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A review on green building for sustainable development

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Abstract
In recent era, the concept of green building has been gradually emerging in most of the courtiers. It became highly popularized and implemented, in the area of sustainability in the building industry. The emerging trends in green building practices aim to reduce the harmful environmental impact of non- eco friendly building; enhance energy-efficiency, uses of environmentally sound methods in designing and construction. The use of energy-saving technologies in green buildings should run through the entire process of building design, construction and use, enabling green energy-saving technologies to maximize their effectiveness in construction. Realize the sustainable development of green building, reduce energy consumption, and reduce people's interference with the natural environment, suitable for people living in "green" building. It can be concluded that to enhance environmental sustainability promotion of green building is essential in our society.

Keywords: Green building, sustainable development, pollution, energy efficiency, development

Introduction
With the rapid development of the economy and society, the shortage of energy and the deterioration of environment have become two major problems faced by human beings. At present, the building industry is the leading source of consumption of world energy sources and various kinds of resources like ores, wood, and so on, as well as the major source of environmental pollution. United Nations Environment Program (UNEP) state that, energy consumption in the building industry accounts for about 30–40% of the world's energy consumption. However, it is midcult for the industry to figure out a green, environmentally friendly, and sustainable road for development. Therefore, there is a crying need for exploring and establishing the sustainable development mode of the building industry in order to transform the current situation of high resource consumption and high environmental pollution. Green building is one which uses less water, optimizes energy efficiency, conserves natural resources, generates less waste and provides healthier spaces for occupants, as compared to a conventional building. A 'green' building is a building that, in its design, construction or operation, reduces or eliminates negative impacts, and can create positive impacts, on our climate and natural environment. Green buildings preserve precious natural resources and improve our quality of life. According to the Ministry of Housing and Urban-Rural Development 2006, Green building refers to maximizing the resources conservation including energy, land, water, materials, and so on; protecting the environment and reduce pollution; providing healthy, applicable, & efficient living room for people; and coexisting harmoniously with nature in the life-cycle of the building. The built environment makes a significant contribution to environmental degradation. Buildings including construction, operations and deconstruction impacts, use approximately 15% of the world's fresh water resources, 40% of the world's energy and produce approximately 30% of the world's greenhouse gas emissions. The analyst forecast global market to grow at a CAGR of 9.6% during the period 2016-2020. To prevent the worst effects of global climate change and minimize other negative environmental impacts, it is important to address the environmental impacts of buildings. In fact, energy efficiency reductions in the construction and operation of buildings, offers one of the single most significant opportunities to reduce man's impact on climate change. Green building has been gradually popularized and implemented in an increasing number of countries, and has become the main direction of the development of the

building industry in the world. The United States Environmental Protection Agency (USEPA) define green building as environmentally responsible and resource-efficient building throughout its life-cycle from sitting to design, construction, operation, maintenance, and deconstruction. Building Services Research and Information Association (BSRIA) considers that the creation and management of a healthy building environment should be based on the principles of high-efficient resource utilization and ecological befits.

Why to go Green?

- Reducing trash, pollution and degradation of the environment.
- Efficiently using energy, water and other resources.
- Protecting occupant health and improving productivity.

Goals of Green Building: The basic goal of green building is attractive, comfortable, affordable shelter that does no harm to the Earth in its manufacture, or its use. This overarching goal is driven by four further goals:

- Reducing impacts on the Earth from constructing buildings and their materials.
- Reducing impacts which arise during occupancy.
- Reducing the impact of the structure at the end of its life.
- Creating a more desirable human experience.

Benefits of Green Building:

1. Profitable, cost-effective and good for the economy: The top two triggers for green building in the U.S. are client demands and healthier buildings, but the economic benefits can't be overlooked. Operating cost savings, shorter payback periods and increased asset value in new green buildings and green retrofits have been reported. Upfront investment in green building also makes properties more valuable, with a growing number of building owners seeing a 10 percent or greater increase in asset value. Green buildings reduce day-to-day costs year-over-year. LEED buildings have reported almost 20 percent lower maintenance costs than typical commercial buildings, and green building retrofits typically decrease operation costs by almost 10 percent in just one year.

2. Prioritizing people's health and well-being: Green buildings positively affect public health. Improving indoor air quality can reduce absenteeism and work hours affected by asthma, respiratory allergies, depression and stress and self-reported improvements in productivity. USGBC's own research reinforces that employees in LEED green buildings feel happier, healthier and more productive. National Institute of Building Sciences (NBIS) 2018, found that each $1 spent on mitigation activities – such as strengthening buildings and improving drainage conditions – saves $6 in response and recovery costs.

3. An environmental solution: Green buildings help reduce carbon, water, energy and waste. The Department of Energy reviewed 22 LEED-certified buildings managed by the General Services Administration and saw CO2 emissions were 34 percent lower, they consumed 25 percent less energy and 11 percent less water, and diverted more than 80 million tons of waste from landfills. According to the EPA, heating and cooling accounts for about 43 percent of all energy use in the country, which contributes to air pollution and generates the largest amounts of greenhouse gases. By improving energy efficiency, green buildings also help reduce indoor air pollutants related to serious health issues.

4. Energy Efficiency: Designers of green buildings try as much as possible to reduce dependency on energy from non-renewable sources such as coal. To this end, they install solar panels to make use of energy from the sun, and design windows in a way that allows as much natural light as possible and, therefore, reduces the use of artificial light; these and other methods ensure that the building uses energy in an efficient manner. Energy efficiency is essential not only for the user but also for the entire world because non-renewable energy sources are expensive and pollute the environment.

5. Enhances Indoor Environment Quality: Indoor environment quality depends on conditions inside a building and how they affect the occupants of the building. These conditions include lighting, ergonomics, thermal conditions and air quality. Good indoor environment quality is one protects the health of the building's occupants, reduces stress and improves their quality of life. Green buildings achieve this through the installation of operable windows that allow in as much sunlight as possible and reducing the use of materials that may emit elements that are dangerous to the health.

6. Water Efficiency: Water efficiency involves using water resources in a manner that saves water and ensures that today and future generations enjoy a reliable supply of clean water. Green building allows for the use of alternative sources of water such as rainwater, reducing water waste through the installation of plumbing fixtures that are efficient and reducing the strain on shared water resources by installing systems that purify water and enable recycling.

7. Carbon Footprint Reduction: Saving the Planet One Step at a Time: There has been an increase in large corporations opting for green initiatives. According to the Environmental Protection Agency (EPA), buildings account for 30% of all greenhouse gas emissions in the United States. Landlords and large businesses have taken heed, as increasing sustainability is an opportunity to do something positive for both business and society as a whole.

8. Keep It Clean: Protecting Our Ecosystem: Global warming has been a growing concern for a number of years, and it's no wonder – our planet has seen a drastic depletion of our natural resources, while pollution and the consequent climate-change is at an all-time high. Sustainable architecture is not only energy-efficient and healthier for its inhabitants, but it also benefits the planet. By reducing our reliance on non-renewable resources (such as coal and oil), green architecture can actually promote and maintain a cleaner environment.

Emerging Trends in Green Building Construction

- **Retrofitting existing buildings:** Retrofitting and renovation or refurbishment of existing buildings are upgraded energy efficiency or decrease energy demand. Generally, this includes the adoption of energy-efficiency strategies. In the commercial sector this includes: utilizing variable-speed drive, HVAC systems and increasing efficiency in lighting by replacing with electronic ballasts and replacing incandescent lighting with CFLs.

- **Low-income housing:** Low-cost housing scheme is to subsidize the construction of each house. Due to these cost constraints the units typically only include a small pre-paid electricity unit, two plug points and two light units and establish a number of energy saving measures which can be incorporated into low income housing. These measures include: Ceilings with insulation; Internal and external plastering; Plastic membrane under floor; Sealing the house at ground level.

- **Water conservation methods:** Buildings consume 15% of the world's fresh water resources. The growing awareness of the global crisis in fresh water supply will lead to reduce water consumption in buildings with ultra-low flow fixtures, rain-water recovery systems, retrofit old plumbing and innovative water technologies.

- **Carbon neutrality:** The threatening of global climate change has forced a focus and move towards carbon neutrality in all human activity. For the built environment this will mean a trend towards zero carbon buildings. The United Kingdom (UK) has pledged that by 2016 all new homes have to be zero carbon homes. This means that all new homes in the UK, from 2016, are to be built in such a way that the building will have net zero carbon emissions over the course of a year, after taking account of: emissions from space heating, ventilation, hot water and fixed lighting To meet the zero carbon homes standard, homes should.

- **Green or living roofs:** One technique that has gained popularity is that of using living or green roofs. A green roof is a roof of a building that is partially or completely covered with vegetation and soil, or a growing medium, planted over a waterproofing membrane. This type of roof has several advantages, including its beauty, its ability to assist the house with blending into the environment and providing climatic stabilization. A living roof reduces heating and cooling loads on a building; reduces storm-water runoff; filters pollutants and carbon dioxide out of the air; and increase wildlife habitat in built-up areas, among other advantages. It is believed that if 8% of roofing in the city is greener then the ambient temperature in the city can be reduced by up to 2 degrees.

- **Living walls or Vertical Garden:** Living walls or bio walls or vertical gardens can be grown on just about any type of wall, with or without the use of soil, and they can be placed both on outdoor and indoor walls. A popular example of a living wall is at the Museedu quai Branly, Paris. These walls attempt to make use of bio-filtration and photo remediation to draw air through the root system of the wall. Beneficial microbes actively

- **Biomimicry:** Biomimicry is the concept of copying designs and innovations found in nature. The East gate Centre in Harare, Zimbabwe is a shopping centre that has mimicked strategies used by termites in termite mounds for temperature control. Termites keep temperatures constant within their large vertical mounds by constantly opening and closing a series of heating and cooling vents throughout the mound over the course of the day. With a system of carefully adjusted convection currents, air is sucked in at the lower part of the mound, down into enclosures with mud walls, and up through a channel to the peak of the termite mound. The termites constantly dig new vents and plug up old ones in order to regulate the temperature. However, it has a ventilation system which operates similarly to a termite mound. Outside air that is drawn in is either warmed or cooled by the building mass depending on which is hotter, the building concrete or the air. It is then vented into the building's floors and offices before exiting via chimneys at the top. The complex also consists of two buildings side by side that are separated by an open space that is covered by glass and open to the local breezes.

- **Cradle-to-cradle design:** An emerging concept of cradle-to-cradle design aims to create buildings, communities and systems that generate wholly positive effects on human and environmental health. Cradle-to-cradle design is based on the closed-loop nutrient cycles found in nature, in which there is no waste, as opposed to cradle to-grave design which sees materials as a waste management problem. For example, these buildings would use materials designed as biological nutrients that could biodegrade safely and restore soil after use. There could also be materials that are technical nutrients as well as potentially infinitely recyclable. The future may in fact have buildings that function more like trees, in that they may make oxygen, sequester carbon, fix nitrogen, distil water, provide habitat for thousands of species, accrue solar energy as fuel, build soil, create microclimate, change with the seasons and are beautiful.

- **Glass Fiber Reinforced Gypsum (GFRG) Panel Building System:** Production of Gypsum in 2014 is 246000 thousand metric tons of stockpiled gypsum, generated as waste at various fertilizer plants and mining. Research has found gypsum to be a durable material, and it is already heavily in use as partition walls. Experts predict that a building made of GFRG panels can have a life span of 60 years. A GFRG building does not require beams & columns.

Advantages of GFRG panels

i.	Less Construction Time	82%
ii.	Less Sand Usage	76%
iii.	Less Cement Usage	65%
iv.	Less Labor Time	50%
v.	Less Steel Usage	35%
vi.	Less Coarse Aggregates	27%

- **Monolithic Concrete Construction System uses Aluminum Formwork Technology:**In this system instead of traditional column and beam construction; all walls, floors, slabs, columns, beams, stairs, together with door and window openings are cast in place in one operation on site by use of specially designed, easy to handle modular form work made of Aluminum. Using the formwork system, rapid construction of multiple units of repetitive type can be achieved. Suitable for both low rises to high rise structure. It is 100% recyclable; the reinforced bars used in this system on average weight 33 Kg per square meter, as compared with about 50 Kg in conventional methods.
- **Low-emittance windows and smart glass:** For instance, a green version of windows is low-emittance windows, which are coated with metallic oxide to block the sun's

harsh rays during summer and keep the heat inside in the winter. More than serving the conventional function of windows, low-emittance windows significantly bring down HVAC costs. A more advanced version of this, which has yet to be widely and commercially available, is smart glass, also known as electro chromic glass. Using a small amount of electricity, the smart glass charges ions to control the amount of light it reflects. In effect, this glass tints during the sun's peak hours and returns to transparent at night There are many types green architecture glasses are available in the market which includes the following;

1. Insulated (doubled and triple glazed glass)
2. Gas filled glazing
3. Heat- absorbing tinted
4. Low emissivity coatings
5. Spectrally selective glass
6. Reflective coatings
7. Electro chromic glass

The design and placement of glass is a fundamental constituent of green architecture. It permits natural light and puts together the interior of office and residential buildings with the exterior. Natural light enhances productivity in the workplace and helps uphold a healthy environment.

- **Green Concrete:** Green concrete is an environment friendly concrete. Green concrete improves the three pillars of sustainability: environmental, economic, and social impacts. Green concrete should follow reduce, reuse and recycle technique or any two processes in the con Crete technology. The three major objectives behind the green concept in concrete is to reduce greenhouse gas emission; to reduce the use of natural resources such as limestone, shale, clay, natural river sand, natural rocks that are consuming for the development of human mankind that are not given back to the earth; and the use of waste materials in concrete that results in the air, land and water pollution. This objective behind green concrete will result in the sustainable development without destruction natural resources.

- **Passive building:** The expression passive building refers to a construction standard that can be achieved using various types of construction materials. It can also mean a green building construction that guarantees an interior climate as comfortable in summer as it is in winter without a conventional heating system. The purpose of the passivhaus is to reduce energy consumption in residential buildings by capturing a passive solar energy contribution, reinforcing building insulation, using renewable energies and recuperating heat. The passive building mark includes many specific and technical elements concerning windows, insulation and facade seals, air renewal, etc. Rigorous testing is carried out to obtain the passive building mark.

- **Building Management system (BMS):** Building management system (BMS), is a computer-based control system installed in buildings that controls and monitor building's mechanical and electrical equipment such as Illumination control, Electric power control, Heating, ventilation and air-conditioning (HVAC), Security and observation, Access control, Fire alarm system, lifts, elevators, Plumbing, Closed-circuit television, Other engineering systems, Control Panel, PA system, Alarm Monitor, Security Automation etc. A fully optimized BMS can save energy to the cost extent of 15% to 20% as compared to a building without BMS.

- **Rain garden with native plants:** A rain garden is a planted depression or a hole that allows water runoff from impervious urban areas, like roofs, driveways, walkways, parking lots, and compacted lawn areas, the opportunity to be absorbed. This reduces rain runoff by allowing storm water to soak into the ground (as opposed to flowing into storm drains and surface waters which causes erosion, water pollution, flooding and groundwater) The purpose of a rain garden is to improve water quality in nearby bodies of water and to ensure that rainwater available for plants as groundwater rather than being sent through storm water drains straight out to sea. Rain gardens can cut down on the amount of pollution reaching creeks and streams by up to 30%. Native and adapted plants are recommended for rain gardens because they are more tolerant of one's local climate, soil, and water conditions; have deep and variable root systems for enhanced water infiltration and drought tolerance; habitat value and diversity of local ecological communities; and overall sustainability once its established

Green Building Project in India

- **Suzlon Energy Limited-Pune:** This significantly unique office is designed by Christopher Charles, Pune based architect and has received LEED Platinum rating in 2010. To ignite our eyes, he and his partner came up with the concept "Office in the garden". Spread over 10 acres, this magnificent structure is one of the largest green building projects of the country and is also one of the India's first buildings to be LEED (Leadership in Energy and Environmental Design) certified. Suzlon one earth is 100% powered by onsite and offsite renewable sources. The campus has 18 hybrid wind turbines that fulfill 7% of the total energy consumption; the rest of energy demand is met from offsite wind turbines. The structure is designed in a way to ensure maximum daylight exposure thereby reducing artificial lighting consumption. The infrastructure within the campus is designed to enable water percolation and thereby control storm water runoff thus, contributing towards an increased water table level.

- **Rajiv Gandhi International Airport (RGIA), Hyderabad:** India's 6th busiest airport, which is situated in the downtown of Hyderabad, has set a benchmark for the green buildings in India. The structure of the airport is designed in a way so as to consume less water, electricity and conserves natural resources. Within the campus of the airport, there is a green belt of 273 hectares with numerous plants. In the last couple of years, RGIA has been successful in saving energy for nearly 3.97 million kWh and have reduced the carbon footprint by 3331 tons.

- **CII- Sohrabji Godrej Green Business Centre, Hyderabad** This architectural masterpiece has set the world's best example of passive architectural design. The CII-Sohrabji Godrej Green Business Center (GBC) was the first building outside of the US to be awarded LEED platinum rating at the time of its inauguration. The building doesn't let out any waste and recycles it all

within. It can be said that building is literally made up of only recycled materials.

- **Infosys Limited, Mysore:** Located in the city of palaces, this green building is an awe-inspiring structure is the third Infosys building to win a Platinum rating, taking the total Platinum certified building area at Infosys to 780,000 sq ft. The 5-story structure has been built keeping in mind a holistic approach to sustainability in five key areas, including – Sustainable site development, Water savings, Energy efficiency, Materials selection and Indoor environmental quality. The smart mechanism and efficient equipment's lead to 40% of less energy consumption.

- **Infinity Benchmark, Kolkata:** At the time of its inauguration, this 20-story structure which is spread over 5, 60,000sq. feet was 7th building in the world to receive the LEED Platinum rating. The building is furnished with Co2 monitor sensors, rainwater harvesting, and waste water recycling system and humidification controls. The exterior of the building is made of brick wall block while the roof comprises of deck thick polyurethane foam for better insulation.

- **I-Gate Knowledge Centre, Noida:** Next on the list of green buildings is the Patni Knowledge Centre with the prestigious platinum LEED rating. The building is built over 4, 60,000 sq.ft. In Suburban Noida and is designed in a way that it captures 73% of daylight within the office. Nearly 50% of land is covered with grass which doesn't let wastes and sewage water go out.

- **Bank of India, Goa:** A world of eco-friendly lights and air-conditioning, intelligent glazing, modern capsule lifts, and indoor fountains – this is what sums of this popular bank in Goa. The building uses Nano Misty Blue, softening color glass manufactured by Saint Gobin Glass, India for producing the cool effect and saving energy. The glass has solar control and thermal insulation properties. The building is a complete package of modern look of today's bank.

- **Biodiversity Conservation India Ltd. (BCIL), Bangalore:** In 1994, BCIL was established when green building concept was foreign to all of us and was something one could not locate even with long-range radar. The building was established with an aim of creating eco-friendly living habitats, especially in the urban space. It is a wonderful example of smart homes where one can turn lights off using mobile phones. That's not all. The building has 44 interconnected rainwater percolation wells that lead to a 400,000-liter water tank. The building makes use of central reverse osmosis system to purify water without the use of chemicals. Grey water is directed to the gardens, toilets and for washing cars.

- **Olympia Tech Park Chennai:** Located in technological nerve centre of the city, Olympia Tech Park is one of the largest and most sought-after IT parks in Namma Chennai. This majestic structure is worldwide famous for being the first green building of its size (1.8 million sq.ft.) and has some of the best fortune-100 companies operating in it. Rated as one of the largest LEED Gold rating buildings of the world, this tech park has the lowest energy consumption, high natural lighting systems, 100 per cent water recycling and other environment-friendly practices. Studies says, by 2030 the Indian building stock is expected to reach 100 billion square feet compared to the existing 25 billion square feet. And to add on to the number, we are coming up with our latest green building project in the heart of Chennai.

Conclusion

At the endthis concludes that the built environment is without any doubt a major contributor to global CO2 emissions and has a larger impact on the natural resource. The uptake of green building concepts and techniques is largely focused on eco-efficiency and healthy living. It should be noted that simply reducing negative impacts by a certain percentage is not going to solve the world's environmental problems; though it can certainly help if it becomes standard practice by all stakeholders. This includes moving towards true sustainability by utilizing holistic measures. The primary focuses of the green building professionals, governments, builders and occupants are adopting innovative sustainable measures in their future construction.

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