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Green Building Construction for Sustainable Future

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Abstract
Green building construction is relatively new phenomenon in Indian construction industry. With increasing awareness about global warming and climate change movement for sustainable development is gaining force. Indian Government also realizes the need for sustainable construction as its economy is growing at fast pace (7 to 8 percent annually) and that needs a rapid and vast infrastructure development. This paper provides a state of the art literature review on green building construction movement in India. This study provides an overview of green building rating systems, cost & benefits, green design strategies, and discusses their implications for future of sustainable development in India. A need for widespread awareness about sustainable development and capacity building for design, construction and operations of green buildings is realized.
Key Words: Green Buildings, LEED, GRIHA, Intelligent Buildings

Introduction

The Indian construction industry is experiencing a fast rate of growth with a continual increase in gross built-up area of 10% [1] per annum over the last decade. Demand for housing, expansion of organized retail, commercial office spaces by multinationals, the setting up of special economic zones (SEZs), are all increasing. This is spurred on by increasing per capita income and standard of living. Energy consumption and associated greenhouse gas emissions will therefore continue to rise unless actions to direct the construction industry towards sustainable consumption and production are taken urgently.

More positively, the practice of green building is becoming more popular in some sectors.A strong high performance buildings movement to rethink the built environment is rapidly emerging and affecting the design, construction, and operation of new buildings; changing the renovation process for existing buildings; and reshaping cities and communities. There are two established rating systems used for certification of Green Buildings in India. The first and most widely used rating system internationally is LEED (Leadership in Energy and Environmental Design). In India IGBC (Indian Green Building Council) has adapted LEED to create LEED-INDIA and is responsible for certifying buildings under this system.

Keeping in view of the Indian agro climatic conditions and in particular the preponderance of non-AC buildings, a national rating system – GRIHA (Green Rating for Integrated Habitat Assessment) has been developed which is suitable for all kinds of buildings in different climatic zones of the country. The system was initially conceived and developed by TERI (The Energy and Resources Institute) as TERI-GRIHA which is modified to GRIHA as national rating system after incorporating various modifications suggested by a group of architects and experts.

Green building construction is getting momentum in India. So far 203 buildings received certification under LEED-INDIA rating system [2] that comprises of around 1 Billion square footage of built up area. GRIHA has certified 8 buildings so far and another 67 buildings are under review for certification [3].

Awareness about green building construction is increasing day by day, thanks to IGBC, TERI and CII (Confederation of Indian Industries) efforts. However, capacity building for green building professionals, green building materials and technologies is needed to achieve the goals of sustainable construction in India.Emerging green building technologies and new green materials market is estimated to be around 40 Billion USD and it is expected to grow [4].This paper gives an overview of green building in general and sustainable construction developments in India. Importance of artificial intelligence (AI) for building intelligent homes is likewise highlighted for constructing high performance buildings.

What is a Green Building?

"Green" or "sustainable" buildings use key resources like energy, water, materials, and land more efficiently than buildings that are just built to code. With more natural light and better air quality, green buildings typically contribute to improved employee and student health, comfort, and productivity

Environmental Protection Agency (EPA) of USA defines green building as follows –

"*Green building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction. This practice expands and complements the classical building*

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design concerns of economy, utility, durability, and comfort. Green building is also known as a sustainable or high performance building."

Some of the salient features of a Green Building are:

- Minimal disturbance to landscapes and site condition
- Use of recycled and environmental friendly building materials
- Use of non-toxic and recycled/recyclable materials
- Efficient use of water and water recycling
- Use of energy efficient and eco-friendly equipment
- Use of renewable energy
- Indoor air quality for human safety and comfort
- Effective controls and building management systems

Basic Green Building Design Strategies

- Carefully planning building orientation. Making sure that smaller surfaces are facing east and west.
- Designing buffer zones on east and west facades like verandas, equipment rooms and staircases.
- Integrating screens to allow natural ventilation and cross ventilation to cool the building.
- Designing inclined windows on the south façade to avoid direct sun radiation on the windows.
- To avoid any openings like windows on the east and west.
- Using ceilings which reflect the natural light and bring it deep into the room.
- Using green roofs and green walls.
- Designing rainwater harvesting pits to collect all rainwater from the site.

Benefits of Building Green

The immediate and most tangible benefit is in the reduction in operating energy and water costs right from day one, during the entire life cycle of the building. Energy costs can be reduced by 25% - 30% in green buildings. A number of corporate are now seeing green building rating as a tool to enhance marketability.

Green Buildings provide financial benefits that conventional buildings do not. These benefits include energy and water savings, reduced waste, improved indoor environmental quality, greater employee comfort/productivity, reduced employee health costs and lower operations and maintenance costs. Various benefits from green buildings are discussed below-

Energy

Energy is a substantial and widely recognized cost of building operations that can be reduced through energy efficiency and related measures that are part of green building design.A detailed review [5] of 60 LEED rated buildings, demonstrates that green buildings, when compared to conventional buildings, are:

- On average 25-30% more energy efficient
- Characterized by even lower electricity peak consumption
- More likely to generate renewable energy on-site
- More likely to purchase grid power generated from renewable energy sources (green power and/or tradable renewable certificates)

In India CII published studies show that LEED certified buildings have significantly reduced energy consumption [6]. Table-1 shows energy savings realized in some landmark green buildings in India.

Table-1 Energy Savings Realized in Landmark LEED Certified Buildings

Building	*Sq. ft*	*Normal Energy Consumption (in similar buildings) (kWh)*	*Actual Energy Consumption (kWh)*	*%Reduction*	*Annual Energy Savings (Rs. in Lakhs)*
Wipro	1,75,000	48,00,000	31,00,000	40%	102
ITC	1,70,000	35,00,000	20,00,000	45%	90
CII Godrej GBC	20,000	3,50,000	1,30,000	63%	9

Productivity and health

The relationship between worker comfort/productivity and building design/operation is complicated. There are thousands of studies, reports and articles on the subject that find significantly reduced illness symptoms, reduced absenteeism and increases in perceived productivity over workers in a group that lacked this features [7]. For example, two studies of over 11,000 workers in 107 European buildings analyzed the health effect of worker-controlled temperature and ventilation. The Report relies in large part on recent meta-studies that have screened tens or hundreds of other studies and have evaluated and synthesized their findings.

Following are some relevant attributes common in green buildings that promote healthier work environments:

- On average 25-30% more energy efficient
- Much lower source emissions from measures such as better siting (e.g., avoiding locating air intakes next to outlets, such as parking garages, and avoiding recirculation), and better building material source controls (e.g., required attention to storage).
- Significantly better lighting quality including: more daylighting (half of 21 LEED green buildings reviewed provide daylighting to at least 75% of building space [8]), better daylight harvesting and use of shading, greater occupancy control over light levels and less glare
- Generally improved thermal comfort and better ventilation—especially in buildings that use underfloor air for space conditioning
- Commissioning, use of measurement and verification, and CO^2 monitoring to ensure better performance of systems such as ventilation, heating and air conditioning

Benefits for building owners

- Potential higher occupancy rates
- Higher future capital value
- Reduced risk of obsolescence
- Less need for refurbishment in the future
- Ability to command higher lease rates
- Higher demand from institutional investors
- Mandatory for government tenants
- Lower tenant turnover
- Costs less to maintain and operate

Cost of Building Green

Green buildings are commonly perceived to be a lot more expensive than conventional buildings and often not worth the extra cost. Considerable research and analysis has been carried out with regard to the cost impacts of a green building. Table-2 lists rise in cost of building green [9] in India. The cost could be slightly higher than a conventional building but then, this needs to be seen with a different paradigm. The question is how do we compare the costs? There needs to be a baseline cost for all comparisons to be alike. The incremental cost is always relative and depends on the extent of eco-friendly features already considered during design. The incremental cost would appear small if the baseline design is already at a certain level of good eco-design; It would appear huge if the base design has not considered green principles.

The second and rather a critical paradigm is to look at the incremental cost in relation to the life cycle cost. This kind of an approach could be revealing. Who knows, buildings would last for a 50 years or 60 years or 100 years! Over its life cycle, the operating cost would work out to 80-85 % while the incremental cost which is a one-time cost is only about 8-10 %. There is a decreasing trend in the incremental cost over the years. This trend would continue and we all look forward to the day when the cost of a green building is lower than a conventional building.

Table-2 Typical Payback Period in the Recently Constructed Green Buildings in India

Building	*Year Awarded*	*Built-in Area (Sq.ft)*	*Rating Achieved*	*% increase in cost*	*Payback (years)*
CII-Godrej GBC, Hyderabad	2003	20,000	Platinum	18 %	7
ITC Green Centre, Gurgaon	2004	1,70,000	Platinum	15 %	6
Wipro, Gurgaon	2005	1,75,000	Platinum	8 %	5
Grundfos Pumps, Chennai	2005	40,000	Gold	6 %	3
Technopolis, Kolkata	2006	72,000	Gold	6 %	3
Spectral Services Consultants Office, Noida	2007	15,000	Platinum	8 %	4
HITAM, Hyderabad	2007	78,000	Silver	2 %	3

Green Building Construction in India

Green building construction has taken-off significantly in last decade. Several institutional and government bodies have come forward to build sustainable buildings.

LEED-INDIA Certified Buildings

LEED-INDIA rates buildings in 4 categories – (1) Certified (2) Silver (3) Gold and (4) Platinum. We will elaborate two green building case studies here, highlighting key green features of these buildings and point out key design strategies applied for making these buildings green.

Suzlon One Earth

Suzlon One Earth is 816,000 SF commercial building. It three levels high and is sited on 10.5 acres. Figure-1 shows completed building picture. It achieved LEED for New Construction Platinum certification from the India Green Building Council, as well as Five-Star GRIHA (Green Rating for Integrated Habitat Assessment) certification. Five percent (154 kilowatts) of its annual energy is generated on-site through conventional and building-integrated photovoltaic panels (20%) and wind turbines (80%). All balance energy required for the campus is generated through Suzlon's off-site wind turbines, making One Earth technically a zero energy project.

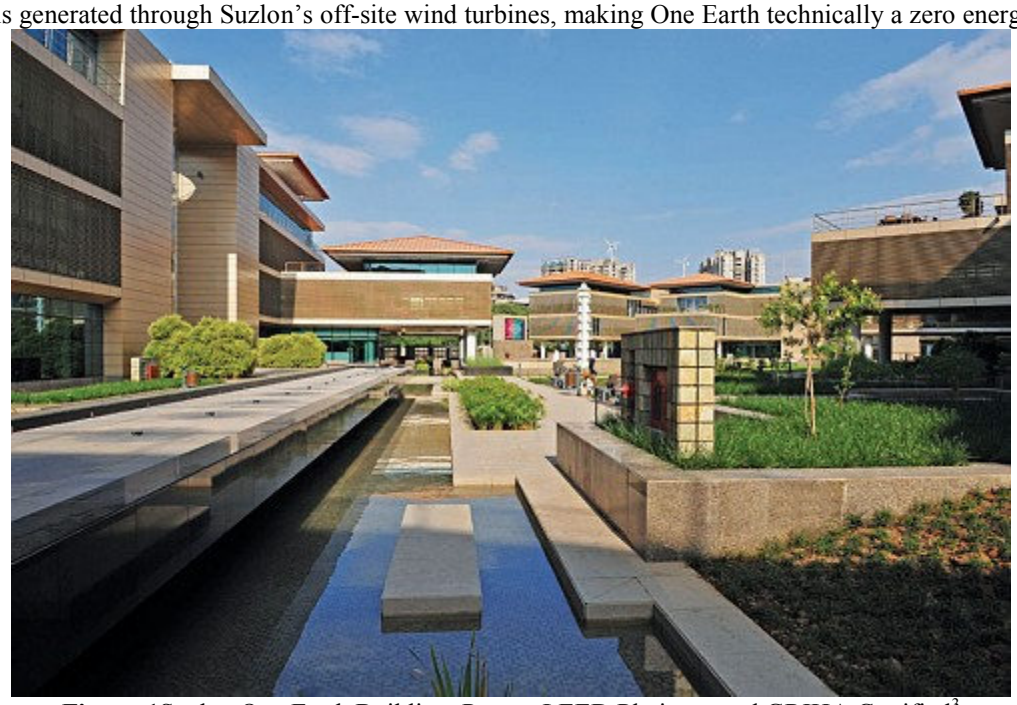

Figure-1 Suzlon One Earth Building, Pune – LEED Platinum and GRIHA Certified[3]

The design provides 90% of the work stations with daylight and external views. Aluminum louvers act as a protective skin, allowing daylight and cross-ventilation. Energy is saved by employing LED lighting systems and solar water heating. 100% of sewage grey water is recycled into flushing, landscaping and air cooling systems, while 100% of rainwater is harvested. Glass exhaust chimneys with tropical plants act as visual connectors between all floors and allow aeration of the basement parking area.

The project site was selected for the advantages of an already-developed area. It is flanked by offices of other corporations and a high-density residential area. Given its location, the building has accessibility to urban infrastructure and facilities, public transport, and established infrastructure for power and water supply.

CII Sohrabji Godrej Green Business Centre

CII Sohrabji Godrej Green Business Centre is a 20,000 SF office building located in Hyderabad. Figure-2 shows completed project picture. It is the first LEED Platinum rated green building in India. Building uses a Building Management Systems (BMS) for real-time monitoring of energy consumption.

The use of aerated concrete blocks for facades reduces the load on air-conditioning by 15-20%. Double-glazed units with argon gas filling between the glass panes enhance the thermal properties. All of the wastewater, including grey and black water, generated in the building is treated biologically through a process called the Root Zone Treatment System (RZTS).The treated water is used for landscaping. The building design was conceived to have minimum disturbance to the surrounding ecological environment. Extensive erosion and sedimentation control measures to prevent topsoil erosion have also been taken at the site during construction.

[3]Source: http://www.architecturenewsplus.com/project-images/7193

Figure-2CII Sohrabji Godrej Green Business Centre, Hyderabad – First LEED Platinum Certified Building in India[4]

Eighty percent of the materials used in the building are sourced within 500 miles from the project site. Most of the construction material also used post-consumer and industrial waste as a raw material during the manufacturing process. Fly-ash based bricks, glass, aluminum, and ceramic tiles, which contain consumer and industrial waste, were used in constructing the building to encourage the usage of recycled content. Office furniture is made of bagassebased composite wood. More than 50% of the construction waste is recycled within the building or sent to other sites and diverted from landfills. 20% of the building energy requirements are catered to by solar photovoltaics. The solar PV has an installed capacity of 23.5 kW.

Indoor air quality is continuously monitored and a minimum fresh air is pumped into the conditioned spaces at all times. Fresh air is also drawn into the building through wind towers. The use of low volatile organic compound (VOC) paints and coatings, adhesives, sealants, and carpets also helps to improve indoor air quality.

GRIHA Certified Buildings

GRIHA awards different levels of certification (one star to five stars) based on the number of points earned. We are giving details of one GRIHA certified building below.

Doon School Residential Buildings

The old buildings at the Doon School, Dehradun, were demolished and five duplex three-bed room master residences were constructed. The built up area of each residence is 2,336 sqft with a total of 11,680 sqft for five houses. The exterior of the buildings have exposed brickwork with sloping profile sheeting.

[4] Source: http://en.wikipedia.org/wiki/File:CII_Sohrabji_Godrej_Green_Business_Centre_in_2008.JPG

Figure-3 Doon School, Dehradun – GRIHA Certified[5]

A summary of the key green features adopted is stated below:

- Effective design planning to allow maximum light and ventilation inside the rooms.Use of double walls with 50 mm polystyrene insulation.
- Use of double roof.
- Use of aluminum windows with insulated double glass.
- Use of natural stone (Kota stone) in flooring.
- Use of low energy materials such as particle boards in cupboards.
- Using minimum area for paving.
- Plumbing system designed for solar water heating and recycling of waste water/rain water harvesting.
- Use of power saving light fixtures.

Conclusion

Benefits of building green include cost savings from reduced energy, water, and waste; lower operations and maintenance costs; and enhanced occupant productivity and health. Despite data limitations and the need for additional research in various areas, the data demonstrates that building green is cost-effective today, particularly for those projects which start "green" design early in the process.

Moreover, achieving higher green building construction area in India would require-

- Bridging the knowledge gap on sustainable building strategies, which exists at various levels within the industry;
- Enforcing implementation of strategies to encourage adoption of sustainable, green and energy efficient buildings; and
- Conducting research and development on technology for lowering costs.
- Support and cooperation between all the players of the sector is required. The immediate actions to be considered include:
- Development of a national platform to project individual efforts and exhibit financial benefits of sustainable buildings;
- Undertaking extensive capacity-building at various levels, including construction of demonstration projects across the country;
- Developing a business model to provide a further impetus to initiatives to minimize the detrimental impacts of construction on the environment and society;
- Introducing a green rating for residential developments and directing real estate developers to adopt this; and
- Developing, enforcing and implementing sustainability performance benchmarking for industry sectors.

[5] Source: http://www.grihaindia.org

In India, green building movement has matured to a point where today's architects, engineers, contractors and facility owners started thinking beyond the rating system and focus is shifting towards sustainable development. This paper has provided an overview rather than focused market research. The next step is to look in more detail at lessons learned across green buildings with design, technical, organizational, business and user perspectives treated equally; providing the crucial information of what works well, what does not, and how we can feed this forward into the design and implementation of the next generation of buildings.

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