Review on Green Buildings and Energy Efficiency

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Abstract— India is experiencing an incredible growth in the construction and real estate industry. Due to this rise in the construction sector raised many issues related to the environment and sustainability. As per economic policy forum, inits report mentioned that in India the energy consumption in buildings is for heating, ventilation and air Condition eraccounts for between 45% and 65% of total electricity consumption. Another study states that the construction sector of India emits about 22% of the total annual emission of CO2 which is very harmful for the Environment. So to handle the adverse situation a new and important concept is emerging in India that is Green Building. So this article gives you the understanding about the green buildings, How the green building get rating from the rating agencies, Importance of green buildings, and examples of some companies and organization that are taking the advantage of green wave and is flourishing. In this paper an analysis has given to compare between Normal buildings and Green buildings and its economical analysis.

Key words: Green Building, Green House Gas, Sustainability, LEED, IGBC, Green Materials, Sustainable Energy, Passive Energy Systems

I. INTRODUCTION

The construction industry of India has seen a great progress over the last few years. In today's scenario, the major portion of our GDP consist of construction industry as in 2011 the industry solely contributed nearly 6708 billion to the national GDP.

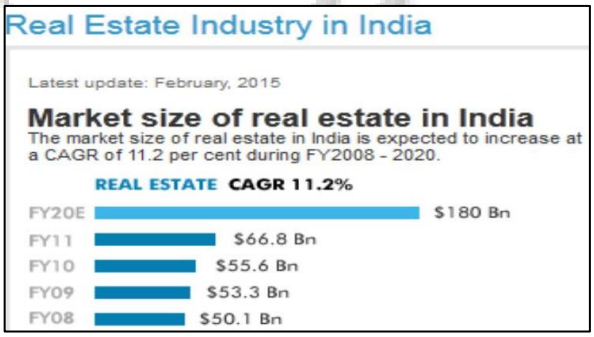


Fig. 1

According to Planning Commission of India the investment requirement of the construction industry in the 12th five-year plan (2012-2017) is approx. USD 1 trillion. So there is a huge potential in India that can be utilized for its future growth.

According to IBEF (India brand equity foundation) the market size of real estate in India

So as the industry is spreading it has also witnessed the considerable transformation from traditional building manufacturing to the green building manufacturing. So this green building concept came into limelight from the last few years .A large number of consumers these days are becoming aware of sustainability and thus demand for the energy efficient buildings that can help in minimizing the adverse effect on the environment. As per economic policy forum, in its report mentioned that in India the energy heating, ventilation and Air Conditioner accounts for between 45% and 65% of total electricity consumption. As per the study of khaled A. Al- Sallel in his paper (review of Buildings Energy Challenges), the construction sector of India emits about 22% of the total annual emission of CO2 which is very harmful for the surroundings. So to tackle the adverse situation it is important to use energy saving appliances instead of conventional appliances that consume less energy could help in saving 20,000 megawatts energy annually. By using smarter lighting system in the buildings that if lights remain on by mistake then it can automatically be switches off when nobody is present in the room can helps in saving the energy or by using air based flushing system toilets or the recycled water can also be used to reduce the wastage of water . To reduce the GHG (Greenhouse gas) emission, solar thermal systems can also be installed in the buildings. There is potential to reduce GHG emissions by 142 megatons a year by 2020 through the adoption of energy-efficient measures. These simple techniques can helps in making your building a green building that is safer for you to live in. So now the question raise here is what is Green Building? What are the advantages of Green buildings? What are the famous structures in India that are labelled as Green Building? What is the procedure to get the green building certification?

A. *Enhanced indoor air quality*

Constructing green building emphases more on the designing of ventilation system so that the people get the filtered, clean air and proper lighting most of the time. Indoor lighting also helps in controlling the dampness which is one of the main cause of dust mites and bacteria and generation of deadly diseases. So good ventilation systems enhanced the air quality of the building and protect the people from the diseases.

B. *Higher productivity of occupants*

Green building consists of the non- toxic material, proper ventilation which helps in reducing the toxic gases, bacteria and also balanced the temperature of indoor and thus make safer and healthier for the people.

C. *Use of non-toxic material*

Green buildings are built from renewable, non-toxic, reusable and recyclable materials. For manufacturing building low emission material are used like nowadays low volatile organic compounds paints are used by the constructor .VOC Paints are dangerous for the environment it quickly enter into air and create an ozone and cause air pollution. So by using non-toxic material also enhanced the life occupancy.

D. *Increased water saving up to 20% - 30% and efficient use of water recycling*

1) What is Green Building?

A green building is one which uses lesser energy, water, natural resources & creates less waste and is healthier & safer for the people to live in. Some of the features of green building are:

a) Energy saving to the extent of 30 - 40 %

A green building has a great capacity to reduce the energy consumption. As few studies had also proved that installing energy saving appliances can Water saving is another important factor in sustainable building. Water can be wasted by leaking (toilet leaking can waste up to 90 gallons per day), pool showers, while doing construction work and from other activities. Recycling rainwater and using it for toilet flushing, gardening, washing and other way can save waste-water.

b) Less Costly

Green building is considered to be expensive than the conventional building. But this theory is not true as per the Californian Sustainable Building Task Force carried out a study in 2003; according to this study even 20% of investment into green building will elaborate 10 times more saving. So there is no significant difference in prices.

2) How the Green Building gets their Certification and what is the Rating System in India?

Green building is a LEED-certified (Leadership in Energy and Environmental Design) building. LEED is established by the U.S. Green Building Council (USGBC), the organization promoting sustainability through Green Buildings. LEED is the rating system developed for certifying Green Buildings and for assessing the building performance against certain fixed criteria. To receive LEED certification, building projects have to satisfy certain minimum criteria and earn points to achieve different levels of certification. Currently, India has 2190 LEED registered buildings and 398 LEED certified buildings with 1.26 billion square feet build-up area. Now how to get the LEED certification the building project must has to get them rated from the rating agencies. The three main rating systems for Green buildings in India are:

1) IGBC
2) GRIHA
3) BEE

Other rating scheme:

– EDGE

a) Indian Green Building Council (IGBC)

Indian Green Building Council (IGBC) has licensed the LEED Green Building Standard from the U.S. Green Building Council and is responsible for providing the LEED Certificate in India. Giving a brief of IGBC. IGBC is formed by Confederation of Indian Industry (CII) in 2001 and is deliberately doing effort to promote eco-friendly concept in the Indian industry. IGBC is the non- profit research institution having its offices in CII- Sohrabji Godrej Green Business Centre, which is itself a LEED certified Green building and was awarded with the prestigious Platinum rated green building rating in India. Since then the Green Building movement in India has boost up and get the recognition.

IGBC promotes sustainability based on the principles of five performances in the following areas:

– Sustainable site development
– Water saving
– Energy efficiency
– Materials selection
– Indoor environmental quality

IGBC has also launched different rating programs to suit variety of building types.

– IGBC Green Homes Version
– IGBC Green Factory Building
– IGBC Green SEZs
– IGBC Green Townships
– LEED 2011 for India - New Construction
– LEED 2011 for India

b) Registration Process:

Registration is the initial step in IGBC. Project team interested in IGBC certification must first register itself by submitting the necessary documents and other important information as required by IGBC. And once the project is registered the project team can start preparing for documentation to satisfy mandatory requirements.

c) Certification

1) To get the IGBC rating, the project must satisfy all the requirements and the must score the minimum number of credit points. At preliminary stage the project team is expected to provide supporting documents after the preliminary submission, review is done by third party assessors and review comments would be provided within 30 working days.
2) The next phase involves submission of clarifications to preliminary review queries and final submittal within 30 days and then the rating is awarded.

3) Green Rating for Integrated Habitat Assessment (GRIHA)

GRIHA is India's own rating system developed by TERI and Ministry of New and Renewable Energy, GOI. The rating process begins with the online submission of documents as per the prescribed criteria followed by onsite visit by a team of professionals from GRIHA Secretariat. GRIHA rating system consists of 34 criteria categorized in four different sections.

1) Site selection and site planning
2) Conservation and efficient utilization of resources
3) Building operation and maintenance
4) Innovation

4) Bureau of Energy Efficiency (BEE)

The Indian Bureau of Energy Efficiency (BEE) developed its own rating system for the office buildings based on 1 to 5 star scales. More stars means that more energy efficiency. BEE has developed the Energy Performance Index (EPI). The unit of Kilo watt hours per square meter per year is considered for rating the building. BEE has launched the Energy Conservation Building Code (ECBC). This code is set for energy efficiency standards for design and construction with any building of minimum conditioned area of 1000 Sq mts and a connected demand of power of 500 KW. The Reserve Bank of India's buildings in Delhi and Bhubaneswar, the CII Sohrabji Godrej Green Business

Centre and many other buildings has received BEE 5 star ratings.

5) EDGE (Excellence in Design for Greater Efficiencies) Program in India

The IFC, a member of the World Bank Group, and the Confederation of Real Estate Developers Associations of India (CREDAI), a body of private real estate developers, have also promoting green buildings in the country through IFC‟s EDGE certification. EDGE focuses on energy and water efficiency in buildings. It allows the builders and home-owners to choose environment-friendly technical solutions while capturing costs and projected savings. And the result is saving of at least 20% in energy, water and material according to the IFC Report. Serge Devieux, IFC‟s Regional Director for South Asia said that "We aim to help builders introduce cost-effective green features into their designs and work with financial institutions and the government, to support their widespread adoption."

II. BUILDING SECTOR AND WATER CONSUMPTION

Water deficit is becoming a serious constraint in Indian cities. With irregular and inadequate municipal water supply, dependence on groundwater is increasing. National Institute of Urban Affairs (NIUA, 2005) concludes that 56 % of metropolitan, class-I and class-II cities are dependent on groundwater either fully or partially. Cities are now drawing water from sources hundreds of kilometres away, giving rise to conflicts among the users of that water. It is within this scenario that the building sector is taking shape in Indian cities. Water is used intensively both during construction and operational phases of buildings. Water is required during construction, foundation lying, brick-soaking, masonry, curing, concreting, whitewashing, setting of roofs and flooring. A study in India looked at a group of high income multistoried apartments in Kolkata with a total built-up area of over 3 million square feet. The buildings had primarily used steel and concrete as their building material. Bardhan (2011) found embedded water (water used in the production of building materials) to be 25.6 KL/sq m, while the water consumed in actual construction was 2 KL/sq m – the total (about 28 KL/sq m) was almost 8 KL higher than in countries like Australia.

According to India Business inside Database (IBID) web site, the 85, 62,021 kl of water was consumed for the construction of an entire building in Kolkata, which is equivalent to the amount of water needed by nearly 34 families with five members each for a whole year at 138 litre per capita daily. However, there is some scope of savings in this sector. For example, research on concrete mixes in Indian conditions has estimated a savings of 75 lakh tonnes of cement and 37 lakh KL of water by using water reducers.

A large part of water used in buildings can be attributed to the operational phase of buildings, where it is directly related to lifestyle of the occupants. The average water consumption in India has been calculated as 135 litres per capita per day (as prescribed by the Central Public Health and Environmental Engineering Organization or CPHEEO). But other agencies have arrived at estimates which are quite different. Attempts have been made to compile and analyse patterns of water use in buildings which indicate that toilets and bathrooms are the biggest water guzzlers in a house, with flushes, taps and showers making more than 60-70 % of the total water used (Shaban, 2008). Rate of water consumption may also depend on the scale of construction, building type and ratio of concrete and steel used.

Froeschle (1999) conducted a study on water poverty in urban India. A study by Tata Institute of Social Sciences (TISS) indicated that bathing consumes the highest amount of water in the household level. It was found on the basis of survey of seven cities that bathing accounts for about 28 % of the total water used followed by consumption in toilets (20 %), washing clothes (19 %) and washing utensils (16 %). On an average, less than 10 % of the total water in a household is used for drinking and cooking. This shows that promotion of water efficiency standards for water appliances and right pricing signals can help reduce water usage. Recycle and reuse of water may be more viable and sustainable option. Green building concept includes these factors in its assessment.

III. ECO-FRIENDLY BUILDING MATERIALS

Green building materials are composed of renewable rather than non-renewable resources. Green materials are environmentally responsible because impacts are considered over the life of project. There are many construction materials and cost involved in green buildings which are given in Table 1.

Construction materials for green building	Steel – with recycled metal	Cement – with fly ash content	Aerated blocks
	Double-glazed glass	Special chillers	Ultra-low plumbing fixtures
	Low side HVAC		
Cost involved	Consultant costs	Energy efficiency costs	Water efficiency technology cost
	Storm water control system cost	Rooftop landscaping costs	
	Energy modeling consultant cost	LEED consultant cost	Building systems consultant cost

Table 1: Construction Materials and Cost Involved in Green Building

Environmental Criteria	**Product**
Low toxicity	Materials the manufacturer demonstrates to have reduced toxicity or is nontoxic and
	Avoids carcinogenic compound and ingredients.
Minimal emissions	Products that have minimal chemical emissions, emit low or no volatile

	organic
	Compounds (VOCs), and avoid the use of chlorofluorocarbons (CFCs).
Low- VOC assembly	Materials installed with minimal VOC-producing compounds or no-VOC
	Mechanical attachment methods and minimal hazardous.
Recycled content	Products with identifiable recycled content in the material including post-industrial
	Content with a preference for post-consumer content.
Resource efficient	Products manufactured with resource-efficient processes including reducing energy
	Consumption, minimizing waste, and reducing greenhouse gases.
Recyclable	Materials those are recyclable at the end of their useful life.
Reusable	Building components that can be reused or salvaged.
Sustainable	Renewable natural materials harvested from sustainably managed sources and
	Preferably that has an independent certification.
Durable	Materials that are longer lasting or are comparable to conventional product with
	Long life expectancies.
Moisture	Products and systems that resist moisture or inhibit the growth of biological
	Contaminants in buildings.
Energy efficient	Materials, components, and system that help reduce energy consumption in
	Buildings and facilities.
Water conservation	Products and systems that help reduce water consumption in building and conserve
	Water in land scaped areas.
Improves IAQ	Systems or equipment that promotes healthy IAQ by identifying indoor air
	Pollutants or enhancing the air quality.
Healthfully maintained	Materials, components or systems that require only simple, nontoxic or low-VOC
	Methods of cleaning.
Local product	Building materials, components, and system found locally or regionally saving
	Energy and resources in transportation to the project site.
Affordable	Building product life-cycle coast comparable to conventional materials or as a
	Whole, are within a project defined percentage of the overall budget.

Table 2: Environmental Material Criteria for Use and Green Building Assessment and Evaluation (Froeschle, 1999)

IV. WATER RESOURCES

The most effective method to minimise storm water runoff is to reduce in progress area. The vegetated roof of green building is designed in such a move that native plant on the roof eliminates the storm water runoff and contaminate which facilitate and cooling of the building.

The waste water inventory develops onsite and this water can be used function that conventionally serves by portable water. This is done by storm water harvest and rain water treatment system. Green building possesses high fixtures and dry fixtures such as non-water urinals which help to reduce waste water volume in the building by disturbing portable water only for specific application benefit entire community through lower range in taxes. The most effective

Method to minimize storm water runoff is to reduce in progress area. The vegetated roof of green building is designed in such a move that native plant on the roof eliminates the storm water runoff and contaminate which facilitate and cooling of the building. The progress area on site increases the natural processes of evaporation and filtration by eliminating storm water runoff while in progress area maximizes the water runoff. Which enter develop soil erosion.

A. *Energy and Atmosphere*

At night the geo thermal heat pump system in which the refrigerant circulates through copper tubing placed in the ground exchanges heat directly with the soil through the walls of the copper tubing which is used to convert the water to ice in the ice storage box.

Green building total energy used is through the use of onsite non-polluting renewable energy systems such as VIP. We have also employed high temperature solar panels on the rooftop, geothermal and wind technologies on site.

We can observe a solar energy system converting solar energy into electricity which is used to operate the building. The use of such renewable energy reduces environmental impacts such as natural resource destruction, air pollution and water pollution.

B. *Materials and Resources*

The indispensable waste particles generated by building occupants, Green building is dedicated to the separation and storage of materials including glass, liquids, and metals.

20% to 50% of the building materials and products used are extracted and manufactured within the region, thereby supporting the regional economy and reducing the environmental impacts resulting from transportation.

Rapidly renewable building materials made from planks such as bamboo. They are typically harvested within a 10 years of cycle or shorter are used in green building.

In Green building, we have used 50% of the total value of wood based materials which are FSC certified. This way we encourage environment responsible for management.

C. *Indoor Environment Quality*

Printers and urinals are designed with offered windows increase thermal mass and other architectural element which allows passive ventilation and space conditioning. These areas should be 25 feet from other area to avoid indoor air contamination Natural ventilation is a process of supplying and removing air through an indoor space by natural means. The exterior designated area for smoking.

Daylight improve indoor environment of building by exposing occupants to natural light. A well designed daylight building is esteemed to reduce lighting energy use by 50% to 80%. Green building provides connection between indoor spaces and the outdoor through the interaction of daylight and views into regularly occupied area of the building to the building occupants.

V. INNOVATIVE IDEAS & IMPLEMENTATIONS

Some of the innovative ideas are given below:

A. *Innovative Water Waste Technologies*

The water from roof is also collected in the tank at the bottom of the building and the excess water is channelled to nearby lake. This water is used for onsite water irrigation process and it can also use portable water after the process of water treatment system.

B. *Water Reclamation System*

Water reclamation is the process where the green water collect is recycled and reused to augment the natural system and also used as portable water.

C. *Geo-Thermal Air Conditioning System:*

At night the geo thermal heat pump system in which the refrigerant circulates through copper tubing placed in the ground exchanges heat directly with the soil through the walls of the copper tubing which is used to convert the water to ice in the ice storage box.

D. *Under-Floor Air Distribution*

The ice produced during geothermal heat pump system is used to cool the building throughout the day time. Cool air is dispersed to the zone through the radiant flooring systems while the diffusers suck the hot air out of the zonal atmosphere.

E. *CFC Reduction in hvac Equipment*

CFC's are the root cause of the serious environmental and health problems. Zero use of CFC and HFC based refrigerants in Green building reduces ozone depletion and global warming. By this way it creates no harm to the mother earth.

F. *Solar Energy System*

We can observe a solar energy system converting solar energy into electricity which is used to operate the building. The use of such renewable energy reduces environmental impacts such as natural resource destruction, air pollution and water pollution.

G. *Green Power*

Installing solar panels offsite encourages investments in offsite renewable energy. This helps in supplying power equivalent to 50% of the total energy requirement of the building anywhere in the country.

H. *Rapidly Renewable Materials*

Rapidly renewable building materials made from planks such as bamboo. They are typically harvested within a 10 years of cycle or shorter are used in green building.

I. *Certified Wood*

In Green building, we have used 50% of the total value of wood based materials which are FSC certified. This way we encourage environment responsible for management.

J. *Low Emitting Materials*

A large number of building products contain compound that have negative impact on indoor air quality and earth atmosphere. We have low VOC product that improve indoor air quality during the construction process as well as lifetime of the building.

K. *Storage & Collection of Recyclables*

The indispensable waste particles generated by building occupants, Green building is dedicated to the separation and storage of materials including glass, liquids, and metals.

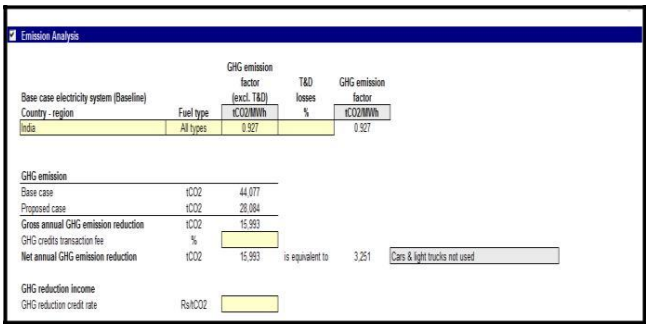
VI. SIMULATION

Our building simulation analysis involves the following steps to ensure accurate output. Understanding the region and its climate conditions, the building information model of the structure is created. A building orientation analysis is conducted to determine the optimum building orientation. A shadow analysis is performed to study the shadow effects of surrounding structures on the building. Reflection analysis is then done to study the sun path for this site. A solar analysis, living analysis and solar radiation study is also performed at this stage, and energy analysis is executed to estimate the energy usage of the building and acoustic analysis is conducted to study the flow sound within the building. A fire and smoke analysis is administered out to study the movement of smoke in the event of a fire in the building. A fluid dynamics analysis is performed to study the ventilation and airflow pattern of the building. A life cycle analysis is conducted to determine the buildings environmental and economic performance throughout its life.

In this analysis the electrical equipment are to be considered are energy efficient appliances. For this equipment the base case and proposed case are considered. By using efficient devices the power saving is of 36.2%.

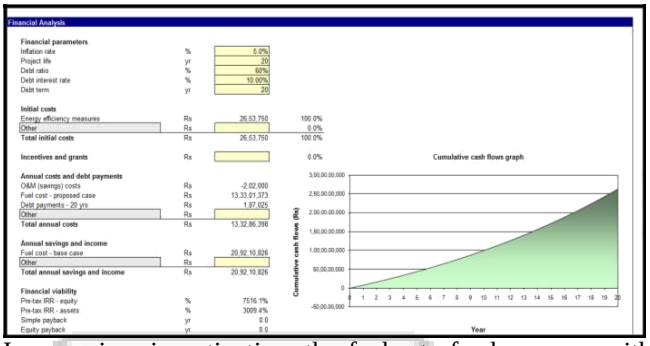
This section summarises key information for the base case and proposed case facilities, including detailed information for each fuel type used, as well as fuel consumption and annual energy use information for heating, cooling and electricity. This section also provides a tool to allow the user to benchmark their project for various energy and reference units.

A. *Emission Analysis*

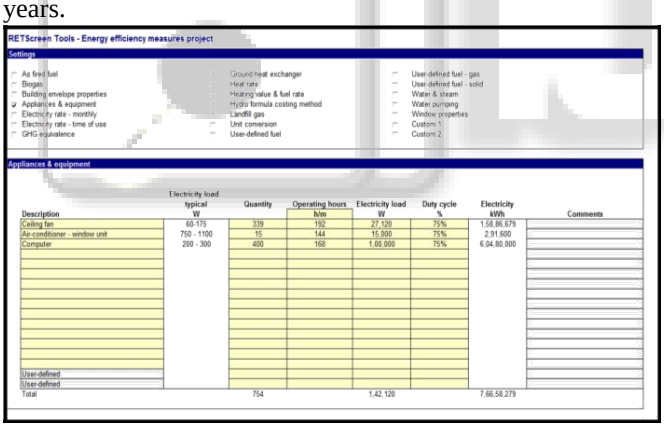


In emission analyses GHG factors are same in anywhere in India for all types of fuels and the value is 0.927 MWH.

B. *Financial Analysis*



In pecuniary investigation, the fuel rate for base case with proposed cases are compared even though the initial venture is high the payback period is very less in some times it may be accepted levels. Here the project life is considered for 20 years.



Ceiling fans, AC's, Computers are considered as tools and there total consumption of electricity is calculated.

C. *Principles of Material Selection*

1) Research

This step involves gathering all technical information to be evaluated, including manufacturers' information such as Material Safety Data Sheets (MSDS), Indoor Air Quality (IAQ), test data, product warranties, source material characteristics, recycled content data, environmental statements, and durability information. In addition, this step may involve researching other environmental issues, building codes, government regulations, building industry articles, model green building product specifications, and other sources of product data [6]. Research helps identify the full range of the project's building material options.

2) Evaluate

This step involves confirmation of the technical information, as well as filling in information gaps.Evaluation and assessment is relatively simple when comparing similar types of building materials using the environmental criteria. However, the evaluation process is more complex when comparing different products with the same function. Then it may become necessary to process both descriptive and quantitative forms of data.

3) Selection

This step often involves the use of an evaluation matrix for scoring the project-specific environmental criteria. The total score of each product evaluation will indicate the product with the highest environmental attributes. Individual criteria included in the rating system can be weighted to accommodate project-specific goals and objectives. Materials with the best score are used for the purpose they serve.

D. *Materials*

The term "materials" refers to all the physical substances that are assembled to create the interior and exterior of a building. Today most buildings are constructed from a multitude of materials, each with very specific functional demands and complex assembly requirements. For instance, an exterior wall assembly contains materials that keep the rain and wind out, thermally insulate the inhabitants from exterior temperatures, structurally support the building and the associated enclosure system, and provide desired interior and exterior finishes. In addition, windows, doors, vents, and other apertures connect to the interior and exterior of the building. The material selection process for a building design and construction is a complex issue.

E. *Desired Properties for Green Material*

There are different criteria that are applied to choose materials that can be used in green buildings. They include:

- Materials made of recycled and salvaged agro-industrial wastes
- Materials that reduce the quantity used without sacrificing the durability
- Materials that are bio gradable
- Materials with low emission of volatile organic chemicals (VOC)
- Materials that avoid toxic emissions or does not add to the ozone depletion
- Natural or minimally processed products
- Alternatives to natural wood but not made of PVC
- Products that reduce or minimize pesticide treatments and reduce pollution
- Materials that save energy and water
- Products that reduce environmental impacts during construction, demolition, renovation or retrofitting.

F. *Factors to be considered before Selecting Material*

1) Natural, Plentiful or Renewable

Are the products made from material that is rapidly renewable such as cork or bamboo? Wood products are also a renewable resource. Many engineered wood products are made from fast growing trees such as aspen and require less wood to make them than conventional lumber.

2) Recycled Content

Using material with recycled content not only reduces strain on our landfills, but reduces the need for raw material. Paper, cardboard, plastic, steel and aluminium are a few of the most commonly recycled materials. Recycled paper is used in cellulose insulation and paper countertops. Plastic is used in carpet. Metals that are recycled can be made into their original form.

3) Reusability and Recyclability

Many products, such as metals, can be recycled after their useable life. Others can be salvaged and reused somewhere else.

4) Durability

Choose products that will stand the test of time and require little maintenance. This will save time, money and energy on repairs at a later date.

5) Embodied Energy

This is the energy used to produce, transport and install a product or material in the place where it will be used. Choose local products when possible and products that do not require a large amount of energy to produce.

6) Air Quality

Products like carpet, cabinetry, plywood and paint can contain petroleum products or formaldehyde and off gas VOCs (Volatile Organic Compounds). There are now many products available that give off little or no VOCs. These products will give you a healthier home to live in. When you are not able to find suitable products, ventilate the new or remodelled space prior to moving into it. Open windows and doors when possible to remove the VOCs from the home.

7) Waste Reduction

Choose material that does not create a lot of waste and can be used efficiently.

From the above discussed criteria or factors that are to be considered while selecting the materials to be used in green construction can be organized around the following aspects that represent areas of improvement to which the building material/product can contribute to [7]:

- Energy Efficiency.
- Water Conservation.
- Indoor Air Quality and
- Affordability

G. *Resource Efficiency can be accomplished by utilizing materials that meet one or more of the following criteria:*

1) Recycled Content

Products with identifiable recycled content, including postindustrial content with a preference for postconsumer content.

2) Natural, Plentiful or Renewable

Materials harvested from sustainably managed sources, preferably having a certification (e.g., certified wood), by an independent third party.

3) Resource Efficient

Manufacturing process: Products manufactured with resource-efficient processes, that aim at reducing energy consumption, minimizing waste (recycled, recyclable and or source reduced product packaging), and reducing greenhouse gas emissions.

4) Locally Available

Building materials, components, and systems found locally or regionally, saving energy and resources in transportation to the project site.

5) Salvaged, Refurbished, or Remanufactured

Materials and products that were not disposed of but renovated repaired, restored, or generally products whose appearance, performance, quality, functionality, or value was improved.

6) Reusable or recyclable

Selected materials that can be easily dismantled and reused or recycled at the end of their use life.

7) Recycled or recyclable product packaging

Products enclosed in recycled content or recyclable packaging.

8) Durable

Materials that are longer lasting or are comparable to conventional products with long life expectancies.

Energy Efficiency can be maximized by utilizing materials, components and systems that help reduce energy consumption in buildings and facilities.

Water Conservation can be obtained by utilizing products, materials and systems that help reduce water consumption in buildings and landscaped areas, and increase water recycling and reuse.

Indoor Air Quality can be enhanced by utilizing materials that meet one or more of the following criteria:

1) Low or Non-Toxic

Materials that emit few or no carcinogens, reproductive toxicants, or irritants as demonstrated by the manufacturer through appropriate testing.

2) Minimal Chemical Emissions

Products that have minimal emissions of Volatile Organic Compounds (VOCs). Products that also maximize resource and energy efficiency while reducing chemical emissions.

3) Low-VOC Assembly

Materials installed with minimal VOC-producing compounds, or no-VOC mechanical attachment methods and minimal hazards.

4) Moisture Resistant

Products and systems that resist moisture or inhibit the growth of biological contaminants in buildings.

5) Healthy Environment Maintained

Materials, components, and systems that require only simple, non - toxic, or low VOC methods of cleaning.

Affordability can be considered when building product life-cycle costs are lower or comparable to those of "conventional" products, or are within a project-defined percentage of the overall budget.

H. *Life Cycle Assessment*

While there are many different approaches to the detailed evaluation of construction materials, in environmental performance terms there is little disagreement as to aspects of performance which should be definitely considered. Comprehensive assessments of materials performance must be in the context of complete life cycle (Life Cycle Assessment, LCA).An LCA considers the following aspects:

1) Extraction, processing and transportation of raw materials.

2) Production, transport and distribution of resulting products.
3) Use, re-use and maintenance.
4) Recycling and final disposal.

The European division of the Society for Environmental Toxicology and Chemistry (SETAC) describes the purpose of LCA as a process designed to [11]:

1) Evaluate the environmental burdens associated with a product, process or activity identifying and quantifying use of energy, materials and waste discharged into the environment.
2) Determine the impact of these resources and waste and their environmental discharges.

I. *Evaluate and put into Practice, Opportunities for Improvement.*

Now have a glance on some of the famous green buildings in India?

1) CII - Sohrabji Godrej Green Business Centre

CII-Sohrabji Godrej Green Business Centre was established in the year 2004, as CII‟s Developmental Institute on Green Practices & Businesses, aimed at offering world class advisory services in the areas of green buildings, energy efficiency, water management, environmental management, renewable energy, green business incubation, and climate change activities. The Green Business Centre in Hyderabad is awarded one of the greenest buildings in the world and through Indian Green Building Council (IGBC) is spreading the Green Building movement in the country.

Fig. 2

Fig. 3

2) Biodiversity Conservation India Ltd (Bcil) – Bangalore

BCIL-ZED (ZED stands for “Zero Energy Development”) is one of Asia’s largest Green Building platinum-rated residential apartment complex is achieving lots of awards related to the designing and the structure of building. BCIL

Fig. 4

Lead to a 400000 liter water tank located under the road behind the housing complex. The water is purified in a central reverse osmosis system without the use of chemicals. Grey water is directed to the gardens, toilets and for washing cars. A biogas digester chews biodegradable waste and generates power for the residential purpose.

3) ITC Green Centre- Gurgaon

The ITC Green Centre is also certified as one of the world's greenest buildings located in the city's famous hub, Gurgaon, the ITC (Indian Tobacco Company) Green Centre, a 170,000 square foot office complex had captured the prestigious LEEDS Platinum Award in 2004. The USGBC has re-certified the ITC Green Centre in 2012 as the world's highest Platinum rated green building. As per the ITC sources the energy use by ITC Green center has reduced by 51% and every drop of the rainwater is recycled and used for the gardening in the building

Fig. 5

Hillary Clinton, then US secretary of state said when she visited the Green Centre "This building may not be a regular stop on the tourist map, and no one would confuse it with the Taj Mahal. But it is a monument to the future,”

4) Suzlon Energy Limited – Pune

Suzlon Energy Limited has also succeeded in adding its name in the famous green building list. The building has three floors and is sited on 10.5 acres area. It achieved LEED for new construction Platinum certification from the IGBC, as well as Five-Star GRIHA certification. As per the organization report, 5% of its annual energy is generated on-site through conventional and building-integrated photovoltaic panels (20%) and wind turbines (80%).

Fig. 6

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.(information taken from www.usgbc.org/projects/suzlon-one-earth

5) Birla International School, Jaipur

Even the international schools are also into the race of green building rating system. Apart from corporate sector and residential areas many schools are also taking the initiative to provide the healthier and safer environment to the students and so they are getting their registration done for the rating.

Fig. 7

The LEED India has thus awarded the prize to Birla international school for its splendid environment friendly Green building

6) Solar Air Conditioning- Turbo Energy Limited, Chennai

The R & D Administrative Building of TEL was awarded with the prestigious Platinum award from LEED USGBC in 2009 and had got 62 points out of 69 from Leed. The solar air conditioning in Turbo Energy systems in Chennai uses solar power to control the air in the building by using photovoltaic cells to generate electricity form solar energy to be used for lighting of the office. Albido paint was applied on the roof with reflectivity of 82% and shading effect by solar dishes.

Fig. 8

The building has on/off type day lighting control to reduce artificial lighting energy consumption. Rain water from roof harvested in ponds through pipes and this water is then used for the factory usage, gardening and for other purpose.

7) 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 exterior of the buildings have exposed brickwork with sloping profile sheeting.

Fig. 9

Authorities can claim that this establishment is one of India's first green school campuses that opted for recycling measures and successfully achieved cent per cent self-sufficiency in energy, water and organic fertilizer.

8) Nokia – Gurgaon

Another India's most sustainable buildings are the office of Nokia in Gurgaon which has been awarded the Green Building Award and prestigious LEED „Gold" rating by USGBC. It's smart lighting and ventilation systems, high-efficiency chillers, heat recovery wheel, green guard certified furniture and online CO2 monitoring system makes it most sustainable & reliable building. According to Nokia India officials, benefits realized from the green establishment include 30 per cent energy savings, 35 per cent water savings and improved health (not quantifiable) of its occupants over a sustained period.

Fig. 10

"The recorded energy consumption at the Nokia office in Gurgaon is 143.96 KWH/SqMtr per year," Kaul said. In 2011, Nokia used 40 per cent of renewable electricity.

9) Indira Gandhi International Airport – Delhi T3

Terminal 3 has been awarded green building "LEED INDIA GOLD" rating from IGBC. The „Leadership in Energy and Environmental Design New Construction' rating was awarded to T3 for features like sustainability, water efficiency, energy and atmosphere, material and resources, indoor environmental quality and innovation in design categories.

Important features of T3:

- Sustainability
- Water efficiency
- Energy and atmosphere,
- Material and resources
- Indoor environmental quality
- Innovation in design

10) Olympia Tech Park, Chennai

By effective usage of grey water in the building, Olympia Techpark in Chennai has able to meet its heating and cooling requirements. They have a dual pumping line where the treated gray water is used for flushing or in irrigation. With a HVAC system they are able to have cool, indoor comfort when it's hot outside providing a year-round indoor comfort solution.

Fig. 12

11) RMZ Millenia Business Park, Chennai

RMZ Millenia Business Park in Chennai is the famous net zero energy building. Its design emphasizes conservation featuring trees to reduce adverse environmental impact, adequate natural light and shaded landscaped areas to reduce ambient temperature.

Fig. 13

The building has installed the Digital Occulux sensor that would dim-up and dim down the lights based on occupancy and daylight availability.

It is just a beginning for the green buildings concept in India. India has significantly huge opportunities for manufacturing the green building. According to the vice-chairman of IGBC, Goa, Bharat Kamat , "by the year 2030 India will expected to reach to building 100billion sq. ft. from the existing 25 billion sq. ft.". India has over 2,380 registered green building projects and is amongst the top five countries in the world involved in spearheading the global green building movement. According to the latest US Green Building Council report, India has been ranked third on the list of top 10 countries in LEED outside America, Canada followed by China occupy the top two slots in the ranking of the top 10 countries for LEED outside the US. The ranking of the top 10 countries is based on cumulative gross square meters (GSM) of space certified to LEED in each nation as of April 2014, a statement said. Canada tops the list, with 17.74 million GSM of LEED space with 4,068 total LEED-registered projects, representing. China and India, two of the world's fastest growing economies, took second and third place on the list having 14.30 million and 11.64 million GSM of LEED-certified space respectively, the statement said.

To gear up the green building concept in India the Energy and Resources Institute (TERI) and the US Green Building Council (USGBC) have entered into a strategic collaboration for the development of high performance buildings in India and Southeast Asia. So now it is also the responsibility of the citizens to save the environment and move their step ahead for the sustainability.

VII. CONCLUSIONS

It can be concluded that there are various materials which can be adopted for green construction, but we need to select the material which may fulfill maximum if not all the factors discussed above. The materials chosen must increase energy efficiency of the structure. A code for the selection criteria for the green material if being developed will help in making the complex issue easy for the common people. This way we can save the environment as well as make the efficient use of economy as well as resource.

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