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Original Article

Review on Alternative Recycled Sustainable Construction Materials

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ABSTRACT

This review paper explores sustainable building practices in the construction industry, driven by the significant environmental impact of traditional materials like cement. It reviews the use of several eco-friendly alternatives, including bamboo, recycled steel, recycled glass, straw bales, and recycled plastic. For each material, the report discusses its properties, applications, advantages, and disadvantages, highlighting their potential to reduce environmental harm and promote sustainable construction. The report concludes by emphasizing the significance of sustainability alongside functional, technical, and economic specifications when selecting building materials, advocating for the adoption of these eco-friendly options to minimize environmental damage and promote a circular economy within the construction sector. The construction industry's significant environmental impact necessitates a shift towards sustainable practices. This report explores eco-friendly building materials, including bamboo, a rapidly renewable resource; recycled steel, reducing reliance on virgin ore; recycled glass, diverting waste from landfills; straw bales, offering excellent insulation; and recycled plastic, addressing plastic waste issues. Each material's properties, applications, and benefits are discussed, highlighting their potential to minimize environmental pollution and promote sustainable construction. The report highlights significance of sustainability alongside traditional criteria, advocating for wider adoption of these alternatives to create a greener, more circular construction industry.

Keywords: Bamboo, straw, recycled iron, recycled glass and recycled plastics

INTRODUCTION

Day by day the production of greenhouse gasses increases. Cement manufacturing produces maximum of these toxic gasses in 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. The construction sector needs more sustainable methods to conserve environment. Introduction of sustainable methods is only solution to improve the quality of life. Building sector during designs and construction should include more green materials. Its aim is to reduce the overall impact of greenhouse gasses for betterment of human health and the surrounding. On a universal scale nearly 25% of wood harvest and 16% of freshwater is used for building. Also, buildings generate 25% of all ozone-depleting chlorofluorocarbons (CFC) which are released by processes to manufacture buildings materials and air conditioners fitted in buildings. Thus, traditional buildings have negative effect over human health and environment. Globalization is the main cause to the depletion of resources and ruin of the environment to fulfil the demands. Hence building from sustainable construction materials is best to avoid depletion of resources [1]. "This paper explores the utilization of sustainable and eco-friendly construction materials, including bamboo, recycled steel, cork, recycled glass, reclaimed wood, hempcrete, recycled plastic, sheep's wool, Ferrock, straw bales, interlocking bricks, and plastic blocks.

II. Detail Review: The selection of appropriate building materials plays a crucial role in determining the environmental impact of any construction project. This review critically analyses the literature on a diverse array of sustainable materials, such as, e.g., reclaimed wood, cork, and recycled glass. This paper focuses on understanding use of sustainable construction material, its environmental benefits,

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limitations, and wide adoption in the construction industry."

III. Bamboo

China have been using bamboo for transportation, firewood, making paper, clothing, food, for constructing bridges and buildings. Later India and South America started using bamboo housing structures. Commercial buildings and high rises fashioned from bamboo are still common in the Asian world.

Fig.1 – Bamboo

In Japanese tradition, bamboo is a symbol of strength and flexibility for its capability to resist the devastating effects of nature. Hence there in Japan, it is widely used as a decorative boost in building. Bamboo does not absorb water therefore can be used in wet environment. From hundreds of years, the light weight, hurricane-resistant houses build from bamboo, called “nipa huts” are very common in Philippines and Polynesia. The nipa huts were made of bamboo that had been split and woven together. In ancient days, bamboo in its round form and bundled or tied together to form was used for house structures. Later, handicrafts worker began to carve and shape the bamboo into shapes like arches and squares to make it stress-free to work with as a building material.

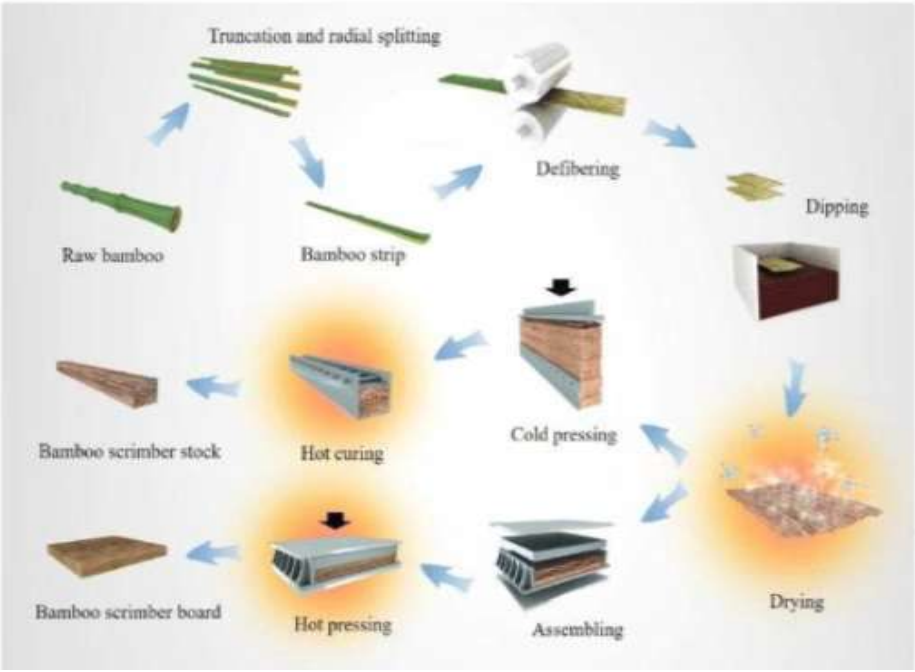

Fig.2- Processing of Bamboo to make Composites

The technique to cut and smooth the bamboo stalks into sheets and planks that look like hardwood was discovered by China in late 20th century. Thereafter it was much preferred material for floorings, roof tops, and other house structures due to its strength, durability and smooth texture. Laminated bamboo

flooring was one of the top choices for builders as an attractive substitute to outdated hardwoods in 1990's when environment, forest protection and green energy was in vague. Bamboo just needs seven years to harvest whereas traditional hardwoods need about 30-75 years to grow, which saved much land from deforestation. Knitting and compacting individual fibres of the bamboo and applying multiple layers of lacquer or resin made bamboo available in beautiful colour which further increased scope of manufacturers for catering bamboo materials for various purposes.

V. Recycled Steel

Obtaining steel from iron ore carries a substantial environmental burden, with significant CO_2 emissions. To address this problem recycling scrap steel, by-products like slag dust, sludge's, and mill scales generated during steel making is crucial and can be beneficially utilized in construction applications, such as concrete production, embankments, road construction, dams, asphalt pavements, concrete masonry and soil improvement, in that way side tracking them from landfills. Reconditioning and reclaiming steel components from demolished structures enables the safe and sustainable reuse of these components in new construction projects, promoting more ecologically accountable building practices.

Fig.3- Recycled Steel

a) Applications: Using recycled steel in new construction projects offers numerous benefits-

It promotes sustainability by diverting materials from landfills and raising a circular economy. It is more energy-efficient than traditional steelmaking, significantly reducing the industry's carbon footprint. Transforms by-products into valuable construction materials. In fact, in road construction, steel slag can even surpass natural aggregates in terms of mechanical performance. Recycled steel slag is radiation-shielding concrete against Gama and neutron radiations. This slag-enriched concrete enhances tensile and compressive strength but also offers higher linear attenuation and a reduced half-value layer compared to traditional concrete. Use of recycled steel fibres controls plastic shrinkage cracks in concrete. Recycled steel fibres derived from old tires were found to be more effective in lowering micro-cracks and plastic shrinkage compared to new ones. However, to improve the quality, durability, cost-effectiveness of recycled steel and making it more competitive for infrastructure, several crucial factors such as better supply chain integration & standardized design practices are most needed for easy adoption of recycled steel can make recycled steel an extra attractive choice in the sprouting sustainable construction.

VI. Recycled glass

Recycled glass in ancient times was used by Romans in mosaics and other ornamental components. Applications of recycled glass in a various field include:

Crushed glass can be used as an aggregate in concrete and asphalt, replacing traditional materials like gravel and sand. This helps to reduce the demand for virgin resources and divert waste from landfills. Recycled glass can be utilized to make fiberglass insulation, which improve the energy efficiency of buildings.

Tiles and countertops: Beautiful and durable tiles and countertops can be made from recycled glass. Unique and noticeable decorative foundations, such as mosaics and statues can be made from it. Recycled glass is an environment friendly and it helps to create beautiful and durable construction products.

Fig-6-Recycled Glass

In 1960s large-scale use of recycled glass in construction was in the Netherlands, where it was used to make road base for first time. The energy crisis of the 1970's led to increased attention in energy-efficient building materials, including recycled glass insulation. In 1980's the first recycled glass countertops were presented. In 1990's use of recycled glass in construction became more extensive, due to its environmental benefits. In 2000's the development of novel machineries made it likely to use recycled glass as a common and versatile construction material. It is applied in a multiple structure, from homes and offices to roads and bridges. With the inclination for sustainable building materials raises, recycled glass is expected to become even more popular in the years to come.

VII. Straw bale

Evidence of straw used as a construction material dates back from the Paleolithic era all the way to the 21st century. Specifically, in the 20th century in Nebraska, United States, there was rapid advancement in farming equipment which led to a flourishing in straw bale constructions such as low-rise public buildings, housing, churches, museums and other structures. Straw is a bio-based material that reduces waste dumping and easily available worldwide. It typically lifts local sourcing while it reduces transport requirements between the raw material source and construction sites.

Fig.5- Straw bale

An important advantage is that straw and clay (which is required for bonding) are abundant materials, making them readily available at very low cost. Straw has outstanding insulating properties; its thick structure absorbs huge amounts of temperature that is emitted constantly into the room, minimizing heat loss and providing a pleasant and cool indoor climate. It is perfect material for keeping the building pleasantly cool during the summer and warm during

the winter a enhancing both the embodied carbon impact of the building but also reducing operational emissions. Ease of construction: Straw-bale construction products can replace, slabs, bricks, insulation, and fascia materials, allowing for resourceful, environment-friendly, all-inclusive substitutes. Its building procedures can be easily understood in very less time, allowing for shorter training and construction programs. Low costs: Since straw is an agricultural by-product, it is cheap and available in abundant quantity in most regions of the world. Being light in weight requires minimal transportation cost.

Disadvantages of straw-bale construction:

NIA (Net Internal Area) impacts: Dimensions of a straw-bale external wall may range between 450–500mm, that means it takes up more net internal area than a standard brick and block work wall, which ranges between 250–300mm.

Planning permissions and insurance:

National building codes do not include straw in building materials. Thus, necessary planning permissions are required. For speedy resolution to this issue, the appointment of expertise of local architects, consultants or engineers with experience in natural materials is most desirable.

Insects and mold:

Straw cannot resist humid and wet weather. Even though conventional buildings are also prone to these, straw is more sensitive to such things than wood-constructed and fiber glass-insulated structures. [2]

VIII. Recycled Plastics

Urbanization leads to high volume of wastes generated and disposed of annually. Human errors in manufacturing sector and post utilization also generates lot of waste. Limited amount of recycling of plastic wastes deposited directly or indirectly to the in land and marine environment is one of the reason to annual increase in solid waste. One of the solid wastes generated in large quantities and being of a high threat to the sustainability of our planet is plastic wastes. It has been reported that damage occurs to ecology, economy, and aesthetics when plastic debris enters into oceans [3]. About 300 million metric tons of plastic wastes have been estimated to be generated annually [4]. Notable attempts such as source reduction, reuse and landfilling have been employed to reduce the critical amount of plastic waste generated annually. Rise in population & rapid industrialization, leads to increase in the amount of plastic waste. Recycling plastic waste can reduce environment pollution to considerable amount. It can help generate revenue by including these recycled materials in construction. Preserve the marine environment. Reduces the overall environmental menace. Significant reduction in energy consumption and carbon emission will ensue when the PW is reused as the amount of new plastic processed and produced will reduce [5].

a. Applications:

There are two types of plastic waste commonly used in construction materials, namely plastic aggregate (PA)and plastic fiber (PF). PAis used to replace coarse aggregates (CA) such as granite, limestone and basal which can help to reduce weight of concrete and make it lighter. Fine aggregates (FA) uses plastic fibres as a reinforcement material instead of steel fiber to improve the strength, corrosion resistance and durability of concrete.

Fig.6- Lego Bricks (Recycled Plastics)

The "Plastic Concept," developed by Fernando Ilanos of Conceptos Plásticos and architect Oscar Mendez, is based on the idea of turning plastic waste and tyres into bricks for housing construction [6]. Lego-like blocks are made by use of plastics that cannot be recycled and other hard-to-dispose-of materials. Every different types of plastics present in it imparts different properties to the bricks, which are combined in various ways to attain the desired characteristics. As a result, the bricks are easy to install, strong, and cost-effective. Lego bricks are stronger than conventional building materials, thermally and acoustically efficient, earthquake-resistant, and non-flammable [7]. Recycled plastic waste can be used in construction for various purposes such as, such as roofs, window lining, furniture, floors and walls. Structures made from recycled plastics can be installed by easy fitting techniques, quick in assembly, high strength, light weight, low carbon footprint, and zero waste generation. Recycled plastics with their application in the production of both structural and non-structural building elements, plays a significant role in promoting a cleaner and more sustainable environment.

CONCLUSION:

Sustainable building materials by definition are materials which are domestically created and sourced which decreases transportation costs and CO_2 emissions, they could consist of reused materials, they possess a lower environmental effect, they are thermally effective, they need less energy than conventional materials, they make use of renewable resources, they are lower in harmful emissions and they are economically sustainable.

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