ISSN: 2582-7219

International Journal of Multidisciplinary Research in Science, Engineering and Technology

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Impact Factor: 8.206

Volume 8, Issue 5, May 2025

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Review on Sustainable Building Materials for Green Building Construction

Ankit S. Gajbhiye , Prof. Hemant Dahake

Student M. Tech, Dept. of Civil Engineering, G.H. Raisoni University, Amaravati, India

Head, Dept. of Civil Engineering, G.H. Raisoni University, Amaravati, India

ABSTRACT*:* An in-depth review of a varied range of eco-friendly options for construction is done in this thorough research on sustainable building materials. With increased worries about environmental deterioration, the building sector is increasingly focusing on long- term solutions. This research looks into a variety of materials, including bamboo, engineered wood products, recycled composites, and optimal concrete mixtures. The study underlines the importance of compressive, tensile, and flexural strengths, which are a basic feature for structural integrity.The study also gives useful insights into their practical applicability in real-world building projects by assessing the flexural strength of various materials. Furthermore, the study examines the environmental effect of these materials, taking into account characteristics such as renewability, recyclability, and energy efficiency. Laboratory tests were conducted to determine the fundamental properties of selected materials as part of the investigations. The study emphasizes the ecological advantages of adopting these sustainable alternatives through life cycle assessments and comparative studies. The research output can be served as a thorough reference for architects, engineers, and policymakers, providing a complete knowledge of sustainable building materials and their critical role in developing a greener, more resilient built environment

I. INTRODUCTION

Buildings have a tremendous impact on the environment, using about 40% of natural resources extracted in industrialized nations, consuming virtually 70% of electricity and 12% of potable water, and producing between 45% and 65% of the waste disposed in our landfills. Additionally, they are responsible for a massive amount of harmful emissions, accounting for 30% of greenhouse gases, due to their operation, and an additional 18% induced indirectly by material exploitation and transportation. Simultaneously, the bad quality of indoor environments may result in health issues to employees in office buildings, hence, reducing efficiency. Also Building construction consumes 40% of the raw stone, gravel, and sand used worldwide annually, and 25% of the raw timber. From the environmental impact perspective, the building sector has a significant effect on the entire environment Residential buildings represent a large percentage of the built environment, and the selections of materials and layouts are necessary for the general sustainability.

The objective of the study is to possible explore and highlight how sustainable building material can contribute to lessen the impact of environmental degradation, and create healthy buildings which can be sustainable to the occupant as well as our natural environment. Development of the green building in order to mitigate the effect of buildings along their life cycle, Green Building (GB) has become a new building philosophy, pushing the application of more environmentally friendly materials, the implementation of strategies to save resources and lower waste consumption, and the improvement of indoor environmental quality, among others. This might lead to environmental, financial, economic, and social benefits. For instance, savings in operation and maintenance costs in GBs can be realized through the installation of high-efficiency illumination and insulation systems or through a suitable material selection process that considers, for example, the daylight roof reflection.

Sustainable building materials can be defined as materials with overall superior performance in terms of specified criteria. The following criteria are commonly used: Locally produced and sourced materials

- Transport costs and environmental impact
- Thermal efficiency

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

- Occupant needs and health considerations
- Financial viability
- Waste and pollution generated in the manufacturing process
- Energy required in the manufacturing process
- Use of renewable resources

1.1 SUSTAINABLE BUILDING POLICY

The innovative Western Cape Sustainable Human Settlement Strategy, includes eco-design principles in an official policy document (for the first time). It requires that all new buildings, infrastructure and open spaces be planned according to ecological design principles, and that existing buildings, especially in the public sector, be retrofitted. Eco- design principles emphasized include orientation, insulation, roof overhangs, sustainable building materials minimizing embodied energy, thermal mass in wall material and energy saving devices like PV and solar water heaters.Cities accommodate more than 50% of the world's population and facilitate a large proportion of the important economic activities of a country. The high concentration of economic activities and population distribution in urban regions has an influence on the environment. Massive increases in carbon dioxide emissions due to human activities have further widened the gap between actual emissions and the goal of controlling global warming. Global carbon dioxide emissions have increased to 35.6 billion tonnes in 2012, which includes 28% from China, 16% from the United States, 11% from the European Union, and 7% from India. Buildings are the largest man-made entities that contribute to huge amounts of carbon emissions. In addition, buildings are the largest energy-consuming asset in a city, accounting for 40% of total global energy consumption. Therefore, reducing life cycle carbon emissions and the energy consumption of buildings is the key to reducing the impact on the environment, economy and society and achieving sustainable development goals (SDGs).

1.2 Defination of Green building and research gap

A green building is often defined as an energy-saving building, ecological building or sustainable building. However, there are many differences in green building definitions.American architects Paola Soleri and Ian Lennox McHarg stated that the concept of "green" is used to emphasize people-oriented and sustainable development to realize harmonious symbiosis among human, architecture and nature.

1.3 Benefits of green building Implementations

The benefits of green building for environmental performance will enable people to cope with serious challenges because of uncertainties in climate change scenarios. The building industry has a substantial influence on the environment, which is considered the most important element in mitigating the effect of global warming on humanity. The improvements of energy efficiency and environmental performance in buildings are the core of the green building transformation. The green building as a positive performance construction has a minimal impact on the environmental aspect, which can also reduce lifecycle environmental implications. Darko further note that one of the major objectives in green building is to minimize environmental interference and construction waste. The treatment of construction and demolition wastes plays an important role in the development of sustainable building design. The value of recovery rate in construction wastes should be over 90%, which can distinctly reduce the effect of waste generation.

II. LITERATURE REVIEW

Kibert (2016) According to Kibert (2016), sustainable building materials are those that minimize environmental degradation while ensuring durability, efficiency, and comfort. The focus is on materials that are renewable, reusable, recyclable, and non-toxic. Their adoption in green building practices aims to balance environmental, economic, and social considerations. sustainable materials should fulfill three key criteria: renewability, low environmental impact, and longevity.

Tam et al. (2019) Recycled concrete reduces landfill waste and lowers the demand for virgin aggregates. Research by Tam et al. (2018) indicates that RCA maintains structural integrity while reducing the carbon footprint of

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

concrete production. RCA has been extensively studied for its mechanical performance, with findings indicating that partial replacement of natural aggregates with RCA can maintain structural strength and durability.

Sharma et al. (2015) Bamboo has been extensively researched for its structural and environmental benefits given Sharma et al. (2015) highlighted bamboo's rapid growth, renewability, and high tensile strength, making it ideal for green construction. Its carbon sequestration potential further enhances its sustainability credentials. Bamboo is a renewable, biodegradable, and high strength material. It has been widely used in Asia for construction due to its rapid growth and minimal environmental impact (Sharma et al., 2015). Studies show that bamboo has a high strength-to-weight ratio, making it a viable alternative to traditional timber. The structural integrity of bamboo has been tested for earthquake-resistant buildings, and its ability to sequester carbon further enhances its sustainability potential. However, challenges such as susceptibility to pests and durability concerns necessitate chemical treatments or innovative preservation techniques. Bamboo's compressive strength is comparable to concrete, and its tensile strength can exceed that of mild steel, making it an ideal choice for load-bearing structures.

Walker et al. (2014) Hempcrete, a bio composite material made from the woody core of the hemp plant, has gained attention for it's the translation and carbon-negative properties. Walker et al. (2014) noted its potential to significantly reduce energy consumption in buildings while acting as a carbon sink during its lifecycle. It offers excellent insulation, moisture regulation, and low carbon emissions. (Walker et al) Studies highlight its potential in reducing heating and cooling costs by up to 50%. Hempcrete is known for its breathability, which helps prevent mold growth and improves indoor air quality.
Hempcrete's primary limitation is its lower structural strength compared to traditional concrete. It is often used in non-load-bearing applications such as infill walls, insulation panels, and flooring. Research on hybrid hempcrete formulations incorporating supplementary materials such as pozzolanic additives is ongoing to improve its strength. Hempcrete is made by mixing hemp shiv (the woody core of the hemp plant) with a lime-based binder and water. The resulting mixture is cast into blocks or sprayed onto formwork to create insulation layers.

Minke (2006) Rammed earth construction involves compressing natural soil, sand, and clay into forms to create durable walls. This technique has been used for centuries and provides high thermal mass, reducing heating and cooling loads. Rammed earth is an ancient yet increasingly popular sustainable construction technique that involves compacting a mixture of soil, sand, clay, and stabilizers into formwork to create durable and thermally efficient walls. This technique is gaining attention due to its low carbon footprint, energy efficiency, and ability to utilize locally available materials. As sustainable construction gains prominence, rammed earth is being revisited as a viable alternative to traditional building materials such as concrete and steel, both of which have high embodied energy and carbon emissions.

Gustafsson et al (2020)CLT is an engineered wood product made by gluing perpendicular layers of timber to create large, stable panels. It offers a sustainable alternative to concrete and steel, with studies showing 30-50% lower CO_2 emissions compared to traditional materials. Cross-Laminated Timber (CLT) is a mass timber product composed of multiple layers of solid wood boards arranged perpendicular to each other and bonded with structural adhesives or **f**asteners. This engineered wood product has gained prominence as a sustainable, high-performance alternative to concrete and steel in modern construction. Its growing popularity is fueled by the need for carbon reduction, energy efficiency, and renewable building materials in the architecture, engineering, and construction (AEC) industry. he development of CLT aligns with the global push for sustainable construction, driven by organizations such as the World Green Building Council (WGBC), the United Nations Environment Programme (UNEP), and various governmental bodies advocating for timber-based construction.

King (2017
Straw bale construction uses tightly packed straw blocks for insulation and structural purposes. Research shows that straw bale walls can achieve R-values up to R-50, significantly reducing heating and cooling demands (King, 2017). Straw bale construction is an ancient yet innovative sustainable building technique that utilizes densely packed straw bales as insulation and structural elements in walls. This method, which dates back to the late 19th and early 20th centuries, has seen a resurgence due to growing environmental concerns and the push for eco-friendly, low-carbon construction. Straw, a byproduct of grain production (such as wheat, rice, rye, and barley), is abundantly available, renewable, and biodegradable, making it an excellent alternative to conventional building materials. In

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

sustainable architecture, straw bale structures are recognized for their low embodied energy, superior insulation properties, and affordability.

Siddique (2008)
Fly ash, a by-product of coal combustion, has been identified as a sustainable alternative to cement. According to Siddique (2008), incorporating fly ash in concrete production reduces embodied energy and enhances durability. It also diverts industrial waste from landfills, aligning with circular economy principles.

Crawford and Treloar (2003) Crawford and Treloar (2003) analyzed materials with low embodied energy, such as rammed earth and natural stone. These materials require minimal processing, reducing energy input and greenhouse gas emissions. Their durability and thermal mass contribute to energy efficiency in green buildings.

Hakkinen and Belloni (2011) Häkkinen and Belloni (2011) emphasized the importance of lifecycle assessments (LCAs) in evaluating the true environmental impact of building materials. They argued that LCAs should account for extraction, processing, transportation, use, and end-of-life disposal to comprehensively measure sustainability.

Ofori (2000) Despite the benefits, challenges such as higher initial costs and lack of standardization persist. As pointed out by Ofori (2000), overcoming these barriers requires governmental incentives, increased awareness, and investment in research and development.

Johansson et al. (2012)
New materials such as bio-based composites and 3D-printed materials are emerging as game-changers in green construction.

III. OBJECTIVES

1. To compare the environmental performance of [specific sustainable material] with traditional materials.
2. To evaluate the mechanical, thermal, and acoustic properties of [specific sustainable material] under various conditions.
3. To proposed strategies for enhancing the adoption of sustainable building materials in the construction industry.
4. To identify the key challenges and opportunities for promoting sustainable building materials.

REFERENCES

1. Chakraborty D, Elzarka H. Advanced machine learning techniques for building performance simulation: A comparative analysis. Journal of building performance simulation 2019; 12(2): 193–207.
2. Xie X, Gou Z. Building performance simulation as an early intervention or late verification in architectural design: same performance outcome but different design solutions. Journal of green building; 12(1): 45–61.
3. Lucy Wang "INFOGRAPHIC: Build Your Green Dream Home With These Eco Friendly Alternatives to Conventional Building Materials.
4. Yudelson J. The green building revolution. Washington, D.C.: Island Press; 2008. Wang W, Zmeureanua R, Rivard H. Applying multi-objective genetic algorithms in green building design optimization. Building and Environment 2005.
5. Shilpa Chauhan, Jagdish Kamboj, " A way to go sustainable: Identifying different means & need to go green in the sector of construction world", International Journal of Civil Engineering and Technology (ICIET) Volume 7, Issue 5, September-October 2016, pp. 22-23.
6. Hemant Kumar, Vaishali Shah, "Performance and rating of residential green building", Civil Engineering and Urban Planning: An International Journal (CiVEJ), Vol.2, No.2, June2015.
7. Geeta Mehta, Amit Mehta, Bidhan Sharma, "Selection of material for green construction. IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume 11, Issue 6 Ver.
8. M. Samer, "Toward the implementation of Green building concept in agricultural buildings", Cairo University, Faculty of Agriculture, Department of Agricultural Engineering, El-Gammaa Street, 12613 Giza, Egypt, July- 2013.
9. Zhang, Y.; Wang, H.; Gao, W.; Wang, F.; Zhou, N.; Kammen, D.M.; Ying, X. A survey of the status and

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

challenges of green building development in various countries. *Sustainability* 2019, *11*, 5385.

10. Gou, Z.; Lau, S.S.Y. Contextualizing green building rating systems: Case study of Hong Kong. *Habitat Int.* 2014, *44*, 282–289.
11. Ruggerio CA. Sustainability and sustainable development: a review of principles and definitions. *Sci Total Environ* 2021; 786.
12. CIB. (1999). "Agenda 21 on sustainable construction", CIB report publication 237, CIB, Rotterdam, the Netherlands.
13. Hill, R., and Bowen, P. (1997), "Sustainable construction: Principles and a framework for Attainment, Construction Management and Economics 15", 223 –239.
14. C. J. kibert, "Sustainable construction," The First International Conference of CIB TG, Tampa, Florida, U.S.A. 1994.
15. L. Bragança, M. D. Pinheiro, S. Jalali, R. Mateus, R. Amoêda, and M. C. Guedes, "Portugal SB07, sustainable construction, materials and practices, delft university press, center for excellence in sustainable Development," Construction Research Centre. 2007.

INTERNATIONAL JOURNAL OF
MULTIDISCIPLINARY RESEARCH
IN SCIENCE, ENGINEERING AND TECHNOLOGY