 28: Ranking on utilization of low-cost construction materials and products its reason behind decision.

Rank	RII	Description
1	0.596	Shortage of skilled labour
2	0.567	High costs
3	0.565	Lack of demonstration projects
4	0.563	Lack of regulation
5	0.561	Insufficient design or performance information
6	0.561	Lack of knowledge on Life Cycle Assessment
7	0.561	Negative perceptions of industry
8	0.552	Lack of design knowledge and skills
9	0.548	Time constraints
10	0.533	Institutional culture and established practice
11	0.524	Conservative nature of clients

Table No. 31: Ranking on the effectiveness of utilizing low-cost materials for construction projects.

Rank	RII	Description
1	0.567	In your experience, how well do low-cost materials perform in different environmental conditions (e.g., extreme weather, high humidity)?
2	0.567	How likely are you to recommend the utilization of low-cost materials for construction projects based on your experience?
3	0.561	How would you rate the long-term maintenance and upkeep requirements of constructions built with low-cost materials?

4	0.554	How would you rate the cost savings achieved by using low-cost materials compared to traditional materials?
5	0.554	To what degree do you think low-cost materials impact the aesthetic appeal of the construction project?
6	0.552	To what extent do you think the use of low-cost materials affects the project timeline and completion efficiency?
7	0.548	How effective do you find low-cost materials in terms of ease of procurement and availability?
8	0.541	How satisfied are you with the performance of low-cost materials in terms of meeting safety standards?
9	0.539	How satisfied are you with the overall quality of construction achieved by using low-cost materials?
10	0.496	To what extent do you believe low-cost materials affect the overall durability of the construction project?

VI. RESULT AND DISCUSSION

In this study, data from 92 construction professionals—13 female and 79 male, mostly aged 21–30—were collected through interviews and digital tools, then analyzed using the Relative Importance Index (RII) in Excel to rank factors influencing the choice of construction materials. Respondents included a mix of project managers, engineers, consultants, contractors, and site managers, with diverse educational backgrounds: 5 PhDs, 28 postgraduates, 38 undergraduates, and 21 diploma holders. Expertise areas spanned civil inspection, project planning, structural consulting, and environmental fields, with work experience from 1 to over 20 years. Results indicate that material selection is highly impactful, with 27.17% and 26.09% of respondents rating it as "most influential" and "very influential," respectively, highlighting the need to prioritize sustainable materials in construction projects.

VII. CONCLUSION

This study examines low-cost construction materials, focusing on their selection, use, and barriers to adoption in the industry. Analyzing 92 responses from construction professionals using the Relative Importance Index (RII), the study highlights the role of structural consultants and architects in material choice. M-Sand and Aerocon Blocks are identified as top materials due to their economic and environmental benefits, with promising alternatives like GFRP, bamboo, and fly ash-enriched bricks. Barriers include high costs, lack of demonstration projects, and skilled labor shortages. Economic benefits, innovation, and client requirements drive the adoption of low-cost materials. The study concludes that with proper support, low-cost materials can play a key role in achieving sustainability in construction.

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