Use of sustainable green materials in construction of green buildings for sustainable development

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Abstract. Sustainability in building construction is now major priority as it is having various advantages. The global trend is moving towards the sustainability and hence sustainable building construction has prime importance in the construction industry. Due to huge urbanization activities lot of environmental issues are originating. Building construction using sustainable materials will lead to reduction in the pollution and also improve the existing situation of environmental problems. This paper discusses the use of recycled design products in the construction industry. Affordable sustainable housing projects made from locally available construction materials are in high demand. It safeguards the natural ecosystem, economy, and energy. As a result, the report considers unique products that could fulfil the minimum requirements for sustainable building construction. The primary goal of this research is to do a comparative review to determine the viability of using recycled building materials instead of conventional building materials.

Keywords: Sustainability; Green building; sustainable materials; sustainable development; affordable

1. Introduction

India is one of the most populated country in the world having population around 138 crore as on 2020. India is developing country where huge number of infrastructure is going on and Government has also announced regarding the 100 Smart cities in India [1]. In this current development, the trend is moving towards the sustainability and hence sustainable building construction having prime importance in the construction industry [2]. Due to huge urbanization activities, lots of environmental issues are originating. Recent advance technology and facilities consume more energy and which directly or indirectly impact on the environment [3]. In addition to this urbanization also lead to consumption of huge quantity of materials, energy, and emits large quantity of carbon content in the air which lead to pollution in the atmosphere and have adverse effect on the human health [4]. These activities are responsible for the climate change and results into various natural and manmade disasters [5]. To reduce the effect of pollution, the only solution is to move towards the sustainable building construction. Building development utilizing maintainable materials will prompt decrease in the contamination and furthermore improve the current circumstance of ecological issues [6]. The vast majority of the structures are really liable for greatest asset utilization thusly green and maintainable structure is the solitary answer for the latest thing of development [7]. A 'green' building is one that, by its design, construction, or operation, reduces or eliminates harmful impacts on...
our environment and common ecosystem while still having the potential to produce positive effects [8, 9]. It safeguards important regular properties while also enhancing our personal satisfaction. Green structure refers to both a structure and the usage of ecologically sound and asset-producing cycles during a structure's life cycle, which includes anything from planning to construction, operation, support, remodel, and demolition [10]. Prior individuals lived in houses built without anyone else utilizing locally accessible materials in nature. So, now in this sustainable development the sustainable green construction materials will be extremely beneficial to environment as well as also helpful to human health [11].

The perk of sustainable green building construction is that it is very much beneficial in many number of way as compare to conventional building construction. It runs more efficiently, are often more comfortable to work in, and are more beneficial to the health of its occupants [12, 13]. To consider the building is green or not there are various code and certification codes that certify the building. The most common green building code is Leadership in Energy & Environmental Design (LEED) [14]. When the total energy consumed by the building is equal to or greater than the energy produced by the building it known as the net zero building [15]. Based on the overall performance of building and the energy consumption by the building including the operation of building, one can identify that the building is net zero or not. To compare the building styles the main important parameter is its performance [16]. For example, during the summer months green buildings can reduce the temperature inside the building by 5 °C compared to conventional building. By using the green roof materials in the building it will help to stay 2 °C warmer in the winter season. As per the past studies carried out by various researcher, 30% less energy will be consumed by a green building compare to the conventional building [17, 18]. Green buildings provide a better indoor environment, with a more comfortable temperatures and they also provide cleaner air. The main objective of this paper is to develop a building using locally available resources without adversely affecting the environment [19]. This paper gives a comparative analysis of the construction cost of sustainable and conventional building. These paper helpful to decide, whether to construct a green sustainable building or conventional building based the environmental benefits.

2. Sustainable materials

A green structure requires exceptional materials and frameworks to adapt supportability contrasted and an ordinary structure. The business of green structure materials and administrations alongside the mounting pattern of green structure advancement is additionally creating in India. Figure 1 shows the rules for green building construction. The practical development fuses various techniques during plan development and activity of building venture. Utilizing green material is one among the manageable plan activity and development systems. The green materials are ecologically capable materials as they help with falling natural effects (Greenomics). asset effectiveness, indoor air quality, energy proficiency and reasonableness should be the critical highlights of the practical structure materials. Green structure rating for coordinated environment appraisal. Green building material that has little or no impact or a positive impact on the surroundings. Most green materials are composed of recycled materials that assist the environment and use of waste energy in a better way, the energy needed in manufacturing them is also reduced [20].
3. Methodology and Materials

When the building materials are made from renewable sources that are sustainably harvested are also considered green. Sustainably grown and chopped wood or bamboo flooring is an example of this. Another advantage of a sustainable product is Durability. The building material which are very durable are also considered to be green. A common example of this that out lasts less durable products are durable siding, which results in significant savings in materials and energy over the life span of the property. Figure 2 shows the various sustainable building materials used in green building construction. Further profit can be attained when sustainable product is generated from recycled waste which is environmentally friendly. A material’s "greenness" is generally founded on specific models; its strength and furthermore whether the material is asset productive in its assembling, inexhaustible, establishment, use, and disposal [21]. An efficient way to deal with total and look at the sources of info and yields of materials and energy and to straightforwardly depict the ecological effects of an item or administration framework for the duration of its life cycle is its Life-cycle evaluation (LCA). An eco-brick and bio-brick will be the upcoming concept in green building construction as they will replace the traditional bricks. Through recycling plastic waste, it can be used in road paving as well as in certain attractive decorative items. Green framework products and materials can have similar properties. Recyclability of building materials or reusability when no longer needed, sustainably derived from rapidly depleting resources, such as asserted tile flooring, bamboo flooring, wool mats, strawboard, and cotton ball safety (created utilising denim scrap). Using renewables reduces the use and fatigue of limited rough materials, increases durability, and reduces the amount of radioactive radiation emitted by the product. The Forest Stewardship Council’s (FSC) Principles and Criteria for Wood Building Pieces, such as post-consumer reclaimed products, may be rescued for reuse, restored, remanufactured, or reused for timber or wood-based items. Buildings that are
environmentally friendly Materials and products made from waste materials, such as fly ash or wool, or a waste-reduction technique, can be minimally packaged and covered in recyclable packaging, and locally refined and collected, which means less energy is used in extraction, storage, and transportation to the workplace. Local economies are helped by utilizing materials and items fabricated regionally, water-efficient, energy-efficient in use, manufactured with a water efficient procedure, minimal waste and contamination created in the assembling procedure, generates sustainable power source, financial reasonability are ideal. In addition to the green materials, green building also required proper waste management facilities where generated waste will first segregated as per the different category. From these segregated waste, raw materials will be generated by Recycling process. For any building main utility services are water, electricity and sewerage. These services are need to be provided in such a way that maximum energy source will be consumed by renewable source which is achieved by Solar panel on roof top, rain water harvesting system, waste treatment plant and reuse the treated water in washroom flush tank as well as in gardening area for irrigation, kitchen waste can be also used in preparation of compost.

![Sustainable materials for green building construction](image)

**Figure 2. Sustainable materials for green building construction**

Green framework products and materials can have similar properties. Recyclability of building materials or reusability when no longer needed, sustainably derived from rapidly depleting resources, such as asserted tile flooring, bamboo flooring, wool mats, strawboard, and cotton ball safety (created utilising denim scrap). Using renewables reduces the use and fatigue of limited rough materials, increases durability, and reduces the amount of radioactive radiation emitted by the component.
| Name of the material | Economic benefit                                      | Uses                                                                 | Environmental benefit                                                                 |
|----------------------|------------------------------------------------------|----------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| Certified lumber (lumber which is harvested or produced sustainably) | Cost as much as conventional material                | Framing, flooring, decking, cabinetry                                   | Renewable, reusable, forests can provide habitat for wildlife                           |
| Bamboo (fastest growing grass and can be an alternative to timber) | Highly durable, less maintenance                     | Flooring, fences, cabinetry                                            | Renewable, performs as a carbon sink, needs few or no fertilizers and pesticides       |
| Natural stone (used as a building material since ancient times) | Durable, cost effective long term service             | From counter tops, fireplaces indoors to fencing, retaining walls outdoors | Non toxic, provides healthy indoor air, low embodied energy                             |
| Cellulose insulation (composed of recycled newspaper 85%) | Reduces drafts and heat/AC leaks                     | Insulating material for frame houses                                   | Recycled, energy efficient, non toxic                                                 |
| Plastic lumber (alternative to traditional wood; resistant to rot, mold, mildew, water and insect infestation) | Virtually maintenance free                            | Decking, fencing, signage, retaining walls                             | Durable, recycled                                                                      |
| Steel studs (provides exceptionally strong and stable framing for building) | Less material needed for structural integrity, fewer repairs and cheaper than wood | Commercial structures and popular choice for homes                     | Recyclable, low construction site waste                                               |
| Perforated metal (panels come in variety of size and materials) | Lasts for generations, perforated sunscreens or building facades decrease cooling and lightning requirements | Sun shades, building facades, rating systems, garage screening, decorative cladding | Recycled (100%), recyclable and indefinitely renewable, can help reduce building energy needs |
| Permeable pavement (lets water through replenishing ground water while reducing pooling flooding and runoff) | Prevents water related issues                        | Parking lots, sidewalks, drive ways, patios                           | Protects surface and ground water qualities                                            |
| Living plants (roof walls covered with vegetation) | Natural insulation can counteract sick building syndrome (increasing productivity) | Homes, commercial and municipal buildings | Improves air quality, removes CO2 from atmosphere, energy efficient, reduces energy consumption, opportunity of equipment downsizing |
| Solar cells (convert sunlight to electricity) | Reduces energy cost over long term, financial incentives (such as tax credits often offered) | Solar lighting, fans panels, etc                                     | Produces emission free, clean energy                                                  |
| Carpets tiles | low maintenance, material wastage, product installation cost | Flooring                                                               | Decreased stress on landfill because of used carpets (carpet roll = 10% wastage) Carpet tiles = 1-2 % wastage Carpet emission level drop in first 24 hours of installation |
| High performance glass (low U-value, low shading coefficient, acoustic performance high, heat absorbing) | Low cost in building energy consumption                | Windows, doors                                                         | Reduce energy load, opportunity of equipment downsizing                                |
| Bricks (bio bricks using sludge 30%) | Low cost (main components are sludge and fly ash which are waste materials) | Temporary structures, partition walls, small masonry structures         | Utilizes sludge which is harms environment                                              |
| Geopolymer concrete (Made from industrial waste and combination of inorganic polymer) | Low cost (made from waste material i.e fly ash) Low maintenance cost, saves heating and cooling cost | Concrete structures                                                   | Less energy in manufacturing, less pollution as compared to coal burning for OPC       |
| Green Plumbing fixtures (discharge ranges from 5 l/day/person to 13 l/day) | Water saving upto 75 L/day/person                     | Plumbing                                                              | Saves water                                                                            |
| Injection wells to recharge drinking water borewells through W.ire technology | Initial cost high                                     | Rainwater collection and usage                                         | Saves water and reuses the water                                                      |
| Lighting fixtures | High cost (payback in electricity, long life (approx 17 years)) | Lighting                                                               | Saves energy upto 70% per year                                                       |

Figure 3. Stepwise process of farming activities
For Wood or wood-based materials Forest Stewardship Council's (FSC) Principles and Criteria for wood building parts like postconsumer reused content, can be rescued for reuse, restored, remanufactured, or reused. Green Building Materials ought to be utilized and Products contrived from a waste material, for example, fly ash or straw or a waste decreasing procedure, Minimally bundled as well as wrapped with recyclable packing, Locally processed and extracted, which implies less energy utilized in extraction, handling, and transport to the place of work [22, 23]. Local economies are helped by utilizing materials and items fabricated regionally, water-efficient, energy-efficient in use, manufactured with a water efficient procedure, minimal waste and contamination created in the assembling procedure, generates sustainable power source, financial reasonability are ideal.

4. Green Building Rating systems

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 (GRIHA), Leadership in energy and environment design (LEED), Indian Green Building Council (IGBC), bureau of energy efficiency (BEE) are commonly used in India [24].

IGBC was founded in 2001 by the Confederation of Indian Industry (CII). Earth – sustainable sites, Power – water efficiency, Fire – electricity and climate, Air – indoor environmental conditions, Sky – day light and night sky emissions are the five aspects of nature that the IGBC rating systems are focused on. In accordance with the US Green Building Council [25], the IGBC has established ranking schemes for virtually any kind of building. IGBC green new houses, IGBC green current buildings O and M, IGBC green residences, IGBC green classrooms, IGBC green factory buildings, IGBC green townships, IGBC green city, IGBC urban rapid transit systems, and several others are among the rating schemes. Green new buildings are rated using the IGBC green new building code, which consists of seven modules with specific points assigned to each, as seen in Tables 1 and 2.

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

| Sr. no. | Modules                                      | Possible points |
|--------|----------------------------------------------|-----------------|
| 1      | Sustainable architecture and design           | 5               |
| 2      | Site selection and planning                   | 14              |
| 3      | Water conservation                            | 18              |
| 4      | Energy efficiency                             | 28              |
| 5      | Building materials and resources              | 16              |
| 6      | Indoor environmental quality                  | 12              |
| 7      | Innovation and development                    | 7               |
|        | **Total**                                     | **100**         |
5. Results and Discussions

It is a greatest myth and is a typical misinterpretation that keeps on lingering despite the fact that it has been exposed on many occasions. Besides, ongoing examination shows that Leadership in Energy and Environmental Design affirmed structures can engrave ozone harming substance, outflows and water utilization by almost half, while costing 25% less to work and getting 30% elevated tenant fulfilment and lower loan fees. Likewise, when thinking green is a part of initial planning process, it is simpler and more affordable to add features and components that has essentially lower working and support costs. Truth be told, by utilizing different sustainable methodologies and approaches, most green structure plans wind up costing less. The fundamental advantages are accomplished by energy saving, amplified worker efficiency, clinical costs (more secure indoor air quality for occupants and property holders), life span of the structure, and a minor environmental footprint. Almost every green structures cost 0–4% more than conventional structures. Many LEED structures can be built in nearly similar expense as conventional structures but in some cases Green premiums might increases with the degree of greenness.

Comparison between affordable green buildings and conventional buildings: The rate increment in total expense is 12-15% in green building construction instead of conventional building as shown in Table 3. After the compensation time of LED installations is finished saving in money is around Rs. 10,000 every year. 440 Liter/day will be saved with the use of plumbing fixtures. Payback period considering savings only is approximately 35 years.

Table 2. IGBC green new buildings certification levels

| Rating   | Points | Recognition           |
|----------|--------|-----------------------|
| Certified| 40-49  | Best practices        |
| Silver   | 50-59  | Outstanding Performance|
| Gold     | 60-74  | National Excellence   |
| Platinum | 75-100 | Global Leadership     |

Table 3. Comparison of cost between green and conventional home

| SR. no | Item name          | Cost in green home | Cost in conventional home | Difference |
|--------|--------------------|--------------------|---------------------------|------------|
| 1      | Windows            | 2,05,000           | 1,35,500                  | + 69,500   |
| 2      | Lightening fixtures| 45,000             | 13,000                    | + 32,000   |
| 3      | Plumbing fixtures  | 1,03,000           | 50,500                    | + 52,500   |
| 4      | Flooring           | 2,85,300           | 2,30,500                  | + 54,800   |
| 5      | Doors              | 1,60,000           | 72,000                    | + 88,000   |
| 6      | Paints             | 1,55,900           | 1,62,300                  | - 6,400    |
| 7      | bricks             | 32,000             | 53,000                    | - 21,000   |
The first reason we get that where we use this product that on that side mostly all the seeds are grown These structures stands in contrast to a typical misperception that green structures are considerably more costly than traditional structures. Cost effectiveness can be achieved by Energy savings alone. Green structures are seeing expanded market value (higher deals/rental rates, expanded inhabitance and lower turnover) compared with equivalent conventional structures. In approximately five years almost 50 % of green premium is paid back by water savings and energy. Noteworthy wellbeing and efficiency benefits imply that more than 90 % of green building repay an underlying interest in less than five years. There are various advantages and drawback of green building as shown in Figure 4.

| Advantages of affordable green building | Drawback of affordable green building |
|----------------------------------------|---------------------------------------|
| Environmental Benefits                 | Initial cost is high                  |
| Decrease in Emissions                  | Depends on Availability of Materials |
| Conservation of Water                  | Time required is more than conventional building |
| Reduced confined flooding              | Implications on air quality due to the use of some recycled materials |
| Waste reduction                        |                                       |
| Economic benefits.                     |                                       |
| Low utility bills                      |                                       |
| Increase in likelihood for the property to be sold |   |
| Social Benefits                        |                                       |
| Improvement to the occupant’s health   |                                       |
| Preservation of the natural environment|                                       |

Figure 4. Advantages and drawback of green building construction

Conclusion

Sustainable materials are identified and it can be replaced with the existing conventional building materials. There are various advantages of using these sustainable green materials for building constriction. This paper will helpful to the people, communities and general public and they will be aware about the benefits of using green building materials for sustainable environmental development and management. Nowadays energy sources are decreasing fast.
and also the use of natural resource is more. This paper conclude that the use of sustainable building materials will lead to optimize energy efficiency. In addition to this, the rate increment in total expense is 12-15% in green building construction instead of conventional building. After the compensation time of LED installations is finished saving in money is around Rs. 10,000 every year. Payback period considering savings only is approximately 35 years.

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