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Designing Techniques of Green Buildings: Literature Review

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Abstract—*Being one of the biggest consumers of energy and also one of the largest producers of greenhouse gases, buildings are a topic of discussion on an international forum. Buildings generate 35 percent of carbon dioxide (a primary greenhouse gas related with climate change), 49 percent of sulphur dioxide, and 25 percent of nitrogen oxide found in the air, according to the statistics of National Institute of Building Sciences (USA). This highlights an immediate requirement to implement sustainability in every new construction, which shall help us create a sustainable environment and a healthy ecosystem. Green buildings follow the principle of optimum usage of water, energy and non-renewable natural resources; generate less waste and provide healthier spaces for residents. It is the practice that aims at creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from sitting to design, construction, operation, maintenance, renovation and deconstruction. This practice aids in expansion of the classical building design concerns of economic feasibility, utility, durability, and comfort. The fundamental point of this paper is green design as a fundamental revolution of contemporary architecture which is being practiced in India. It aims to look at some environmental and physical design approaches for green buildings in India. Thereby, the paper presents an analysis of ideology of green architecture, theories and viewpoints outlined in the field and also the analysis of successful cases of environment friendly buildings in India.*

1. INTRODUCTION

Tremendous growth in economic activity across the globe leading to increase in human activities is causing an irreversible damage to the global environment, which in future will have an undesirable impact on the quality of life of future generations.

As per UNEP Report, at present, buildings contribute as much as one-third of total global greenhouse gas (GHG) emissions, principally through the use of fossil fuels during their operational phase. The building sector contributes up to 30% of global annual green house gas emissions and consumes up to 40% of all energy [2]. One of the main culprits is carbon dioxide emissions, which is implicated to contribute up to 40% of all global emissions in which India's position is 144th (1.4 metric ton) in carbon emission rating in the world [11].

Due to tremendous growth in new infrastructural developments in transitional economies of developing countries, and the insufficient and improper use of existing building stock universally, it is an imperative of the industry to develop sustainable building technologies. If no tangible steps are taken soon, greenhouse gas emissions from buildings will more than double in the next two decades.

Consequently, if targets towards GHG emissions reduction are to be fulfilled, then emissions from the building sector must deal with as a prerequisite by the policy makers. Reduction of GHG emissions from buildings must be one of the noteworthy milestones of each national climate change strategy. The planet needs to have alleviated GHG emissions by at least fifty percent, in the next forty years to dodge the worst-case scenarios of climate change. Across the world at least twenty five percent reduction in emissions needs to be achieved in the coming eleven years [1]. With time flying by, the nations need to work faster to achieve the objectives to avoid irreversible damages.

Green building is a key architectural concept of the 21st century. Green building is the technique of constructing or transforming structures to be environmentally conscientious, sustainable and resource-efficient throughout their life cycle. This amalgamates numerous features like efficient water use, energy-efficient and eco-friendly environment, use of renewable energy and recycled/recyclable materials, effectual use of landscapes, effective control and building management systems and enhanced indoor quality for good health and comfort of the residents. The concept of green buildings not only favors human health but also safeguards earth from harmful and poisonous after-effects, fulfilling the accountability of the concept of sustainable development.

2. AFTER-EFFECTS AT THE GLOBAL LEVEL

The amount of pressure that human race exerts upon the planet for realization of his/her desires is far greater than and ever escalating at a distressing rate.

However, , as cited from the Brundtland Report, 'Sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs' [12].

According to MEA Report, 2005, the ability of the global ecosystem to nurture future generations can no longer be counted upon [8]. With the practices human beings are following in the last four decades, as per MEA (Millennium Ecosystem Assessment) Report, 2005, there has been a decline of sixty two percent in resources like fresh water or any non-replenishing resources, or ecological balance [8], which in turn has brought about an undeniable trepidation that earth is under the danger of not only destructive but possibly irreversible changes.

From the environmental perspective, buildings account for nearly half of the entire energy utilization and raw material consumption around the globe. As stated by IEA (International Energy Agency), buildings are responsible for thirty two percent of the energy consumed globally [3]. As indicated by a research carried out by Willmott Dixon Group (2010), buildings are liable for forty five to fifty percent energy consumption, fifty percent water usage, utilization of materials for construction of buildings and roads (by bulk) is sixty percent, eighty percent of the fertile agricultural land is lost to buildings, sixty percent of timber products (ninety percent of hardwoods) are utilized for construction, around the globe [11]. It also highlights that, the estimate of global pollution that can be attributed to buildings is outsized. As per some other researches, the air quality in the cities is graded inferior by twenty three percent, buildings attribute to fifty percent GHGs, the input to landfill waste is fifty percent and input to drinking water pollution is forty percent. Another most important challenge faced is ozone depletion, the deterioration of which gets accelerated by fifty percent due to the pollution caused by buildings [13].

Residential and commercial buildings consume approximately sixty percent of the world's electricity [2]. As per the report of the Bureau of Energy Efficiency (BEE) 2006, 116 billion residential units consume 23.4 per cent of the energy and the 33 billion commercial units guzzle 6.6 per cent of the India's consumption [3]. As per the estimate of Indian Union Ministry of Urban Development there is a near consistent 8 percent rise in yearly energy consumption in the residential and commercial sectors buildings. This massive requirement for energy originates due to technological advancement which has lead to additional needs such as air conditioning, refrigeration, water heating etc., other than the prior basic needs in all kinds of buildings. For example, in Delhi during summer months this could be nearly 52 per cent of the electricity consumption [3].

Likewise, the quality of air and water is deteriorating as each day passes by. Also, there is an immense increase in the landfill waste as well, and with some of the non-recyclable building materials such as lead-based paints, asbestos, mould, wastes containing mercury, fluorescent bulbs, batteries which pose serious environmental and health problems[4], the challenge becomes bigger. These concerns clearly highlight the need for compelling efforts towards creating sustainable designs and design techniques for buildings.

3. GREEN BUILDING RATING SYSTEM

Buildings are long-lasting, and cities have even longer life span: their impacts translate into the lives of several generations to come; into a future of unknown resources, pollution and unstable climatic conditions.

The green building movement has led to the materialization of an assortment of green rating systems. The leading systems being:

- LEED - Leadership in Energy and Environmental Design, developed by the US Green Building Council (USGBC) and used in the United States of America;
- BREEAM -Building Research Establishment Environmental Assessment Method, widely used in the United Kingdom;
- CASBEE - Comprehensive Assessment System for Building Environmental Efficiency, developed by Japan Sustainable Building Consortium and is used in Japan;
- Green Star - developed by the Green Building Council of Australia and used in Australia. The New Zealand Green Building Council have tailored the Green Star tool to their own requirements;
- NABERS - National Australian Built Environment Rating System managed by the NSW (New South Wales) Department of Environment and Climate Change. This is the only rating system to measure ongoing operational performance.
- Green Mark - used in Singapore and mandated by the Building & Construction Authority for all new development and retrofit works;

The green rating systems that are currently being followed in India are:

- LEED India - administered by the Indian Green Building Council (IGBC);
- GRIHA - Green Rating for Integrated Habitat Assessment developed by TERI (The Energy and Research Institute).
- SVAGRIHA - Small Versatile Affordable Green Rating for Integrated Habitat Assessment developed by TERI (The Energy and Research Institute).

These tools are relatively new and are still in the process of improvising and evolving. More and more developers are resorting to these systems to get their buildings certified as it makes the buildings more worthwhile to the buyers due to their sustainability credentials. Many occupiers and investors

are using these tools as a guide to selecting properties for lease or acquisition.

However, as the Indian construction industry is an intricate system in which functions vary from builder, manager and designer at one end to skilled and unskilled labour at the other with no single set of specific guidelines to work upon, maintaining inter-personal communication, reaching the right drawing to the right person in time and ensuring execution as per prescribed standards is a challenging task.

Despite the challenge, TERI has endeavored to set out an agenda for green buildings through GRIHA (Green Rating for Integrated Habitat Assessment) and SVAGRIHA (Small Versatile Affordable Green Rating for Integrated Habitat Assessment). GRIHA codes and guidelines have made approach used by the Bureau of Energy Efficiency, the Ministry of Non-Conventional Energy Sources, MoEF (Ministry of Environment and Forests), Government of India, and the Bureau of Indian Standards their guiding principle. GRIHA was developed by TERI and has now been further adopted and put to implementation by the Ministry of New and Renewable Energy (MoNRE) as the Indian National Rating System for Green Buildings.

GRIHA is a rating system which evaluates the environmental performance of buildings on 34 criteria listed under varied sub-headings such as site selection and planning, building envelope design, building system design, selection of ecologically sustainable materials, integration of renewable energy, indoor environmental quality, conservation and efficient utilization of resources, building maintenance and innovation points on a scale of 0-104 points. On the basis of number of points scored, a building can be rated between 1 and 5 stars. Whereas SVAGRIHA is a recently designed system especially for small scale projects i.e. buildings with built up area less than 2500 meter square [11]. The rating system aims to achieve efficient resource utilization, enhanced resource efficiency, and better quality of life in the buildings.

GRIHA is being used to promote the concept of green buildings in India. Therefore, to oversee the various activities associated with GRIHA, MoNRE and TERI jointly established an independently registered society called ADaRSH (Association for Development and Research of Sustainable Habitats). ADaRSH functions as a platform for interaction between various stakeholders as well as promotes GRIHA, SVAGRIHA and other similar green building rating systems in India [11].

4. DESIGN TECHNIQUES EXPLAINED THROUGH CASE STUDIES

4.1 Suzlon - One Earth, Pune, Maharashtra, India

Introduction

The Suzlon - One Earth is a 5 star green rating building by GRIHA (India) and a corporate office of 45392 meter square. Suzlon One Earth is one hundred percent powered by an amalgamation of onsite & offsite renewable energy sources. Out of this, seven percent of the total energy consumption comes from 18 onsite hybrid wind turbines, solar panels & photovoltaic cells and ninety three percent of the remaining is from offsite wind turbines. It has also achieved LEED for New Construction Platinum certification from the IGBC.

Key Sustainable Features

The key strategies adopted to reduce the impact of the proposed building on natural environment:

- ***Sustainable Site Planning***:
  - Dust screens were provided around construction area to prevent air pollution.
  - Soil erosion control measures were adopted on site.
  - Utility corridors were designed along roads and pathways on site [5].
- ***Reduction in water consumption (compared to GRIHA benchmark)***:
  - Using low-flow fixtures there is a reduction in building water consumption by sixty five percent reductions.
  - Fifty five percent of the water is recycled and reused within the complex.
  - By planting native species of trees and shrubs and by using efficient irrigation systems, landscape water consumption has been reduced by fifty percent [5].
- ***Passive architectural design strategies adopted in the building***:
  - Orientation of the building is such that facades of the building face north, south, north-west and south-east
  - External louvers provide hundred percent shading on first and second floor.
  - Partly self-shading blocks have also been used.
  - Small terraces have been created in all blocks to promote interaction with external environment [5].
- ***Reduction in energy consumption (compared to GRIHA benchmark) while maintaining occupant comfort***:
  - For achieving visual comfort adequate day lighting and glare control measures have been adopted and all the work desks are equipped with LED lights governed by motion sensors.
  - Pre-cooling of fresh air as a method has been used for achieving thermal comfort and heat recovery/exchanger mechanisms have been installed to minimize energy consumption.
  - High efficiency mechanical systems have been used to reduce energy consumption [5].
- ***Renewable energy technologies installed on site***:
  - The installed capacity of solar energy is 13.44 KW.
  - The installed capacity of wind energy is 18 windmills of 4.75 kW each.
  - 250000 units of electricity generated annually.

- ***Use of low-energy/green materials***:
  - Thirty seven percent reduction in quantity of structural concrete by using Post Tension slabs.
  - Fifty percent reduction in quantity of structural steel by using Post Tension slabs.
  - Use of siporex fly-ash blocks for better insulation [5].

4.2 IOCL DO Office Building, Indore: Passive Architecture Design

Introduction

Indian Oil Corporation Limited office makes use of the concept of passive architectural design. Integration of passive architectural techniques in a building design helps to lessen the load on conventional systems of heating, cooling, ventilation and lighting. This is a 5 star SVAGRIHA rated project**.**

Key Design Features

- The building is designed optimally to reduce direct heat gain, while maximising daylight infiltration.
- More than eighty two percent of total area falls under the day lit zone.
- 2kWP solar photovoltaic panels have been fixed in to meet the energy requirements.
- Building envelope has been maximised through suitable wall and roof edifices to increase the thermal efficiency of the structure.
- More than seventy one percent of the overall open area on site is soft paved and shaded.
- Turf pavers have been used that allows vegetation growth and penetration of water [7].

4.3 One India Bulls Centre, Mumbai, Maharastra, India – Ongoing Project.

Introduction

One Indiabulls Centre is being developed by Indiabulls Real Estate Limited, a group company of Indiabulls Limited. It is one of the first commercial projects to come up on the former textile mill land situated in central Mumbai. It is a Grade A commercial property that is spread over 11 acres of land. It has a total built-up area of 1.89 million sq ft, 1.54 million sq ft of which is commercial space and 0.35 million sq ft is retail space.

One India bulls Centre is aspiring for a LEED gold certification. To achieve this, the project has followed LEED standards in the construction process, materials, energy efficiency and resource management equipment and technology.

Key Design Features

- ***Sustainable Site Planning***:
  - Recycle material such as rock and rubble on the basement of the old mill which was existing on the site earlier was used as a base for One Indiabulls Centre's foundation.
  - 30% of the material was sourced from the distance of less than 500 miles [10].
- ***Use of low cost building materials:***
  - High quality Steel with recycled content has been used.
  - Cement with twenty two percent fly ash content has been used.
  - Aerated blocks has used for solid masonry.
  - Double-glazed glass has been used to ensure heat efficiency.
  - The interior paints have low VOC (volatile organic compounds) that evaporate and become in-toxic air particles [10].
- ***Water efficiency technology:***
  - Water fixtures have fixed flow rate due to use of Ultra low plumbing Fixtures.
  - The storm water drainage system traps 100% of the storm water and does not add to the burden.
  - The Sewerage Treatment Plant (STP) treats 100% of the used water and the same is reused for landscaping and AC (meeting their 100% demand) [10].
- ***Energy efficiency:***
  - Special chillers with coefficients-of-performance (COP) equivalent to 6.5 have been designed and used.
  - Low side HVAC has been used for heating and ventilation.
  - Solar water heaters are used for heating the water for domestic use purpose.
  - The heat island effect on the roof of the mall will be reduced by developing a roof/terrace garden [10].

5. CONCLUSION

The fast paced growth in economic and human activity across the globe has put environmental resources under tremendous pressure thereby becoming a cause for irreversible damages to the environment at large and putting the quality of life of future generations to unknown risks. The increasing apprehension towards the environment is pushing the policy makers to seek sustainable solutions, leading to the origin of the theory of green buildings. The concept and criteria of green buildings is being incorporated in new as well as old structures around the globe. Even though green buildings are the need of the hour worldwide, developers face a major challenge in the development of green buildings due to increase in construction costs and lack of awareness on the benefits of green buildings, materials and technology.

In India, some of the world class Green Buildings have been constructed in the last few years, but still the concept of green buildings for general masses is in its formative years. Present work is an attempt in the direction to make people,

communities and general public aware about the advantages of green architecture for sustainable environmental development and management and highlight a few green buildings which are sustainable to the environment and profitable to the end user.

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