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Use of Sustainable Materials and Technologies in Construction Practices

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***Abstract*: Rapid urbanization in India is causing major environmental issues in the building sector. Increased demand for residential housing units leads to increased use of energy, resources, and raw materials, resulting in an increase in carbon footprint. All metropolitan cities are already dealing with environmental challenges including changing weather patterns and ecological devastation. The answer rests in long-term development that employs environmentally friendly materials and technology. Sustainable development is defined as meeting current demands without jeopardizing future generations' ability to fulfil their own requirements. This article elaborates on the notion of sustainable development, which has gained prominence in the recent two decades. This progress is possible because to the use of environmentally friendly construction materials and technologies. The notion acknowledges that human civilization is an inherent component of the natural world, and that nature must be conserved and perpetuated in order for the human society to survive. Sustainable development expresses this concept via designs that embody conservation principles and urges us to use such principles in our daily lives. A different approach to traditional design is required for sustainable development. Every material and technology decision must be evaluated for its influence on natural and cultural resources in the local, regional, and global habitats.**

***Keywords*: Sustainability, Sustainable materials, Sustainable technologies, Life cycle designing, Conservation, CO2 emission.**

1. Introduction

The built environment and construction sector are brought into sharp focus by the aim of sustainable development. The building sector is a well-known fact that contributes significantly to socio-economic growth in most nations. According to statistics, the construction sector accounts for more than half of total national capital investment and up to 10% of G.N.P. in every country. Buildings, for example, account for more than 40% of overall energy consumption in the European Union, and the construction industry is projected to create almost 40% of all manufactured garbage.

Globally, the development of sustainable building has become a major topic of policy, research, and innovation. The formation of institutions by the IGBC, the TERI introduction of LEED, and the TERI-GRIHA are examples of green building movements in India.

Sustainable development makes use of locally accessible, energy-efficient, and long-lasting building materials. It allows the building's occupants to live in healthy, pleasant circumstances for the duration of the building's life cycle. Material manufacturing, construction planning, design, construction, operation, and maintenance procedures are all part of the life cycle.

The goal of sustainability is to accomplish efficient resource utilization, such as energy, water, and construction materials, while minimizing the impact of buildings on the environment. However, due to the complexities of sustainability and the dispersion of the building sector, the usage of sustainable construction approaches is currently limited.

2. What is Sustainability

Addressing our own needs without risking future generations' capacity to satisfy theirs is what sustainability means. We also require social and economic resources in addition to natural resources. Long-term viability isn't just determined by environmental management. Concerns about social fairness and economic success are common themes in most definitions of sustainability.

3. What is the Origin of the Term Sustainability?

While the phrase "sustainability" is relatively new, the movement as a whole has roots in social justice, environmental protection, internationalism, and other long-standing issues. Many of these ideas had converged under the banner of "sustainable development" by the end of the twentieth century.

4. What does Sustainability Impacts On?

In general, sustainability has an influence on society, the environment, and the economy.

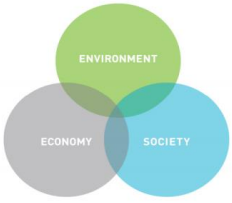

Fig. 1. Conceptual diagram for impacts
(Source: https://www.prakati.in/wp-content/uploads/triple-bottom-line-approach-Three-pillars-of-Sustainability-1.png)

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5. Why Sustainability

The reasons for sustainability can be complex, personal, and varied. It's difficult to list all of the reasons why so many people, organizations, and communities are working toward this goal.

However, for the vast majority of people, sustainability is defined by our legacy to future generations. Sustainability is important to many people and organizations, as seen by their policies, daily activities, and habits.

Individuals have had a significant impact on the evolution of our current social and environmental environments.

Today's citizens, as well as future generations, must devise and implement solutions like those depicted in fig. 2.

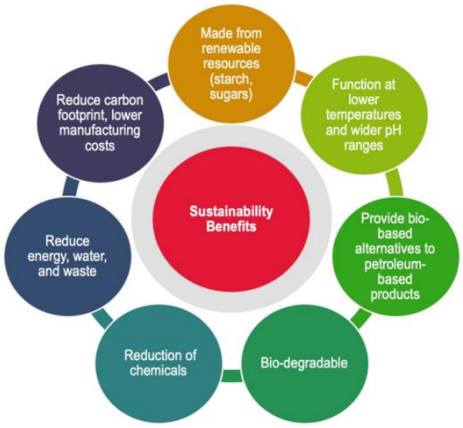

Fig. 2. Benefits of sustainability
(Source: https://www.enzymetechnicalassociation.org/wp content/uploads/2020/10/sustainabilitybenefits-lg.jpg)

6. Why Sustainability in Construction

"The discipline of creating structures and using techniques that are ecologically responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation, and deconstruction," according to the Environmental Protection Agency.

In layman's terms, sustainable construction is a method of constructing structures and establishments that protects the natural environment and decreases the process' environmental impact by using non-toxic materials and ecological resources.

7. Use of Sustainable Materials in Construction

A. Bamboo

Fig. 3. Bamboo as a sustainable material
(Source: https://www.conserve-energy-future.com/sustainable-construction-materials.php)

Bamboo is often regarded as one of the most environmentally friendly construction materials on the market. It self-generates at a breakneck speed, with some examples reaching three feet in less than 24 hours. It doesn't need to be replanted after harvest since it spreads and thrives. Except for Europe and Antarctica, bamboo is a perennial plant that grows on every continent. It also offers a greater strength-to-weight ratio than concrete and brick, as well as a longer lifespan than concrete and brick. As a result, it is the most suitable material for cabinets and flooring. Unfortunately, bamboo must be treated to protect it from insects and decay. Bamboo possesses a starch that attracts insects, and if left untreated, it can swell and break after absorbing water.

B. Precast Concrete Slab

Fig. 4. Precast concrete slab as a sustainable material
(Source: https://www.conserve-energy-future.com/sustainable-construction-materials.php)

The slabs are produced at a factory and delivered to building sites in entire chunks. Concrete blocks, for example, are totally formed of concrete yet include huge air holes. Precast concrete slabs are commonly used for walls and building facades due to their weather durability, while others can be used for floors and flat roofs. Concrete is a low-cost building material that may be used to regulate the temperature within a structure.

Because they take less energy to make and construct, precast concrete slabs are more ecologically friendly than many other concrete solutions. Instead of being exposed to a range of unfavourable weather conditions while curing on a building site, precast concrete allows the material to cure correctly in a controlled environment. As a result, precast concrete slabs avoid concrete fractures, structural flaws, and damage.

C. Cork

Fig. 5. Cork as a sustainable material
(Source: https://www.conserve-energy-future.com/sustainable-construction-materials.php)

Cork, like bamboo, is a fast-growing plant. It might potentially originate from a living tree that is still producing cork, which is a type of tree bark. Cork is a strong, flexible material that, even when exposed to constant pressure, returns to its original shape. It is commonly used in floor tiles due to its

durability and resistance to wear. It also absorbs sound well, making it ideal for insulation sheets and sub-flooring. It's also a good thermal insulator since it's fire resistant, especially when left untreated, and produces no toxic pollutants when burned. Cork is almost non - porous and does not deteriorate. It's only accessible in the Mediterranean, which makes it prohibitively pricey.

D. Straw Bales

Fig. 6. Straw Bales as a sustainable material
(Source: https://www.conserve-energy-future.com/sustainable-construction-materials.php)

Another eco-friendly building material that may be used for framing is bamboo. They may be used as a soundproofing material and provide good insulation. It may also be used as a fill material between columns and in the framework of beams, and it has some fire-resistant properties since it does not allow air to get through. Straw may be easily harvested and replanted with little environmental impact. The impact of turning straw into bales is insignificant. They may also be used to keep the house cool in the summer and warm in the winter by being put in walls, attics, and ceilings.

E. Recycled Plastic

Fig. 7. Recycled Plastic as a sustainable material
(Source: https://www.conserve-energy-future.com/sustainable-construction-materials.php)

Instead of sourcing, mining, and milling new components for construction, manufacturers are using recycled plastic and other ground-up trash to produce concrete. Rather of filling landfills and contributing to plastic pollution, this strategy minimizes greenhouse gas emissions while also providing a new purpose for plastic waste. Polymeric timbers, which are constructed from a combination of recycled and virgin plastic, are used to construct fences, picnic tables, and other structures while also helping to save trees. Plastic from two-liter bottles may be spun into fibre and used to make carpets. Recycled plastic may be used to make cable pipes, roofs, floors, PVC manholes, and PVC windows.

F. Reclaimed Wood

Fig. 8. Reclaimed Wood as a sustainable material
(Source: https://www.conserve-energy-future.com/sustainable-construction-materials.php)

Salvaged wood is one of the most environmentally responsible ways to save trees and reduce the amount of wood in landfills. Reclaimed wood may be discovered in a variety of areas, including abandoned barns, excavation businesses, home remodeling contractors and enterprises, salvage yards, and shipping crates and pallets. Reclaimed wood is suitable for structural structure, cabinetry, and flooring. It's light, but it's frail, and each piece's integrity should be assessed before it's utilized in a project. Additionally, all type of wood is susceptible to insects and deterioration, demanding treatment and reinforcement.

G. Reclaimed or Recycled Steel

Fig. 9. Reclaimed Steel as a sustainable material
(Source: https://www.conserve-energy-future.com/sustainable-construction-materials.php)

Steel can be used in replacement of wood in the framing process, increasing the structure's earthquake and wind resistance. It takes around 50 trees to build a 2,000-square-foot house, but a recycled steel frame only requires the steel equivalent of six scrapped automobiles. Steel is 100% recyclable, reducing the environmental impact of new construction. Aluminum and steel products require a lot of energy to mine, heat, and shape, but appropriately and successfully reusing or recycling them into new products saves energy and makes the material more sustainable. Recycled metal lasts a long time and does not require replacement on a regular basis.

Because it does not burn or shred, it is perfect for roofing,

building facades, and structural support. Water and bugs aren't a problem for recycled steel.

H. Plant Based Poly-urethane Rigid Foam

Fig. 10. Plant based Poly- Urethane Rigid Foam as a sustainable material (Source: https://www.conserve-energy-future.com/sustainable-construction-materials.php)

Rigid foam has long been used in building as a kind of insulation. It was first employed when the EPA fined and pushed a major surfboard material manufacturer out of business for using a harmful ingredient. Bamboo, kelp, and hemp-based polyurethane rigid foam were used to create the new surfboard material, which has revitalized the surfboard business. It's now employed in a range of sectors, including turbine blade manufacturing and furniture manufacturing. The material may be used as insulation since it is rigid and unyielding. Mold and vermin are also kept at bay by this product. It may also be used as sound insulation and is heat, mould, and insect resistant.

I. Sheep's Wool

Fig. 11. Sheep's Wool as a sustainable material (Source: https://www.conserve-energy-future.com/sustainable-construction-materials.php)

Sheep's wool is a great alternative to chemical-based insulation. It provides the same level of insulation as standard insulation while using less energy. Sheep's wool can save you money on power while also soundproofing your home. Sheep's wool is more common, simpler to collect, and regenerates quickly than other insulating materials like straw, and when compared to some natural insulators like cotton, it is more common, easier to collect, and regenerates quickly. Regrettably, it isn't the most cost-effective insulator on the market. To keep flies out and fungus from forming, it must also be treated. This treatment may make sheep's wool less eco-friendly, depending on the chemicals used.

J. Hempcrete

Fig. 12. Sheep's Wool as a sustainable material (Source: https://www.conserve-energy-future.com/sustainable-construction-materials.php)

The woody core fibres of the hemp plant are used to create a concrete-like product. To make strong and light concrete-like forms, the fibres are bound with lime. Because hemp concrete bricks are light, they take less energy to transport. Hempcrete is a fire-resistant, long-lasting material that is also thermally and acoustically insulating. The fact that it is CO2 negative, meaning it absorbs more CO2 than it emits, is its most important sustainable attribute. In and of itself, hemp is a rapidly developing, renewable resource.

K. Mycelium

Fig. 13. Mycelium as a sustainable material (Source: https://www.conserve-energy-future.com/sustainable-construction-materials.php)

It is made entirely of natural materials. Mycelium, a natural unicellular organism, forms the root system of fungus and mushrooms. It might be induced to grow around a composite of natural materials, such as ground-up straw, in moulds or forms. After that, the lightweight and durable bricks or other shapes are air dried. When coupled with pasteurised sawdust, mycelium can be moulded into almost any shape and used as a surprisingly robust building material. It's possible to make sturdy, lightweight bricks and construction elements in unique designs. The mushroom-based building material offers a natural and biodegradable alternative to housing insulation, Styrofoam, and even concrete since it can withstand extreme temperatures.

L. Ferrock

It's a new material that uses recycled resources such as steel dust from either the manufacturing sector or ferrous stone left over from manufacturing processes that otherwise would have been discarded. It creates a building material that resembles

concrete but is more sturdy than concrete. It holds and absorbs co2 from the atmosphere during the curing and stiffening process. As a consequence, ferrock emits much less CO2 than conventional concrete and is carbon neutral. It may be mixed and poured to create roads, stairwells, walkways, and other buildings, and it's a good substitute for cement. Several experts claim that ferrock is more weatherproof than concrete.

Fig. 14. Ferrock as a sustainable material
(Source: https://www.conserve-energy-future.com/sustainable-construction-materials.php)

M. Timber Crete

Fig. 15. Timber Crete as a sustainable material
(Source: https://www.conserve-energy-future.com/sustainable-construction-materials.php)

This one-of-a-kind building material is made up of sawdust and cement. It has a lower density than concrete and produces fewer emissions during shipping. Sawdust is another recyclable waste material that may be utilised to substitute a few of the emission components of conventional concrete. Timber concrete may be used to make traditional shapes like pavers, bricks, and blocks.

N. Terrazzo

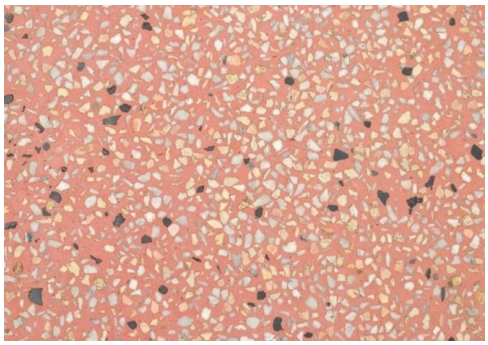

Fig. 16. Terrazzo as a sustainable material
(Source: https://www.conserve-energy-future.com/sustainable-construction-materials.php)

In this mosaic form of flooring, little bits of marble or granite are embedded in concrete floors or epoxy resin. When properly maintained for, terrazzo flooring may last up to four decades without losing its brilliance. The initial terrazzo was set in cement and was inspired by twentieth-century Italian designs. 90% of today's terrazzo flooring are made with epoxy resin. Terrazzo & Marble Distribution Company, for example, creates 'forever flooring' from brass, aluminium, & zinc, and also reclaimed glass, beer bottles, marbles, and porcelain, in their patented epoxy.

Carpets must be replaced, even if terrazzo floors are much more costly than carpets. Terrazzo, but at the other end, is a long-lasting construction material capable of lasting roughly 4 decades. You may also pick the colour and design of your floor before pouring the terrazzo. It creates easy-to-clean floors that may be used in high-traffic places like as school, airports, and stadiums.

O. Fly Ash Bricks

Fig. 17. Fly Ash Bricks as a sustainable material
(Source: https://5.imimg.com/data5/GQ/TD/MY-459066/fly-ash-brick-500x500.jpg)

Fly ash, lime, gypsum, and sand are used to make fly ash bricks. Fly ash, cement, sand, and water are mixed together. Mortar is poured into the moulds. For a total of 28 days, the product was dried at room temperature and under pressure. After removing the moulds, acquire fly ash bricks. There is virtually no breakage during transit and usage due to the great strength. Water seepage through brickwork is significantly decreased due to lesser water penetration. Without a lime plaster base layer, gypsum plaster (POP) could be placed straight to these bricks. There is no need to soak these bricks in water for 24 hours. A little sprinkle of water before usage is sufficient. The structural bonding strength is poor, although this can be improved by including marble debris. It has a size restriction. Only modular sizes are available. Cracks and breaks will occur as a result of the larger sizes.

P. Siporex

Siporex blocks are lighter and heat resistant pre-cast AAC blocks. They're used in construction projects that demand a high level of thermal insulation and temperature resistance. Other term for them is cellular concrete. Siporex blocks have now been employed as the major construction element in some of the nation's largest and most complex projects. They have a really fair pricing policy.

Superior characteristics and performance. Building material that is environmentally friendly. Performance and construction speed are improved. Ensures that the building is cost-effective. Siporex blocks are industry-leading building materials that may

be utilized in residential, industry, and infrastructure projects. Their innovative manufacturing techniques allow them to make long-lasting AAC blocks while adhering to green manufacturing standards for long-term production.

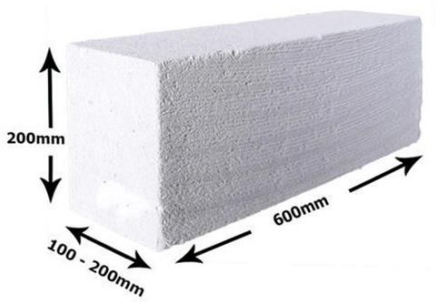

Fig. 17. Fly Ash Bricks as a sustainable material
(Source: https://5.imimg.com/data5/WM/JU/MY-64436943/siporex-fly-ash-block-500x500.jpg)

8. Use of Sustainable Technologies in Construction

A. Water Storage Systems (Recycled water, reusable water etc.)

Using low-water appliances, toilets, and faucets, recycling grey water (water produced by sinks, showers, and laundry), and removing irrigation are all examples of this. Instead of being dumped into the municipal sewer system, recycled grey water can be utilized to irrigate the landscape.

Flush Toilets: These specialized water-saving toilets use 10 to 15 litres every flush, and some specialist flush systems save up to 90% more water than standard toilets.

Toilets Composting: These have the potential to cut waste volume by 90%. Human wastes breakdown into nutrient-rich fertilizer when combined with enough plant matter (i.e., kitchen leftovers, garden wastes, etc.) and exposed to adequate air.

Heating of Water: All cold and hot water pipelines should be insulated. To reduce heat loss into the floor, a bottom board can be put beneath the heater. A timer can be fitted on the tank to turn it off automatically at night when no hot water is required, or a tank less or "demand" heater can be utilized. Solar energy can be utilized to complement the needed energy intake.

Heating of solar Water: In this system, solar panels gather heat from the sun and transfer it to copper coils containing a glycol solution. To supply heat to the water tank, the coils pass to a heat exchanger. Insulate the water tank, insulate the interior/exterior plumbing, install water-saving fixtures, and decrease the thermostat setting to reduce energy usage. Solar Water Heating Systems: The majority of solar water heating systems employ flat plate collectors that are oriented toward the sun.

Closed Loop Systems

a) Thermo siphoning.
b) Open Loop Systems.
c) Drain Back Systems.
d) Batch Heater Systems

B. Heating, Cooling, and Ventilation

There is a drive in this new technology to use an integrated mechanical system. This implies that room heating and cooling, water heating, ventilation, and heat recovery are all integrated into a single system. Furthermore, to maintain excellent indoor air quality, energy efficient airtight houses require a ventilation system. Space heating, water heating, passive solar storage, heat recovery from grey water, and partial cooling are all provided by the mechanical system. It uses a heat recovery pump to transfer heat from an ice water storage tank to a hot water tank. Heat is recovered from the frozen water and sent to the hot water tank in the winter. A fan coil unit is used to meet the space heating needs.

C. Indoor Air Quality

Controlling pollutants at their source is the greatest technique for improving indoor air quality. Select low-emission materials,Plants as Environmental Air Cleaners are two sustainable ways to improve indoor air quality.

D. Use Sustainable Building Materials

If you want to create a green home, you should consider choosing ecologically or eco-friendly items that will lessen the impact of construction on the environment. Roofing materials, structural materials, cabinets, counter tops, and insulation, as well as flooring, should all be ecologically friendly. Use recovered lumber, recycled plastic, recycled glass, or natural items made of natural, renewable resources such as bamboo, cork, and linoleum.

E. Cold Roofs

A cold roof is a roof designed to maintain a lower surface temperature in bright sunshine than a traditional roof. The surface of a cool roof reflects more sunlight and releases more heat than a so-called hot or dark roof.

F. Zero-energy Buildings

Zero-energy buildings are constructed and engineered to rely on renewable energy sources such as solar and wind power to run independently of the electric grid. This environmentally friendly solution not only saves electricity but also reduces greenhouse gas emissions. Solar cells and panels, wind turbines, and biofuels, among other things, are used to meet the building's electrical and HVAC demands in a zero-energy design.

G. Rammed Earth

It's a technology that's been around for thousands of years and has a lengthy shelf life in human history. Compacting natural materials such as chalk, earth, gravel, or lime is a typical and cost-effective way of making strong foundations, floors, and walls. It makes concrete-like walls when pressed forcefully into wooden shapes. In rammed earth constructions, the inclusion of rebar or bamboo makes them safer or more strengthened. The use of a mechanical tamper can significantly reduce the time and effort required to construct solid walls. Thermal storage may be accomplished with rammed earth walls and floors, which allow the sun to warm them during the day and slowly release the warmth during the colder hours.

9. Discussion

The importance of materials in ensuring long-term sustainability is emphasized. Reducing the energy required to run buildings (lifetime energy), reducing the high level of waste in construction, utilizing wastes to make construction materials, reducing emissions during the production of building materials, sequestering carbon by using carbon-containing materials, and building with more durable materials are all suggested as ways to make the construction industry more sustainable. Any of these strategies have no economic downsides, and some, such as lowering embodied energy, are plainly cost-effective. All of this is fuelled by technical advancements, notably in the field of materials. Materials are critical to the built environment's sustainability, and inventive new materials will enable architects and engineers to create structures that are more valuable to use, live in, and look at, as well as healthier and more sustainable. Technology can help us attain a far higher level of sustainability by allowing us to reduce, reuse, and recycle at a lower cost.

10. Future Scope

Solar panels, Integrated HVAC & Electrical systems, and other technologies perform better as a result of technological improvement in the field of automation with greater levels of microprocessor based controlling systems. In the framework of the Indian scenario, new experiments with the use of agro-waste as a sustainable construction material should be investigated. Non-traditional materials for a sustainable building material can be explored, as might a bio-construction system reinforced with cellulose fibers. Meta-kaolin + lime + hemp hurds + waste paper pulp in place of standard concrete is an example of such a system. An integrated design method is used in a digital computer-based sustainable design tool for building material usage for a specific construction project. This entails doing a Life Cycle Analysis using a Computer Aided Design model. The problem, however, does not have a correct/optimal solution due to current technology limits. Such technologies may be fine-tuned with algorithm improvements and more realistic data for the analysis engine. It will alter the current landscape of architectural design.

11. Conclusion

Locally made or obtained construction materials are considered sustainable. These materials are made up of recycled and industrial waste materials, as well as industrial byproducts. Sustainable materials have a lesser environmental effect and are more energy efficient. When compared to modern or traditional construction materials, these building materials consume significantly less energy in their manufacture.

The advantages of using sustainable construction materials are that they are not only cost-effective, but they also minimize hazardous emissions, lowering total environmental impact. In each community development, sustainable construction materials and technology should be used effectively and culturally. The use of sustainable materials and technologies not only decreases transportation and manufacturing costs, as well as carbon emissions, but also creates opportunities for community people to get work and improve their skills.

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