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ijirset@gmail.com



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Cost-Effective Construction Materials: Study for Sustainable Development

Ms. Sayali Thorushe, Prof. Dr. D. B. Desai

P.G. Student, Department of Civil Engineering, Dr. J. J. Magdum College of Engineering, Jaysingpur, Kolhapur, India

Associate Professor, Department of Civil Engineering, Dr. J. J. Magdum College of Engineering, Jaysingpur,

Kolhapur, India

ABSTRACT: Construction activity serves as backbone for economic advancement of any nation. It, however impacts the environment quite adversely. Building construction involves huge amount of energy in terms of production, transportation of the materials and associated activities. Housing continues to be a basic need for human beings in view of rapid industrialization and urbanization. It is well known that the energy requirement of a building activity constitutes 1/3 of the total energy produced in the world. On average global economic activities are likely to increase by fivefold for a population increase by 50% and the corresponding increase in global energy consumption is likely to strike threefold. This increase in overall needs of building activity has resulted in shortage of supply of raw materials, exhaustion of energy resources leading to use of sustainable materials and strategies. Sustainable strategies begin with planning of building construction and continue throughout the estimated design life of structure and subsequent demolishing and recycling of resources to reduce the supply of materials. Consequently, the project development becomes inexpensive to build, sustains for a longer period with reasonable maintenance and ends with nature when abandoned. Engineers, designers, and architects involved in a construction project have a unique responsibility to plan, design and execute the works in order to mitigate adverse environmental impact through implementation of sustainable materials and technologies. Though, there is a growing concern in respect of optimizing the use of resources, still are accepted form of practice has not yet been developed in a comprehensive and coherent manner for use by practicing engineers. The topic of cost-effective construction materials for sustainable development is highly relevant in today's context due to its potential to address environmental concerns, economic efficiency, and resource scarcity while contributing to global sustainability goals and meeting market demands.

KEYWORDS: Low cost Construction Materials, Sustainable Development, Recycled Aggregate, Affordable Housing.

I. INTRODUCTION

In the realm of civil engineering, where the demand for infrastructure development is incessant, the judicious selection of construction materials plays a pivotal role in project success. As the global population burgeons and urbanization accelerates, the need for sustainable and cost-effective construction materials becomes more pressing than ever before. The construction industry is not only a major contributor to economic growth but is also a significant consumer of natural resources. Therefore, finding innovative ways to balance economic viability with environmental sustainability is imperative.

Cost-effective construction materials are instrumental in addressing the financial constraints that often accompany large-scale civil engineering projects. The economic efficiency of a project is inherently tied to the materials utilized, encompassing factors such as material production, transportation, installation, and long-term maintenance costs. By strategically incorporating cost-effective materials, engineers and project managers can not only enhance the overall economic viability of a project but also contribute to the broader goals of sustainable development. Furthermore, the impact of construction materials extends beyond the economic realm; it permeates the environmental and social dimensions of a project. The extraction, production, and disposal of traditional construction materials contribute significantly to carbon emissions and environmental degradation. Recognizing this, the engineering community is increasingly turning its attention to sustainable alternatives that minimize the ecological footprint of construction activities.

Low-cost housing is a novel idea that addresses clever financial planning, the use of techniques that reduce building costs by utilizing locally accessible materials, and the provision of improved expertise and technology all without sacrificing the robustness, functionality, or longevity of the structure. Low-cost housing is defined as housing that appears to be affordable for people making significantly less than the median pay. Three things will influence it: affordability, overall living space size, and income. As a result, it became crucial to build homes utilizing economical, innovative, and environmentally friendly methods while also maintaining their affordability. This research will look into how various building components can be made using locally sourced materials to give low-income clients more affordable options. Utilizing affordable housing building materials during the construction process can assist cut costs by 20% to 30% without sacrificing the strength, longevity, or other characteristics of the project. There is always a need in any overcrowded rural shelter because, as we already know, there are currently housing issues resulting from increased urbanization. there seems to be an increase in supply.

1.1. Climate Change and the Initiative of India

The climate system is warming, as evidenced by rising global average air and ocean temperatures, extensive melting of snow and ice, and rising global normal sea level, as documented by the Intergovernmental Panel on Climate Change in its recent release. Greenhouse gases released by man's ambition for progress are to blame for global warming and climate change, which has been identified as the greatest severe threat to human civilization. The largest contributor to Greenhouse Gases is carbon dioxide, which is created by the combustion of fossil fuels. CO₂ emissions from fossil fuels account for the majority of India's emissions.

According to World Bank research, the six countries that emit the most CO₂ into the atmosphere are the United States of America, China, the European Union, the Russian Federation, India, and Japan. India emits approximately 1.35 billion tons of CO₂, accounting for nearly 5% of total global emissions. India, a party to the Kyoto Protocol in 1992, has already taken several steps to achieve the goals of the United Nations Framework Convention on Climate Change (UNFCCC). The measures are already in place in industries such as coal, oil, gas, power generation, transportation, agriculture, manufacturing, and housing. Though emphasis has been placed on energy consumption in every possible sector, the emphasis is also on consumption reduction in various fields and rationalization of uses of energy-intensive systems, which will eventually contribute to our country's efforts in reducing Greenhouse Gases and mitigating global warming (Nilanjan Sengupta, 2008).

1.2. Current practices in sustainable material:

Concrete is a multipurpose, eco-friendly building material that can create structures that endure for millennia. Concrete is the second most consumed material on Earth, only surpassed by water, due to its wide range of applications. Global cement output is expected to reach 4.1 billion tons in 2021, while yearly concrete consumption is around seven times higher. Given that the construction sector has a significant environmental impact and uses a lot of concrete as a key building material, sustainability in concrete construction is crucial. Roughly 7–8% of the world's CO₂ emissions come from the production of Portland cement, a major ingredient in concrete.

This substantial carbon footprint has sparked growing worries about the sustainability of concrete building and sparked a global shift towards climate neutrality, along with the depletion of natural resources like water and aggregates. The need for additional housing and infrastructure is rising due to factors including population increase and rapid urbanization, which exacerbates the building industry's negative environmental effects. More sustainable concrete construction methods are desperately needed, as resource scarcity and climate change continue to be key obstacles. The building sector is actively investigating and introducing new environmentally friendly methods and materials in concrete construction as a reaction to these difficulties. This change intends to minimize resource use, increase the service life of structures, and lessen the environmental impact of concrete manufacture. Researchers, business leaders, and legislators are working together to create and advance cutting-edge technologies, materials, and approaches that can drastically cut down on the energy consumption, waste production, and carbon footprint of concrete building.

A growing number of construction companies are focusing on sustainability and developing eco-friendly techniques in response to growing worries about waste generation, resource depletion, and climate change. Using sustainable materials when building with concrete is a key component of this transition. As a result, a number of cutting-edge materials and technologies have been developed with the goal of improving concrete's performance and durability while lowering its environmental impact and adding to the built environment's overall sustainability. The phrase "green concrete" refers to a variety of concrete mixtures that include waste products, recyclable resources, and ecologically

beneficial ingredients. The objective of these formulations is to minimize the environmental impact of concrete building while simultaneously reducing the consumption of natural resources and carbon emissions related to cement manufacture. Using recycled aggregates, additional cementitious materials, and industrial byproducts like slag and fly ash are a few examples of green concrete ingredients that help create a more environmentally friendly concrete mixture. One more sustainable strategy that can help to lessen the impact on the environment while building with concrete is the use of locally sourced materials. Energy use and emissions associated with transportation can be greatly reduced by purchasing materials locally. Furthermore, regional materials frequently include special qualities that might improve the functionality and robustness of concrete constructions. Examples of locally sourced resources are natural fibers or aggregates, which can be used to make more affordable and environmentally friendly concrete mixtures, and limestone-calcined clay cement, which can partially replace conventional cement. A type of concrete called permeable concrete is made to let water pass through it, which lowers stormwater runoff and encourages groundwater recharge. Because it lowers the risk of flooding, enhances water quality, and mitigates the effects of urban heat islands, this novel material can be extremely important for sustainable urban development. Because permeable concrete can replace traditional stormwater management systems like gutters, drains, and retention ponds, it may also result in lower construction costs and maintenance needs. Another environmentally friendly substance that is intended to lessen the impact of concrete construction is cool concrete. This kind of concrete has elements that are light-colored or reflective, which can help reduce heat absorption and bring down the surface temperature of concrete buildings. By doing this, cool concrete can lessen the effects of urban heat islands and lower the energy needed by buildings to cool themselves. Furthermore, by reducing thermal stress and consequent cracking brought on by temperature variations, the usage of cool concrete might increase the longevity of concrete structures.

The highly developed cementitious composite known as Ultra High-Performance Concrete (UHPC) provides remarkable mechanical qualities, high strength, improved fire properties, and durability. Because of UHPC's improved performance, less material is required for a given project, which reduces the environmental impact of concrete building as a whole. Furthermore, the longer service life of concrete structures due to UHPC's greater resilience can mean less maintenance, repair, and replacement required. Because of its great strength and low permeability, this material also presents potential advances in building thermal performance and energy efficiency. To increase the sustainability, performance, and efficiency of structures, the concrete construction industry has been investigating cutting-edge technologies and techniques in addition to sustainable materials. The industry's continuous attempts to lessen its impact on the environment and improve the resilience of the built environment depend heavily on the adoption of these cutting-edge methods. Self-healing concrete is one example of an innovation; it contains ingredients or agents that allow the concrete to mend itself when it is damaged. With the use of this technology, constructions can last longer, require less care, and require less expensive repairs.

Reduced material consumption and waste production are achieved by using additive manufacturing techniques to precisely and efficiently build complicated structural components in 3D-printed concrete. Additionally, it makes it possible to design unusual geometries that would be difficult to do using conventional techniques. When exposed to sunlight, photocatalytic elements in concrete break down organic molecules and pollutants on the surface, enhancing air quality and creating a cleaner environment. This process is known as photocatalytic concrete. By combining the energy efficiency of high-performance insulation materials with the structural strength of reinforced concrete, insulated concrete forms improve thermal comfort and save energy in buildings. By substituting conventional fossil fuels in the cement production process with waste-derived fuels like biomass or industrial waste, greenhouse gas emissions and the overall carbon footprint of concrete building may be decreased. In concrete construction, electrification of machinery and trucks reduces emissions and noise pollution by eliminating the need for fossil fuels.

Electric motors, charging infrastructure, and battery technology have advanced to the point where this shift is possible. By storing and releasing thermal energy, phase change materials (PCMs) may be added to concrete to improve structural thermal performance and lower energy usage for heating and cooling. Technologies for carbon capture, utilization, and storage (CCUS) provide the potential to drastically cut the carbon emissions related to the manufacture of cement and concrete. CCUS technology can help lessen the impact of the concrete industry on climate change by collecting CO₂ released during the manufacturing process and either using it to produce new materials or permanently storing it in geological formations. The latest developments and prospects for environmentally friendly concrete building, with an emphasis on cutting-edge substances, methods, and equipment that might drastically lessen the negative effects of concrete use and manufacturing on the environment.

The study covers new developments in sustainable materials, such as green concrete and supplemental cementitious materials, as well as cutting-edge methods and technologies, like 3D-printed concrete, self-healing concrete, and concepts for carbon collection, utilization, and storage. The importance of incentives, policies, and research in advancing sustainable concrete building will also be covered in this presentation. This study is important since it identifies and examines novel technologies, sustainable materials, and concrete building processes. With regards to resource depletion, waste creation, and climate change, the construction industry is becoming increasingly concerned. This research adds to a comprehensive understanding of how to reduce environmental effect and improve built environment performance. This study is to assist the construction industry, academics, and policymakers in adopting more sustainable ways by assessing emerging trends and offering insights. This will eventually facilitate the transition towards a more resilient and environmentally responsible building sector.

II. LITERATURE SURVEY

Jain, A. K. et.al (2012); the article underscores the significance of comprehending a variety of materials and technological options for cost-efficient building construction while upholding performance characteristics, crucial for economical housing solutions. State governments, Building Centers, and the Building Materials Technology Promotion Council (BMTPC) have played notable roles in advocating low-cost housing technologies, resulting in considerable cost reductions in comparison to conventional construction techniques. Prefabricated roofing components have been effectively employed in extensive housing projects, leading to efficient construction and savings of 10 to 30 percent. The housing deficit in India, particularly for the economically disadvantaged segments, is a critical issue exacerbated by rapid population expansion, underscoring the immediate requirement for inventive and cost-efficient housing solutions.

A Moghayedi et.al (2023); the investigation examines the sustainability efficacy of innovative prefabricated construction methods (IPCMs) for affordable housing in Southern Africa. This fills a void in the assessment of IPCMs' sustainability within the region, utilizing the Sustainable, Innovative, Affordable Housing (SIAH) framework for calculating sustainability index scores. The research demonstrates that IPCMs surpass traditional methods and underscores the appropriateness of monolithic IPCMs for constructing net-zero carbon buildings. The article underscores the significance of continuous innovation adoption in sustainable affordable housing to tackle sustainability issues in Southern Africa. Recommendations suggest the utilization of sustainable construction techniques such as prefabrication, especially the monolithic system, to enhance insulation levels and overall sustainability performance in affordable housing initiatives.

A Manewa, et.al (2015); the study concludes that adaptable buildings are essential for the promotion of sustainability within the built environment. It emphasizes the significance of incorporating adaptability into building designs, highlighting the economic, environmental, and social advantages that adaptable buildings offer. Moreover, the research stresses the role of adaptability in addressing urban changes, reducing waste, and enhancing overall sustainability in the built environment. Suggestions put forward in the paper include focusing future research efforts on promoting adaptability through incentives, stakeholder involvement, and technological advancements to enhance building sustainability.

Bredenoord, J. et.al (2017); the conclusion underscores the durability of the building materials examined in the paper. The significance of considering local factors and regional contexts in the utilization of materials is underscored. The necessity for backing from institutions, advancement in technology, and expansion of sustainable materials is deliberated. The obstacles and constraints encountered in the implementation of sustainable building materials are acknowledged, alongside the involvement of aid organizations and governing bodies in surmounting these challenges.

Danso, H. et.al (2018); The study is wrapped up by summarizing the main criteria established for evaluating sustainable construction materials in terms of their environmental, social, and economic aspects. A total of twelve essential indicators, such as human toxicity, climate change impact, adaptability, and maintenance expenses, were highlighted as crucial for determining the sustainability of construction materials. It is recommended in the research that these indicators should be taken into account in future studies to improve the assessment of sustainable construction methods and advocate for environmentally conscious building materials. Through underlining the significance of these indicators, the study contributes to the progression of sustainable development within the construction sector and the encouragement of responsible material selections.

Aamir Hussain Malik et al. (2021); The idea of affordable housing places a strong emphasis on cost-cutting strategies and budgeting while utilizing locally sourced materials, enhanced labor, and cutting-edge technology all without sacrificing the longevity, performance, or strength of the structure. It makes clear that affordable housing doesn't have to be of inferior quality; rather, it just calls for careful resource management and a delay in completion projects. There includes discussion of sustainable building methods such as mud floors, rammed earth walls, Trombe walls, and rat trap bonds. Earthen building systems research highlights the need for well-designed, long-lasting, and ecologically responsible building practices.

Vishal Kumar S D et al. (2019); the study examines affordable building materials and design strategies with an emphasis on the financial and environmental advantages of such approaches. AAC blocks and fly ash concrete are contrasted with more traditional materials like cement concrete and burned clay bricks. By employing both traditional and alternative materials, a duplex's cost is estimated, showcasing possible cost reductions. The research findings indicate that the utilization of substitute materials such as AAC blocks and HVFAC can result in a about 26.03% decrease in the overall project cost.

Vivek Kumar et al. (2017); the study examines various building design materials and methods, with an emphasis on affordable and ecologically sustainable solutions. It emphasizes the use of fly ash bricks, which are stronger and more affordable than traditional clay bricks, as a sustainable substitute. The study highlights how incorporating industrial waste, such as fly ash, in building may help the environment by lowering pollution and waste of land. Citations are made to several tests that demonstrate the great compressive strength and potential use of fly ash bricks as a construction material.

U. J. Phatak et al. (2014); the article addresses methods and supplies for building at a lower cost without sacrificing durability or strength. It illustrates substantial cost reductions in walling and roofing when low-cost housing technologies are compared with conventional approaches. emphasizes the use of sustainable building methods and locally accessible resources to provide affordable homes. includes Indian case studies that illustrate the financial advantages of low-cost housing technology.

S. Chavan et al. (2019); the focus lies on the significance of incorporating eco-friendly construction practices and utilizing cost-effective building materials to increase the accessibility of housing for low-income populations. The utilization of non-traditional construction materials is proposed as a means to lower construction expenses, mitigate material scarcity risks, and improve energy efficiency within buildings. The primary objective of the study is to explore a variety of construction materials and methodologies, specifically examining cost reduction techniques such as Rat Trap Bond and Filler Slab. Through an examination of these approaches, the aim is to pinpoint effective strategies for reducing construction costs while upholding structural stability and environmental friendliness. The emphasis placed on Rat Trap Bond and Filler Slab highlights the importance of innovative methods in realizing affordable and long-lasting housing solutions. The methodology section introduces the Rat Trap Bond method, a technique in brick masonry that introduces voids in walls to enhance thermal insulation and cost-effectiveness.

A Kurup et al. (2018); Researchers suggest the substitution of traditional materials with economical alternatives such as Laterite stone in wall construction to decrease building costs. In addition to the utilization of cost-effective materials, approaches like minimizing waste and streamlining processes can play a role in providing affordable housing solutions. The acceptance and trust of consumers in the market are crucial factors influencing the adoption of different techniques and materials, underscoring the significance of selecting materials that instill confidence. The final analysis emphasizes the necessity of efficient planning, consumer trust, and market feasibility in the implementation of affordable housing solutions to tackle the housing deficit in India.

D. B. Tapkir et al. (2016); The significance of affordable housing for low-income households and its influence on their quality of life is emphasized. The study's approach includes an extensive examination of large-scale projects to evaluate different construction methodologies. This involves a thorough investigation of traditional, prefabricated, and alternative construction techniques to determine their financial and temporal impacts. Additionally, the methodology integrates on-site assessments and field surveys to grasp the obstacles and possibilities in constructing low-cost housing. The findings and conversations may provide insights into the financial and temporal ramifications of the various techniques under examination. This segment is essential for comprehending the real-world implications of the research outcomes on low-cost housing construction.

Joygopal Jena et al. (2020); The segment delineates the essential materials essential for the production of the innovative bricks, emphasizing the straightforwardness of the procedure utilizing earth, fly ash, and water. It establishes the groundwork for the manufacturing process by specifying the crucial elements required to produce the Fly-ash enriched earthen bricks for economical housing. The findings section showcases the compressive strength of the Fly-ash enriched earthen bricks as tested in the laboratory, confirming their appropriateness for construction purposes. By conducting thorough examinations, the study assesses the bricks' performance, delivering valuable insights into their mechanical characteristics and structural soundness.

Malysa, T. (2023); the paper examines the legal definitions of workplace accidents, the importance of occupational health and safety management systems, and the crucial role of top management in promoting workplace safety. The study's methodology involved analyzing statistical data from Statistics Poland spanning from 2006 to 2021 to assess the relative risk within the construction sector. Various hypotheses were developed, and statistical tests were carried out to validate the risk levels across different categories. Predictive models such as Brown double exponential smoothing and Winters' model were applied to predict relative risk values for the years 2022 to 2024. The conclusions emphasize the importance of continuous efforts to mitigate accident risks in construction and the effectiveness of using econometric models for forecasting relative risk patterns. The research offers insights into the efficacy of safety protocols and the necessity for ongoing enhancements in occupational health and safety practices to uphold secure working environments.

III. PROBLEM DEFINITION

The identification 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. In addition, the project will investigate digital technologies for waste reduction and material optimisation, as well as sustainable manufacturing and construction practices. The project intends to discover best practices and region-specific difficulties by evaluating global and local case studies, considering the opinions of diverse stakeholders such as local people, government, and the construction sector.

Along with suggestions for training programmes to instruct professionals and students, the initiative will also create recommendations for the use of economic and ecological materials. By examining the economic, environmental, and social elements of construction methods, the project's overall goal is to give a thorough knowledge of how affordable building materials may support sustainable development.

Objectives:

The proposed work is based on the following objectives.

1. To study in details the existing scenario of cost-effective construction material.
2. To identify various cost-effective construction materials considering sustainability.
3. To evaluate different benefits of these materials against conventional materials.
4. To differentiate methodology and advantages in construction using cost effective Sustainable material.
5. To discuss the cost benefit ratio against conventional construction.

IV. METHODOLOGY

4.1. Material selection:

Nowadays wide range of low-cost construction material is available in construction industry. Perhaps the use of such material depends on various aspects as many researchers suggested in their studies. This study targets such materials which are easily available, durable, reliable and sustainable. Through the literature study it was observed that variety of material used in construction as per the suitability and purpose of intended use. Furthermore, keeping in mind, the scope of study following materials were selected for the study.

1. Fly Ash Enriched Earthen Un-Burnt Bricks
2. Aerocon Blocks (Autoclaved, Aerated Concrete Blocks)
3. M-Sand (Manufactured sand)
4. Glass Sand
5. Bagasse-PVC Boards.

6. Gypsum Area Separation Wall
7. Concrete using Copper Slag, Phosphogypsum.
8. Concrete using Construction Waste Residue and Asbestos Fiber
9. Steel with Specific Chemical Composition
10. Reclaimed Steel (Recycled)
11. Glass Fibre Reinforced Polymer (GFRP)
12. Bamboo

4.2 Overview, Properties and applications of material:

1. Fly Ash Enriched Earthen Un-Burnt Bricks:

Fly ash bricks are made up with combination fly ash, Lime and gypsum. They are molded into the shape of brick without need for baking. It utilizes industrial waste and reduces environmental impact. This type of bricks gives high compressive strength, better insulation and lower water absorption. Particularly suitable for the construction of load bearing and non-load bearing partition walls in low-cost housing projects.

Properties of Fly Ash Enriched Earthen Un-Burnt Bricks:

Compressive strength ranges from 3 MPa to 10 MPa, Density ranges in between 1800 kg/m^3 to 2000 kg/m^3 , water absorption is less than 20 % with low thermal conductivity.

2. Aerocon Blocks (Autoclaved, Aerated Concrete Blocks):

Aerocon blocks are lightweight precast concrete which is mixture of cement, lime, sand and aluminum powder with autoclave process. These are light in weight so easy to handle on site with excellent thermal and acoustic insulation also provides fire resistance. Preferably used in construction of internal and external walls of high-rise buildings.

Properties of Aerocon Blocks (Autoclaved, Aerated Concrete Blocks):

Compressive strength ranges from 3 MPa to 5 MPa, Density ranges in between 600 kg/m^3 to 800 kg/m^3 , thermal conductivity is in range 0.16 to 0.20W/mK with water absorption 5% to 20 %.

3. M-Sand (Manufactured sand):

M-sand is a substitute material widely used in industry for river sand, it produced by crushing hard large stones comes with consistent quality and gradation which mainly reduces the exploitation of river sand also helps to increase strength and durability of concrete.

Properties of M-Sand (Manufactured sand):

Particle size ranges from 150 micron to 4.75 mm, Specific Gravity between 2.5 to 2.9, Fineness Modulus 2.6 to 3.6 with Moisture Content between 2 % to 6 %.

4. Glass Sand:

Glass sand is derived from crushing of recycled glass waste material, finely crushed to be used as fine aggregate in construction. As it is derived from waste material it reduces landfilling burden in large extent. It gives good strength, durability and better aesthetics to concrete surfaces.

Properties of Glass Sand:

Particle size ranges from 0.1 to 4.75 mm, Hardness 6 to 7 on Mohr's Scale, Specific Gravity between 2.4 to 2.8, colour Transparent to white

5. Bagasse-PVC Boards:

Bagasse-PVC Boards are composite material made from bagasse which is agriculture waste and Polyvinyl Chloride (PVC) manufactured by squeezing out the mixture into board form. It is Termite and water resistant also lightweight, ecofriendly, sustainable and easy to install mostly used for decorative purposes.

Properties of Bagasse-PVC Boards:

Flexural strength ranges from 10 MPa to 15 MPa, Density ranges in between 550 kg/m^3 to 700 kg/m^3 , low thermal conductivity with water absorption less than 2%.

6. Gypsum Area Separation Wall:

These are fire resistant panels made from gypsum panels. Due to high fire resistivity capacity, it is used as fire barriers between two adjacent units. also provides sound insulation property due to which it is used in theaters and auditoriums.

Properties of Gypsum Area Separation Wall:

Compressive strength ranges from 5 MPa to 10 MPa, Density ranges in between 700 kg/m^3 to 800 kg/m^3 , high Fire Resistance and low thermal conductivity.

7. Concrete using Copper Slag, Phospogypsum:

In concrete copper slag is used as partial replacement of sand and Phospogypsum as partial replacement of cementitious materials. As these replacements are byproducts of industry it reduces environmental impact. It gives high strength and durability to concrete with improved workability. Mostly used in marine structures.

Properties of Concrete using Copper Slag, Phospogypsum:

Compressive strength ranges from 20 MPa to 40 MPa, Density ranges in between 2300 kg/m^3 to 2500 kg/m^3 . Workability is good and high Durability.

8. Concrete using Construction Waste Residue and Asbestos Fiber:

In such concrete waste residue and asbestos fiber is used to enhance the properties of concrete. It reduces construction waste. Used in pathways and road construction.

Properties of Concrete using Construction Waste Residue and Asbestos Fiber:

Compressive strength ranges from 20 MPa to 30 MPa, Density ranges in between 2300 kg/m^3 to 2500 kg/m^3 . Workability is moderate and high Durability.

9. Steel with Specific Chemical Composition:

Steel is manufactured specially with specific chemical composition which will improves strength and corrosion resistance. Which helps steel to improve the durability and reduces frequent maintenance.

Properties of Steel with Specific Chemical Composition:

Yield strength ranges from 250 MPa to 450 MPa, Tensile strength ranges from 400 MPa to 650 MPa, Density 7850 kg/m^3 , thermal conductivity 0.50 W/mK .

10. Reclaimed Steel (Recycled):

It is recycled steel obtained from demolished structures and scrap material reprocessed and reused in construction. As compared to new steel its cost is less with comparable strength and durability. Ecofriendly which reduces need of new steel production used in prefabricated construction products.

Properties of Reclaimed Steel (Recycled):

Yield strength ranges from 250 MPa to 450 MPa, Tensile strength ranges from 400 MPa to 600 MPa, Density 7850 kg/m^3 , corrosion resistance moderate to high (depending on treatment).

11. Glass Fiber Reinforced Polymer (GFRP):

It is composite material made of glass fibers embedded in polymer matrix, also known for lightweight, high strength, durability, corrosion resistance and less maintenance properties.

Properties of Glass Fiber Reinforced Polymer (GFRP):

Tensile strength ranges from 600 MPa to 1200 MPa, Flexural strength ranges from 700 MPa to 1000 MPa, Density 1.8 to 2.0 g/cm^3 and low thermal conductivity.

12. Bamboo:

Bamboo is fastest growing renewable resources which is used as an alternative to timber in construction due to its high tensile strength comparable to steel and flexibility.

Properties of Bamboo:

Tensile strength ranges from 100 MPa to 400 MPa, Compressive strength ranges from 40 MPa to 80 MPa, Density 600 to 800 Kg/m³ and low thermal conductivity.

V. CONCLUSION

This study focused on evaluating cost-effective construction materials through the lens of sustainability and economic efficiency. This study offers understanding of how low-cost materials can be leveraged in construction projects to achieve sustainable development goals. Structural consultants and architects emerged as the most influential professionals in selecting construction materials, underscoring the importance of their role in promoting sustainable practices. M-Sand (Manufactured sand) and Aerocon Blocks were consistently ranked as the top materials for their economic and environmental benefits. Their frequent use and strong performance highlight their viability as primary alternatives to traditional materials. Materials such as Glass Fibre Reinforced Polymer (GFRP), bamboo, and fly ash-enriched bricks demonstrate promising applications, aligning with sustainability objectives. The study identified key barriers to adopting low-cost materials, including high costs, lack of demonstration projects, and insufficient design information. Professionals indicated a shortage of skilled labor and a lack of regulation as significant challenges, emphasizing the need for industry-wide education and policy support to facilitate broader adoption. Economic benefits and the drive for innovation were the primary reasons professionals chose low-cost materials, indicating that cost savings and technological advancement are critical motivators. Improved health and safety and client requirements also influenced material selection, reflecting a balance between financial considerations and project-specific needs. The study identified that more environmentally conscious construction professionals and training on alternative materials are crucial developments needed to encourage greater use of low-cost materials. Demonstration projects and reductions in material costs were also highlighted as vital factors that could drive industry transformation. Low-cost materials were found to perform well across various environmental conditions, with professionals expressing a likelihood to recommend their use based on personal experience. The study highlighted the importance of long-term maintenance, cost savings, and the aesthetic impact of these materials, suggesting that they can meet safety standards while providing quality construction.

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