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Sustainable Building Materials for Green Building Construction

Mr. Ankit S. Gajbhiye¹, Prof. Hemant Dahake²

Student M.Tech, Dept. of Civil Engineering, G.H. Rasoni University, Amaravati, India¹

Head, Dept. of Civil Engineering, G.H. Rasoni University, Amaravati, India²

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

The production of greenhouse gasses increases day by day. The major producer of these harmful gasses is the building industry as cement manufacturing produces about 8 % of the world's carbon dioxide (CO₂). Alone CO₂ produced by cement manufacturing can beat the whole china and U.S.A. contribution in CO₂ production. So from the environmental point of view, it is seen that the construction sector needs more sustainable methods. The basic concept behind the introduction of sustainable methods is to improve the quality of life. In our current global setting, building construction and operation results in 50% of all CO₂ emissions worldwide. Five to ten tons of cement are used to build the average middle class house, and for every ton of cement manufactured, a ton of CO₂ is released, (Department of Local Government and Housing. 2007), Thermally efficient, low CO₂ emission, structurally sound and inexpensive materials and technologies exist, some of which have been used for centuries. Materials that have great potential for building include adobe, sandbag construction, cob, thatch, brick, stone, hemp and the use of recycled materials. Other low cement options, including SABS approved compressed earth blocks are currently being investigated and proposed for sustainable neighborhood designs. sustainable building materials are environmentally responsible products with minimal impact, low embodied energy, and high durability, sourced responsibly and produced with minimal impact. They include renewable resources, recycled materials, and materials with certifications ensuring sustainable practices throughout their lifecycle.

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.

AIMS

1. Identify and evaluate sustainable building materials that can minimize resource consumption and reduce greenhouse gas emissions.
2. Assess the environmental, economic, and social impacts of using sustainable materials in construction projects.

3. To develop strategies to promote the adoption of sustainable building materials and overcome barriers to their widespread use.
4. Contribute to the development of a more sustainable and resilient built environment.
5. Promote the use of renewable, recycled, and locally sourced materials.
6. Minimize construction and demolition waste by using recyclable and reusable materials.
7. Encourage materials that have longer life cycles and durability.

II. MATERIALS AND METHODOLOGY

Sustainable materials are described as items that are produced and used by humans in an environmentally-responsible way. They can be produced in the necessary quantities throughout consumer and industrial economies without depleting non-renewable resources or upsetting the environment and major natural resource system established steady-state balance. These materials come in a wide variety and can include highly recyclable materials like glass that can be processed an infinite number of times without the need for new mineral resources, bio-based polymers made from polysaccharides, and many others. As the world continues to move towards a more sustainable future, it is important to understand what makes a material "sustainable."

Bamboo

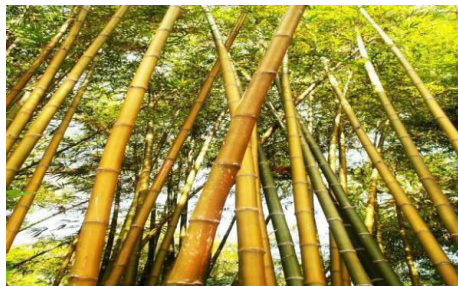


Figure 1: Bamboo

Bamboo is one type of grass, which is surprising considering its tough and durable structure. Bamboo, for thousands of years, is diverse and can grow in various environments, from mountainous regions to hot tropical areas. Bamboo has emerged as one of the most popular and sustainable material recently. With its fast growth rate and wide range of applications, it is being hailed as an environmentally friendly alternative to traditional hardwoods. This article will delve into the various aspects of bamboo and its sustainability.

Cellulose Insulation



Figure 2: Cellulose Insulation

Cellulose has a high density, which means it minimizes airflow to provide effective insulation. As a result, homes and buildings will need less electricity for heating in the winter and for air conditioning in the summer. Using less electricity, gas and oil in your home not only saves you money but also helps reduce carbon emissions, which helps reduce the amount of gases that can hurt the earth's ozone. Designed to regulate temperature room by room,

when installed in exterior walls, Sanctuary can lower heating and cooling costs by up to 25%.¹ By designing your home with a sustainable insulation material such as cellulose, you could be helping the home all of us share.

Recycled Plastic lumber



Figure 3: Recycled plastic lumber

Recycled plastic lumber, as the name suggests, is primarily composed of recycled plastic, with high-density polyethylene (HDPE) being a key component. HDPE is commonly sourced from everyday items like milk jugs and detergent bottles, making it an environmentally responsible choice. However, it's important to note that the exact composition of recycled plastic lumber can vary depending on the manufacturer. Manufacturers of recycled plastic lumber may use a range of recycled materials, and the percentage of recycled content can differ from one product to another. Some companies prioritize a higher percentage of recycled content in their lumber, striving for a more sustainable and eco-friendlier product.

Silicate paints



Figure.4: Silicate paints

Silicate paint is a mineral paint. All mineral paints for interior or exterior use contain mineral binders as ingredients. Traditionally, one mineral binder was lime. Silicate (potassium silicate or potassium silicate) is another inorganic binder. Both lime and silicate are water-soluble, which is why no further solvents are required. Pure silicate paint is a two-component paint, usually in white. It bonds insolubly with the substrate and is therefore weatherproof and durable. This process is called "silicification". Pure silicate paint is used for façades and in the preservation of historical monuments, among other things.

Living plants walls

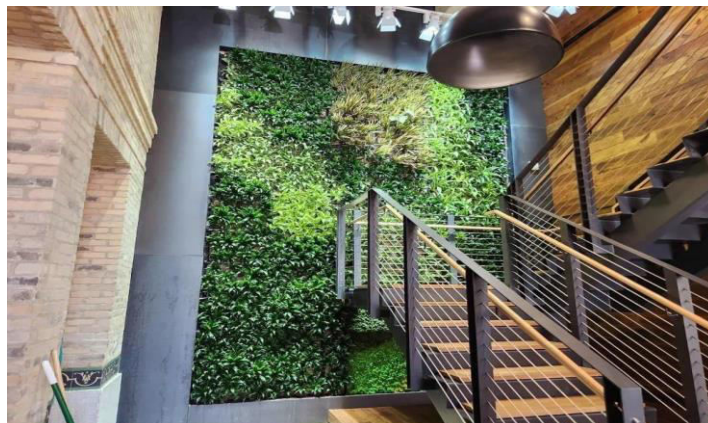


Figure 5: Living plant wall

Living green walls are panels of plants, grown vertically using hydroponics, on structures that can be either free-standing or attached to walls. Living green walls are also referred to as vertical gardens, green walls, living walls or living green walls are comprised of plants that are inserted into a growing medium and then placed on the wall of buildings and properties to provide greenery and the benefits of plants, but using a minimum of horizontal space. An Ambius Green Wall is made up of various proprietary systems which are assembled in pieces on a structure which holds the plants and their respective growing mediums to the wall. Some of the Green Walls created by Ambius also include a system that allows the plants to be watered automatically. Living Green Wall products use a variety of plants in their creation, based upon client needs and a number of factors that go into installing and maintaining them. Green walls are constructed much the same way actual walls are. They are built with a skeletal structure that is hung with sections containing the plants and flowers that will make up the Green Wall.

Solar cells



Figure6: Solar cells

Traditional solar cells can be fairly efficient, but there's an environmental impact. They're often made using expensive high-vacuum techniques, or their materials are solution processed from harmful solvents. Traditional solar cells are produced from crystalline silicon, which costs a lot of energy to make. There are efficient alternatives to silicon, but these materials are scarce. And if the world is going to increase its use of solar energy then we need to find more easily sourced alternatives. As part of a consortium of eight universities working to improve the efficiency of next generation photovoltaic devices, researchers at the University of Bath are looking for such sustainable materials.

Carpet Tiles



Figure 7: Carpet Tiles

For sustainable carpet tile specification, it is important to think holistically about the circular economy and whether the carpet is designed at the outset for potential re-use. Initiatives such as Milliken's, maximize the environmental and social value of the product where carpet tiles are recovered, cleaned and given a new life. High performance products can be re-used through either charities and social enterprises or via specialist 'second life' suppliers for commercial re-sale. When considering a carpet tile's re-use potential, it is crucial to determine firstly, whether the product been engineered for longevity – how long is its wear warranty? And secondly, how easy will it be to recover in the future? Choosing a glue free installations will ensure the product and the sub-floor are protected from damage and the carpet tile recovery volume can be maximized.

Natural stone



Figure8: Natural Stone

Timeless, classic and luxurious, natural stone is the most iconic building material. What other material could be used for both restoration of our important heritage projects and the performance needs of modern architecture. For the professionals who restored the historic Saint Patrick's Cathedral and those who designed and built the ADNOC tower in Abu Dhabi, the answer is the same – natural stone. Natural stone requires no chemicals for production. In fact, "production" for natural stone means extraction, cutting and polishing. Contrast that with other building materials like quartz surfaces, which use a combination of crushed stone and resins to manufacture products

Bio Bricks



Figure9: Bio Bricks

Bio-brick is an innovative sustainable building material made using biological processes, typically involving microorganisms like bacteria to create solid bricks from organic or waste materials. It is an emerging alternative to conventional clay bricks and concrete blocks, designed to reduce environmental impact. A Bio-brick is produced through a process called microbial-induced calcite precipitation (MICP). This process uses bacteria to produce calcium carbonate (limestone), which binds loose materials (like sand or industrial waste) into a solid, brick-like form.

Green Building Rating System

When a green building is built, it must be graded by a ranking system so that its efficiency and environmental effect can be assessed. The rating system has predefined criteria, which green buildings must meet in order to receive a high rating. In India, terms such as green ranking for integrated habitat evaluation (GRIHE), Leadership in energy and environment design (LEED), Indian Green Building Council (IGBC), bureau of energy efficiency (BEE) are commonly used In India.

| Sr no | Modulus | Possible points |
|-------|----------------------------------|-----------------|
| 1 | Sustainable architech and design | 05 |
| 2 | Site selection and planning | 14 |
| 3 | water conservation | 18 |
| 4 | Energy efficiency | 28 |
| 5 | Building materials and resources | 16 |
| 6 | Indoor environmental qualities | 12 |
| 7 | Innovation and development | 07 |
| | TOTAL = | 100 |

Table 1 - Product Dosage and details for 1 Acre land area

| Rating | Points | Recognition |
|-----------|--------|-------------------------|
| Certified | 40-49 | Best practices |
| silver | 50-59 | Outstanding performance |
| Gold | 60-74 | National excellence |
| Platinum | 75-100 | Global leadership |

Table 2 IGBC Green new building certification level

III. COST EFFECTIVENESS

| Material Type | Environmental impact | Mechanical properties | Cost effectiveness |
|---------------------|----------------------|----------------------------|--------------------|
| Recycled aggregates | Low | Varies | Cost saving |
| Bamboo | Low | High tensile strength | varies |
| Rammed earth | Low | Good compressive strength | Cost competitive |
| Straw bales | Low | Good insulation properties | Cost competitive |
| Engineered wood | low | Varies | varies |

Comparative study of sustainable materials

| Material | Environmental Impact | Compressive strength (mpa) | Tensile Strength (mpa) | Production cost |
|---------------------|----------------------|----------------------------|------------------------|-----------------|
| Recycled aggregates | 150 | 30 | 3 | 80 |
| Bamboo | 50 | 40 | 6 | 120 |
| Rammed Earth | 80 | 25 | 2.5 | 90 |
| Strawbales | 100 | 15 | 1.5 | 70 |
| Engineered wood | 120 | 35 | 4 | 110 |

Comparative study of ecofriendly materials

IV. CONCLUSION

In conclusion, this extensive study on eco-friendly options for construction materials provided numerous critical conclusions that highlight the necessity and promise of sustainable building methods. The examination of diverse materials' environmental, technological, and economic characteristics has offered significant insights into their feasibility and influence on the building industry.

The study also highlighted the importance of technology and innovation in promoting the use of sustainable materials. Material characterization showed these materials' technical feasibility and performance characteristics, highlighting prospects for further improvement and refinement. The outcomes of the study imply that developing technologies can improve the design, manufacture, and application of sustainable materials.

Finally, the study's findings highlight the critical significance of eco-friendly options in forging a more sustainable future for the construction sector. Stakeholders can work together to drive the adoption of sustainable building materials by addressing environmental concerns, economic considerations, and technological innovations, fostering a resilient and environmentally conscious built environment that meets the needs of current and future generations.

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