iJETRM
International Journal of Engineering Technology Research & Management
Published By:
https://www.ijetrm.com/

A REVIEW ON GREEN BUILDING MATERIALS FOR SUSTAINABLE INFRASTRUCTURE

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ABSTRACT
The construction sector significantly impacts environmental sustainability, necessitating the adoption of greener alternatives. Green building materials provide a sustainable solution by lowering carbon emissions, improving energy efficiency, and reducing construction waste. This review analyzes various green materials, their advantages, challenges, and implementation, with a focus on the Indian context. The findings are based on research prior to December 2017 to assess advancements in sustainable construction.

Keywords:
Green Building Materials, Sustainable Construction, Renewable Materials, Recycled Materials, Energy Efficiency, Environmental Impact, Sustainable Development, Green Technology, Eco-Friendly Construction, Smart Materials

INTRODUCTION

Green building materials (GBMs) are designed to minimize environmental damage while enhancing building performance. These materials include renewable, recycled, and energy-efficient options that promote ecological balance. The move towards sustainability is driven by government regulations, green certifications, and growing public awareness. Increasing urbanization has intensified the demand for sustainable alternatives to reduce excessive resource consumption and pollution.

By incorporating sustainable materials, the construction industry can significantly lower greenhouse gas emissions, improve resource efficiency, and enhance building longevity [1]. Several global and national initiatives, such as Leadership in Energy and Environmental Design (LEED) and the Indian Green Building Council (IGBC), have advocated for the use of eco-friendly construction materials [2].

TYPES OF GREEN BUILDING MATERIALS

RECYCLED AND WASTE-BASED MATERIALS

- **Fly Ash Bricks:** Produced from fly ash, a waste product from coal combustion, these bricks reduce landfill accumulation. They offer improved durability, lower water absorption, and enhanced insulation [3].
- **Recycled Steel:** Minimizes mining activities and energy-intensive production compared to virgin steel. Due to its high recyclability, steel remains a long-term sustainable choice without compromising strength [4].
- **Plastic Waste Bricks:** Incorporate plastic waste into construction, helping to mitigate pollution. These bricks resist weathering and contribute to reducing the environmental impact of non-biodegradable plastic waste [5].

NATURAL AND RENEWABLE MATERIALS

- **Bamboo**: A highly renewable material with an excellent strength-to-weight ratio. It is widely used in structural applications due to its flexibility and earthquake-resistant properties [6].
- **Straw Bale**: Acts as a natural insulator and is biodegradable. Straw bale construction improves energy efficiency by regulating indoor temperatures and lowering heating and cooling costs [7].

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- **Hempcrete**: A composite material made from hemp fibers and lime, known for its breathable and fire-resistant properties. Hempcrete is also carbon-negative, contributing to sustainability [1].

ENERGY-EFFICIENT MATERIALS

- **Aerated Autoclaved Concrete (AAC):** Lightweight and highly insulating, AAC blocks reduce material consumption and improve energy efficiency in buildings [2].
- **Cool Roofing Materials:** Reflect heat through coatings and tiles, minimizing urban heat island effects and lowering cooling demands in warm climates [3]
- **Phase Change Materials (PCMs):** Store and release heat, stabilizing indoor temperatures and reducing the need for active heating and cooling systems [4].

BENEFITS OF GREEN BUILDING MATERIALS

- **Environmental Benefits**: Sustainable materials contribute to reducing carbon footprints, lowering energy consumption, and minimizing construction waste [5]. They also help in preserving biodiversity by reducing deforestation and resource exploitation.
- **Economic Benefits**: Although initial investment costs may be high, green materials result in long-term savings through energy efficiency, reduced maintenance, and increased property value [6].
- **Health Benefits**: By reducing toxic emissions such as volatile organic compounds (VOCs), green materials improve indoor air quality. This leads to healthier living and working environments, enhancing overall well-being [7].

CHALLENGES IN IMPLEMENTATION

- **High Initial Costs:** Green materials often have higher upfront expenses, discouraging their adoption despite long-term benefits [1].
- **Limited Awareness and Availability:** Many builders are unaware of sustainable alternatives, and sourcing green materials can be challenging in some regions [2].
- **Regulatory and Technical Barriers:** Government policies and building codes need to adapt to accommodate innovative sustainable materials, ensuring their widespread implementation [3]..

CASE STUDIES IN INDIA

INDIRA PARYAVARAN BHAWAN, DELHI

This net-zero energy building utilizes solar panels, AAC blocks, and passive design techniques. It has achieved a 50% reduction in energy consumption compared to conventional structures [4].

ITC GREEN CENTRE, GURGAON

A LEED Platinum-certified building, ITC Green Centre incorporates recycled materials and energy-efficient lighting. The structure features water recycling, smart HVAC systems, and fly ash-based concrete to minimize environmental impact. Intelligent energy management systems further optimize energy consumption [5].

SUZLON ONE EARTH, PUNE

One of India's most sustainable corporate campuses, Suzlon One Earth integrates renewable energy sources such as solar and wind power. It utilizes bamboo, fly ash bricks, and rainwater harvesting systems, achieving 90% of its energy needs through sustainable means [6].

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COMPARISON OF CASE STUDIES

Feature	Indira Paryavaran Bhawan	ITC Green Centre	Suzlon One Earth
Certification	GRIHA 5-Star, LEED Gold	LEED Platinum	LEED Platinum
Energy Efficiency	50% lower than traditional buildings [5]	Intelligent automation for energy savings [6]	90% energy from renewable sources [7]
Water Conservation	Rainwater harvesting [1]	Water recycling systems [2]	Greywater recycling and rainwater harvesting [3]
Material Efficiency	AAC blocks, solar panels [4]	Fly ash-based concrete [5]	Bamboo, fly ash bricks, solar energy [6]
Sustainability Focus	Net-zero energy design [7]	Efficient lighting & HVAC [1]	Renewable energy integration [2]

FUTURE PROSPECTS

Advancements in nanotechnology, self-healing materials, and smart insulation solutions continue to shape the future of green construction. Sustainable innovations, including bio-based insulation and graphene-enhanced concrete, show promise for reducing environmental footprints. Government incentives and policy reforms will further accelerate the widespread adoption of green materials [3].

CONCLUSION

Green building materials are essential for mitigating the environmental impact of the construction sector. Their adoption can lead to lower carbon emissions, enhanced energy efficiency, and improved building resilience. However, challenges such as high costs and lack of awareness need to be addressed through policy interventions and industry collaborations.

To ensure widespread implementation, regulatory bodies must incentivize sustainable construction practices and support research into innovative materials. A shift towards green infrastructure will pave the way for environmentally friendly, cost-effective, and long-lasting buildings, benefiting both current and future generations [7].

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