Advances in Agricultural Technology & Plant Sciences
ISSN: 2640-6586
Academic Strive
Researcher's perception is our reality

Research Article *Volume 4 Issue 2*

Green Buildings - An Emerging Concept towards Sustainable Urban Environment

Choks N[1], Badrakiya K[1], Aghara P[1], Bhavsar A[2], Menon M[3], Bhattacharjee A[4], Jain S[5] and Bhargava A[6]*

[1]Bachelor in Environmental engineering, LD collage of engineering, India
[2]Bachelor in Civil engineering, LD collage of engineering, India
[3]Bachelor of Architecture, Manipal Academy of higher education, India
[4]NIMS University, India
[5]CEPT University, India
[6]Rajasthan Pollution Control Board, CEPT University, India

***Corresponding author:** Akshey Bhargava, Ex Member Secretary, Rajasthan Pollution Control Board, Jaipur, Ex. Senior Professor, CEPT University, Ahmadabad, Environmental Adviser, Green Circle, Vadodara, India, Email: draksheyb@gmail.com

Received Date: August 25, 2021; **Published Date:** September 28, 2021

Abstract

The green building can be classified as economical building which deals with ecological issues within or outside the building premises. These natural issues incorporate effectiveness ventures to spare vitality, water protection and decrease in water utilization, indoor air quality, building air ventilation and light, diminishment of contaminations, better wellbeing, and reduction in heat island and albedo impacts. The urban communities confronting natural issues have begun receiving green building ideas as a stage towards environmental protection. The authors of the present paper have briefly dealt the significance of green buildings structures alongside the expected steps to be taken in creating green structures and the subsequent advantages there from. An effort has also been made in the present paper about green roof, green walls, natural air ventilation, and transformation of waste to value added products, solar panels, etc. to make the green building eco-friendly and environmentally compatible. An emphasis has also been made to assess the impacts of green buildings on urban environment.

Keywords: Green Buildings; Sustainable Buildings; Energy Saving; Environment; Natural Air Ventilation; Green Roofs and Walls; Waste to Value Added Products

Abbreviations: IGBC: Indian Green Building Council; NHB: National Housing Bank.

Introduction

Urban agglomeration leading to increasing population and associated infrastructure is posing a serious threat not only to local environment but also on a global scale. Urban areas are emerging as concrete jangles. The building sector assumes significant dimensions towards greenhouse gases (GHGs) which include carbon dioxide (CO_2), methane, nitrous oxide and ozone, all of which contribute to climate change. In fact, natural gas and oil are burned for electricity generation, industrial uses, transportation, and to heat homes and

Copyright © 2021 Bhargava A, et al.

commercial buildings. This emission saving potential is said to be as much as 84 giga tons of CO_2 by 2050, through direct measure in building [1]. The green building market in the US is expected to hit $99.8 billion by 2023. Green buildings achieving the Green Star certification in Australia have been shown to produce 62% fewer greenhouse gas emissions than average Australian buildings, and 51% less potable water than if they had been built to meet minimum industry requirements. Green buildings achieving the Green Star certification in South Africa have been shown to save on average between 30-40% energy and carbon emissions every year, and between 20-30% potable water every year, when compared to the industry norm. Green buildings achieving the LEED certification in the US and other countries have been shown to consume 25 per cent less energy and 11 per cent less water, than non-green buildings [1]. Global energy efficiency measures could save an estimated €280 to €410 billion in savings on energy spending and equivalent to almost double the annual electricity consumption of the United States. Green building industry statistics show that the global green construction materials market was forecasted to reach $1 trillion in 2020. Australian Green-Star-certified buildings produce 62% lower greenhouse emissions. Green buildings achieve a 7% increase in asset value compared to non-green ones. The global green building industry has the potential to cut energy consumption by 50% or more by 2050.

Green buildings certified by the Indian Green Building Council (IGBC) results in energy savings of 40-50% and water savings of 20-30% compared to conventional buildings in India [1]. IGBC (Indian Green Building Council) indicates about 25 million tons of municipal waste and 10million tons of hazardous waste generated annually. In the present waste management scenario almost 90% of the waste generated requires around 1200 hectares of land per year for disposal. The construction industry in India is one of the largest economic activities and is growing at an average rate of 9.5% as compared to the global average of 5%. India's National Housing Bank (NHB) has projected that India's real estate sector is expected to surpass US$ 150 Billion by 2020. As per the industry estimates, for the new buildings, India's green building market is projected to be in the range of US$ 30 Billion to US$ 40 Billion.

Literature Review

It's a known fact that the whole world is facing the consequences of global warming and climate change. One of the most effective ways to minimize the impacts of global warming and climate change is to adopt the concept of green buildings. Green sustainable construction makes way for green designs that are less damaging to both humans and environment. The benefits of green building can be grouped within 3 categories: environmental, economic and social.

- **Green Building trends in Australia:** Australia currently has one of the most active green building markets. 94% of the citizens have at least some green building projects whereas 46% reported that they are doing the majority of their projects green now.
- **Green Building trends in China:** The current levels of green activity in Hong Kong are much higher with 53% population doing more than 30% of their projects green.
- **Green Building trends in Europe:** Ireland has the highest percentage of those currently doing more than 60% of their projects green. Spain has the highest percentage of high and moderate levels of green work. On the other hand, Poland has the lowest level of green activity.
- **Green Building trends in India:** 90% of people have some level of green building experience but majority of them reported that less than 60% of their projects are green.
- **Green Building trends in North America:** All of the three major markets in North America- Canada, Mexico and the US have relatively high levels of green building activity. Canada has the highest percentage (35%) of those doing the majority (over 60%) of their projects green.
- **Green Building trends in South America, Central America and the Caribbean:** 95% population from Brazil and 87% from Colombia are doing at least some green projects. The highest percentage in Brazil (31%) of those doing green building reported that 16% to 30% of their projects are green. Some examples of green buildings from different parts of the world.

Shanghai Tower, Shanghai

The Shanghai Tower incorporates several green architecture features [2]. It is designed to capture rainwater for internal use and to recycle a portion of its wastewater. The design pf the tower's glass facade is designed to reduce wind loads by 24%. The Shanghai Tower used 25% less structural steel than any conventional building of se height. As a result, the constructors saved US $58 million in material costs.270 vertical-axis wind turbines are located in the facade and near the top of the tower and are generating up to 3, 50,000 kWh of supplementary electricity per year and are expected to provide 10% of the building's electrical needs. The double layer glass facade reduces the need of indoor air conditioning and is composed pf advanced reinforced glass to adjust with temperature changes. Furthermore, rain and wastewater are recycled to flush toilets and irrigate the tower's green spaces.

Bank of America, New York

It uses environmentally friendly technologies like floor-to-ceiling insulated glazing to contain heat and maximize natural light, and an automatic daylight dimming system. The tower

also has a grey water system, which collects rainwater for reuse [3]. Air entering the building is filtered and also the air exhausted is cleaned as well. Bank of America Tower is the first skyscraper designed to attain a Platinum LEED Certification. It is constructed using slag, a byproduct of blast furnaces. The mixture used in the tower concrete is 55% cement and 45% slag. This, in turn, reduces the greenhouse gas emissions. Conditioned air for the residents is provided by multiple air column units that deliver 50°F air into a raised access floor plenum. The cooling system produces and stores ice during off-peak hours and allows the ice to melt to cool the building during peak load.

One Central Park, Sydney, Australia

One Central Park has adopted two measures for sustainability: a low carbon tri generation power plant and an internal water recycling plant. Central Park is designed to utilize its own low-carbon natural gas power plant to produce thermal energy [4]. It involves a 2 MW tri generation energy plant which runs on natural gas and has the capacity to produce carbon thermal energy, heating and cooling for 3000 residences and 65,000 square meters of retail and commercial space. Central Park's recycled water network houses the world's biggest membrane bioreactor recycled water facility in the basement of the residential building. It is designed to serve approximately 4,000 residents and more than 15,000 visitors and workers daily. Water sources are:

- Rainwater from roofs
- Storm water from impermeable surfaces
- Groundwater from basement drainage System
- Sewage from an adjacent public sewer
- Sewage from all buildings within Central
- Park
- Irrigation water from all green walls
- Drinking water from public water main

Suzlon One Earth, Pune

This building has been designed on the principle of energy efficiency, water recycling and harvesting, and waste management. It has achieved Five-Star LEED (Leadership in Energy and Environmental Design) for New Construction Platinum Certification from the India Green Building Council as well as Five-Star GRIHA (Green Rating for Integrated Habitat Assessment) Certification. 5% (154 KW) of its annual energy is generated on-site through building-integrated photovoltaic panels (20%) and wind turbines (80%) [5]. The design provides 90% of the work stations with daylight and aluminum louvers allow daylight and cross-ventilation. LED lights and solar water heating help Dave energy. 100% of sewage grey water is recycled into flushing, landscaping and air Colling systems while 100% of rainwater is harvested. Glass exhaust chimneys with tropical plants allow aeration to basement parking area.

Types of Roofs

The important indicator of green building is its roof. There are different types of roofs which are reflected below and may be considered in green buildings depending upon the local availability of materials.

Clay Tile Roofs

- Also known as terra cotta, clay tiles are also extremely durable as well as heavy and expensive.
- Authentic clay tiles are made with natural clay that is shaped and fired, similar to ceramic tile [6].
- Some tiles receive special glazes or paints for color or other added properties.
- The clay used for tiles is such a plentiful resource that many clay tile manufacturers claim their products to be sustainable.

Wood Shakes and Shingles

- Wood shakes and shingles are sustainable roofing materials because wood is a sustainable resource. Of course, that assumes the roofing comes from sustainably harvested sources.
- Shakes and shingles are fairly energy-intensive to produce and are moderately durable [6].
- Disposal of wood roofing is easy because it is a biodegradable material, provided it has not been treated with synthetic additives or preservatives.

Green Roof

- A truly unorthodox type of roof, the green or living roof nevertheless holds much promise [7]. It can put oxygen back in the air, provide thermal insulation to your house, absorb rainwater, and even allow you to grow plants. To create a green roof, one first installs a layer of waterproof membrane and provides adequate drainage. A green roof can be intensive, meaning capable of supporting large plants and people, or extensive, which means that it is thin and intended only for light-weight growth such as moss.
- Costs for a green roof vary widely, but this is definitely a roof for those willing to spend money to make an environmental statement. Such roofs will also require regular maintenance to keep them lasting a long time.

Solar tiles

- Solar collectors integrate seamlessly into existing shingles, generating up to 1 KW of energy per 100 square feet. They're particularly good for sunny roofs. They may help offset energy costs with solar power.

Spray Polyurethane Foam (SPF)

- Spray Polyurethane Foam (SPF) is installed by spraying it on existing roof.
- The material expands like foam and hardens. SPF presents a ton of benefits to building owners who want more energy savings.

SPF roofing saves you more energy by keeping the heat inside during winter months. When it's summer, it reflects back heat to maintain a cool indoor temperature. Since the material expands when sprayed, small holes are sealed. Your roof increases in strength. As a result, SPF protects your building from the entry of pests and moisture penetration.

Green walls

Green walls, commonly known as plant walls, living walls or vertical gardens are emerging as new trend of built environments bringing nature close to living conditions. It can even be defined as vegetation growing on or against a vertical surface. In other words, Green walls are vertical structures having different types of plants or other greenery attached to them. The greenery is usually planted in a growth medium consisting of soil, stone, or water. Because the walls have living plants in them, they usually feature built-in irrigation systems. With the advancement of technology and emerging concepts, smart and active green walls are now a day's coming into existence. Such walls are more beneficial due to the use of artificial intelligence and technology. In addition to the visual and biophilic benefits of all green walls, smart and active green walls can feature natural air purification and humidification by employing the combination of enhanced air circulation, specialized growth medium, and technology. Figure 1 below shows the salient features of green walls.

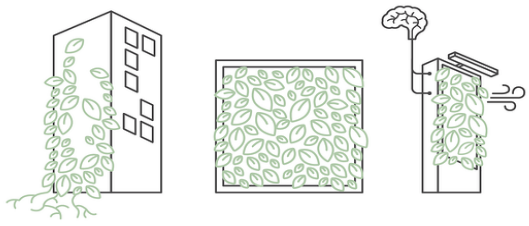

Figure 1: From left to right: green facade, green wall, smart and active green wall.

The benefits of green walls may be summarized as under:

- Livening of space
- Visual benefits
- Eye catching
- Alternatives for urban agriculture, gardening, and indoor decor.
- Make us happier and more productive
- Connection with nature
- Reduce negative behavior such as aggression and anxiety.
- Act as scavenger to reduce air pollution and reduce noise pollution.

Sustainable & Green Building Construction Materials

The selection of material is of prime importance for the green building depending upon local availability and its sustainability. Some of the identified materials are listed hereunder but lot of research needs to be undertaken to identify more materials which are eco-friendly and environmentally compatible for use in green buildings

- Bamboo
- Precast concrete slabs
- Cork
- Straw bales
- Recycled plastic
- Reclaimed wood
- Reclaimed steel
- Plant based Polyurethane
- Rigid foam
- Sheep's wool
- Rammed earth
- Hemp Crete
- Mycelium
- Ferrock
- Timber Crete
- Terrazzo

Brief description of above materials is given hereunder:

Bamboo

Bamboo is a one of the best eco-friendly building materials which is a perennial grass and not wood and grows on every continent except Europe and Antarctica. It has high strength compare to the concrete and brick [8]. It is a best choice for making flooring and cabinets.

Precast Concrete Slabs

Precast concrete slabs are used for walls and building facades [8]. It has very strong sustainability rather than many traditional concrete. It is proper cure for environment. This type of slab avoids the cracks and structural faults within the concrete.

Cork

Just like bamboo, cork grows very quickly [9]. It has absorbed notice, so that it is perfect for making sheets and also has shock absorption quality, so that it is also used for making

sub-flooring. It is very light and requires less energy.

Straw Bales

Straw Bales is a type of material that can be used as a farming material and act as good soundproof material [10]. Also, they have some fire-resistant properties, so that air cannot be allowed through it. It is used for making columns and framework. It can be easily harvested and replanted with minimal Environmental impacts. It is also used for cooling material in summer and warmer material in winter.

Recycled Plastic

Recycled Plastic reduces greenhouse gas emissions, so that it is used as clogging landfills and contributing to plastic materials [11]. It is also used to making so many things like picnic tables, fences and other structures. So, we can save our time and save the trees. It is also used to have designed product such as cable pipes, roofs, floors, PVC manholes and PVC windows.

Reclaimed wood

Reclaimed wood is one of the best environmental products to responsible for saving the trees and also reduce the amount of lumber [9]. It is good for making structural framing, cabinetry and flooring. It is light weight but has less strength.

Reclaimed or Recycled Steel

Steel is used for framing process, in place of wood [9]. It has good durability against earthquake and high winds. It is 100% recycled and reduce the ecological impact of new construction. Mining, heating and shaping products made from steel requires high energy and very much costly. But if we using proper recycled or reclaimed steel so that all the products are made perfectly and very strong sustainability. It is long-lasting and does not required replacement.

Plant Based Polyurethane Foam

Polyurethane foam is used as insulation material. It is now used in the manufacturing process that is turbine blades and furniture [9]. It is also used as heat resistant, protects against mold and pests and also used as a sound insulation.

Sheep's Wool

Sheep's wool is used as insulation. It can increase energy efficiency and soundproof of your materials [9]. It is more prevalent and can be easily harvested and regenerates quickly. In addition to above, other materials like Rammed earth, Hemp Crete, Mycelium, Ferrock, Timber Crete and Terrazzo are also used to making "Green buildings".

Natural Air Ventilation

A natural air ventilation system uses pressure differences to flow fresh air throughout a structure. Wind or the buoyancy effect caused by temperature changes cause pressure differences. There are no mechanical units in this system, like as fans or ducts. Natural ventilation can be classified into the following categories:

Wind Driven Ventilation

As the wind blows, it impinges on the windward wall, creating a positive pressure. Simultaneously, a negative pressure builds on the opposing wall, the leeward wall [12]. Fresh air enters through an entrance on the windward side and escapes through an opening on the leeward wall to balance the pressure Differential. Figure 2 shows a schematic diagram to demonstrate the above statement.

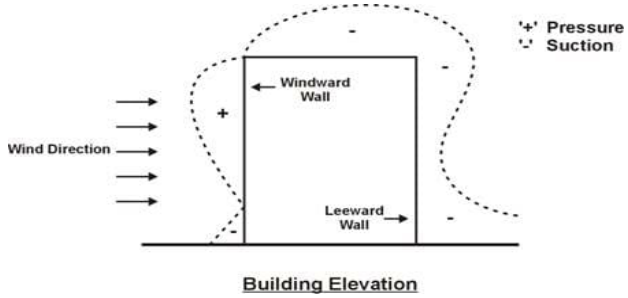

Figure 2: Behavior of wind on the building structure.

Stack Ventilation

In this case, temperature difference is the driving force. When the air in your home heats up, it gets less dense and rises. Warm air rushes out of windows Located at higher elevations, while cooler air rushes in via windows located at lower elevations [12]. Wind speed and direction, surrounding environment, building footprint and orientation, Outdoor temperature and humidity, Window sizing and position are all factors that affect natural ventilation [12]. Figure 3 shows the dynamic behavior of natural air ventilation.

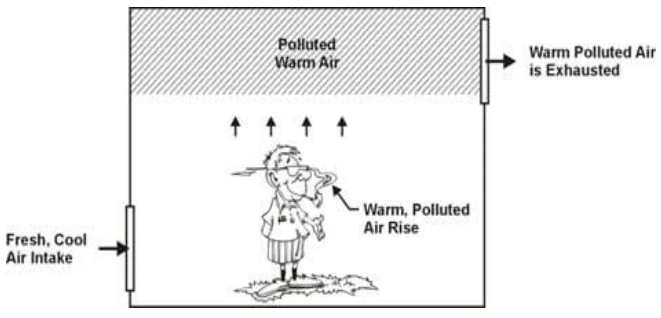

Figure 3: Dynamic behavior of natural air ventilation.

Design Considerations

While designing natural air ventilation in green buildings, following issues need to be considered.

- **Building orientation and location:** Structures should be placed so that the windward wall is perpendicular to the summer breeze. For this, a wind rose diagram is employed [12].
- **Building shape and dimensions**: Naturally ventilated buildings should not be too deep because wind-driven air will have a difficult time passing through.
- **External Obstructions:** Trees, surrounding buildings, and other structures can all hinder the wind.

Air inlets and outlets should be located low in the room, with air outlets higher and across the room from the lower inlet. To take use of the stack effect, there should be a significant vertical distance between the inlet and exhaust
Holes.

Vertical Farming

Vertical farming refers to the process of growing food on vertically inclined surfaces. Instead of growing vegetables and other things on a single level, such as in a field or a greenhouse, this approach grows them in vertically stacked layers, which are typically integrated into other structures such as a skyscraper, shipping container, or refurbished warehouse [13]. This current concept incorporates indoor farming techniques and Controlled Environment Agriculture (CEA) technology. Producing foods and pharmaceuticals indoors is possible thanks to the artificial regulation of temperature, light, humidity, and gases. Vertical farming resembles greenhouses in many respects, where metal reflectors and artificial lighting supplement natural sunlight. Vertical farming's main purpose is to maximize crop output in a limiting space Awareness how vertical farming works requires an understanding of four key areas: Physical arrangement, lighting, growing medium, and sustainability features are all factors to consider [14]. To begin with, vertical farming's primary purpose is to produce more food per square meter. Crops are grown in stacked layers in a tower life structure to achieve this purpose. Second, to keep the ideal light level in the room, a perfect combination of natural and artificial lighting is used. Lighting efficiency is improved using technologies such as revolving beds. Finally, growing mediums such as aeroponic, aquaponic, and hydroponic are employed instead of soil. In vertical farming, peat moss, coconut husks, and other non-soil mediums are commonly used. In the end, to counteract the energy cost of farming, the vertical farming system employs a variety of sustainability elements. Vertical farming, in fact, consumes 95 percent less water.

➢ **Advantages**

- It lays up a strategy for meeting future food demands.
- It permits crops to be grown all year.
- It consumes a lot less water.
- Crops are unaffected by the weather.
- It is possible to raise more organic crops.
- Exposure to pollutants and disease is reduced.

➢ **Disadvantages**

- It could be very expensive to build, and economic feasibility studies have yet to be completed.
- Pollination would be difficult and expensive.
- It would entail a rise in labor costs.
- It is overly reliant on technology, and a power outage would be disastrous.

Waste to Value Added Products

Each house is going to generate waste in the form of sewage or sullage and solid waste. The waste so generated shall be transformed into value added products in the form of bio fuels, compost, fuel pallets and even power [15]. All such facilities would be more compatible if cluster of such green buildings are considered together to make the system more viable. An attempt should be made to take care of waste at the source to avoid process of conveying.

Impacts on Urban Environment

With the present pace of development on a time scale, urban areas are facing significant and alarming problems in respect of air pollution, water pollution, and noise pollution coupled with unbalancing of albedo thereby enhancing urban heat island effect, etc [16]. The infusion of green buildings in urban sector will lead to balancing of albedo effect resulting into reduction of urban heat island. Such a reduction would lead to less urban energy and water consumption. Green buildings would also act as scavengers for absorbing air pollutants and also noise caused pollution in urban area to great extent. It would also help in water harvesting, conservation and effective ground water recharge during rainy season. If the entire city is developed with green buildings, aesthetic look shall be provided in an urban area to attract tourists thereby bringing economy to urban area to make it sustainable.

Conclusion

Green buildings are gradually emerging not only in India but globally partly because of threat to global warming and climatic change and partly due to alarmingly increasing environmental problems in urban areas. Green buildings if widely accepted and implemented in urban areas, can significantly address the emerging issues related to

deterioration of environment in a broader perspective. The present paper has listed the eco-friendly raw materials that can be used in green buildings [17]. However, more and continuous research needs to be taken up finding more raw materials which are sustainable and eco-friendly. Green buildings can reduce energy and water consumption thereby addressing the issues relating to global warming and climatic change. Such a concept facilitates natural air ventilation in buildings for reduction in energy and water consumption coupled with restricting indoor air pollution. Green roofs, green walls and vertical farming provide aesthetic sense and bring us in the midst of nature to reduce aggression, anxiety, stress, and tension. If an urban area is provided green buildings, it can have positive environmental impacts on urban environment in the form of balancing albedo effect, reduction in heat island, reduction in urban energy and water consumption coupled with reduction in urban air pollution. However, lot of research needs to be undertaken in respect of green buildings, its economic viability, sustainability and its overall impact on the urban environment.

References

1. (2021) About Green Building, the benefits of green buildings.
2. (2016) Shanghai Tower, Global Height Rank.
3. (2010) Bank of America Tower (Manhattan), Global Height Rank.
4. (2014) One Central Park/Ateliers Jean Nouvel.
5. (2010) Suzlon One Earth, Maharashtra, India.
6. Bernard M (2021) Sustainable Roofing Materials: what to know the Spruce.
7. Wallender L, Bacon K (2021) 12 Roofing Materials to Consider for your house the Spruce.
8. Jerse S (2018) 5 of the world's most sustainable building materials, Modelur.
9. (2021) 15 Sustainable and Green Building Construction Materials. Conserve Energy Future.
10. (2021) 23 Different Green Building Materials. The Constructor Building ideas.
11. Peckenham E (2016) 11 green building materials that are way better than concrete, Inhabitat.
12. (2021) Natural Ventilation. Green Home Technology Center, Ohio State University Extension.
13. Leblanc R (2020) What you should know about vertical farming, is it the future of agriculture?
14. (2021) 26 Amazing Green Building Statistics for a Cleaner 2021.
15. Wallender L, Bacon K, Dara J (2021) 12 Things to Know About Metal Roofing, no longer a novelty, metal roofing has many advantages the Spruce.
16. Mustonen T (2017) What are Green Walls-the definition, benefits, design and greenery, NAAVA.
17. (2021) As consumers cut the cord, more cities sue Netflix and other streaming giants for lost revenue, Smartcities Dive.