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A Case Study of Planning, Design and Construction Strategies for Green Buildings

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Abstract: A green building is concerned with the energy, thermal, visual aspect of built environment. Such buildings have minimum energy consumption and the carbon emissions generated annually are also minimum. A green building can be autonomous and independent from the energy grid supply. The energy required can be harvested on-site; usually through a combination of renewable sources like Solar, Wind and Bio-mass. The overall use of energy can also be minimized by the use of extremely efficient Heating Ventilation and Air Conditioning (HVAC) and Lighting technologies. While a green building focuses on the aspects such as waste reduction, use of recycled building materials, site sustainability etc

If we look at a building site as a closed system and the electric and fuel meters as the entry and exit points for all energy used or generated on the site including in and on the building, we can define the minimum site energy target. Further, as the intent of a green building is to reduce CO2 emissions from burning fossil fuels, the site energy must be from renewable sources. So, a green building is one whose amount of energy "imported" into the site is nearly equal to the amount of renewable energy generated on site that is "exported" off the site. For electricity this would be equivalent to the electric meter rotating backward, electricity to the grid, and equal number of forward rotations, electricity from the grid, over the course of a year.

Keywords: Heating Ventilation and Air Conditioning, waste reduction, sustainable construction

I. INTRODUCTION

Green building (also known as green construction or sustainable building) refers to both a structure and the application of processes that are environmentally responsible and resource-efficient throughout a building's life-cycle: from planning to design, construction, operation, maintenance, renovation, and demolition. This requires close cooperation of the contractor, the architects, the engineers, and the client at all project stages. The Green Building practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Leadership in Energy and Environmental Design (LEED) is a set of rating systems for the design, construction, operation, and maintenance of green buildings which was developed by the U.S. Green Building Council. Other certificates system that confirms the sustainability of buildings is the GRIHA (Green rating for integrated habitat assessment), IGBC (Indian Green Building Council). Although new technologies are constantly being developed to complement current practices in creating greener structures, the common objective of green buildings is to reduce the overall impact of the built environment on human health and the natural environment by:

1) Efficiently using energy, water, and other resources
2) Protecting occupant health and improving employee productivity. Reducing waste, pollution and environmental degradation.

A similar concept is natural building, which is usually on a smaller scale and tends to focus on the use of natural materials that are available locally. Other related topics include sustainable design and green architecture. Sustainability may be defined as meeting the needs of present generations without compromising the ability of future generations to meet their needs. Although some green building programs are unable address the issue of the retrofitting existing homes, others do, especially through public schemes for energy efficient refurbishment. Green construction principles can easily be applied to retrofit work as well as new construction.

The development of modern green buildings became possible not only through the progress made in new energy and construction technologies and techniques, but it has also been significantly improved by academic research, which collects precise energy performance data on traditional and experimental buildings and provides performance parameters for advanced computer models to predict the efficiency of engineering designs.

The green building concept allows for a wide range of approaches due to the many options for producing and conserving energy combined with the many ways of measuring energy (relating to cost, energy, or carbon emissions).

II. AIM AND OBJECTIVES OF THE PROJECT

The primary goal of construction of Green Buildings is to reduce energy, water, thermal consumption. This project will review some of the available efficiency promoting technologies as well as renewable energy generation technologies that can be utilized to construct green buildings. In addition, the economic viability of green buildings will be examined. The economic enabling factors are discussed in consideration of the future for green buildings. The emphasis in a green energy home is to take a radical approach towards attaining maximum sustainability by utilizing resources efficiently.

Following are main objectives of Green building

1) Minimize overall environmental impacts by encouraging energy-efficient building design and construction (i.e. LEED)
2) Meet the Federal/State mandates associated with energy/carbon
3) Provide Energy Security for critical infrastructure
4) Reduce carbon emissions and environmental permitted requirements
5) Eliminate our dependence of volatile/finite sources of energy
6) Better forecasting for long-term strategic energy planning
7) Ensure that power will be available over the lifetime of the building
8) Eliminate line loss from the electrical grid (improve efficiency)
9) Reduce external costs (transportation and conversion losses)

III. REVIEW OF LITERATURE

The following is a review of literature related to Green building definitions and research projects. The reviewed literature is divided into a number of main important topics for the discussion of Green building.

A. Green Building and Environment

"Sustainable Development" is a necessary condition for continuation of the earth; "Healthy and Comfortable" is a necessary condition for the continuation of life. Additionally, we are facing serious energy and natural resource shortage, where global climate change is the
problem cannot be ignored (Hsieh et al., 2011).

Environmental indicators for buildings have the potential to serve as a means of making the environmental impacts (and possibly benefits) of buildings visible to all relevant factors. In addition, indicators facilitate the consideration and management of an array of environmental issues in the relevant decision-making situations. The broad acceptance of indicators across different groups of decision-makers in different phases of a building's life cycle is especially important when indicators are not mandatory, but are to be used in voluntary bottom-up initiatives. (Dammann andElle, 2006).

Assessing the environmental impacts of buildings is inherently an interdisciplinary issue. The concept of ecological capacity extends into an architectural context, and is developed as a time and area dependent tool to evaluate the effectiveness of environmental building design. By basing the measure of building impacts on the ecological capacity of a site, a common language between architectural and ecological disciplines can be found as well as useful analyses for establishing sustainability parameters can be generated. This method offers the additional benefit of generating environmental design criteria that can reduce the environmental impacts of construction. The use of ecosystems services criteria is a simple and effective method for objectively assessing the ecological impacts of a building. The overall size of the impact is measurable, as well as the ecological efficiency of the building. (Olgyay and Herdt, 2004).

The changing environmental effects have an impact on building behavior and performance. Typical areas affected are energy use and emissions, inefficiency and malfunction caused by systems confronted with a shift in operation conditions, and problems caused by overloading. Furthermore the environmental effects might cause issues, like failures in the electrical grid, which can cause problems for buildings that in themselves are functioning (Editorial, 2012).

The impact of climate change on buildings is deeply intertwined with consequences for the building occupants and key processes that take place in those buildings. As buildings have different functions, climate change impact assessment studies must be tailored towards the specific needs and requirements at hand. Complex interactions exist for instance between the comfort as experienced by occupants, control settings in the building, and energy consumption of heating and cooling systems. (Nicol and Humphreys, 2002).

For the building sector, numerous energy-efficiency market changes and benchmarking resolutions, like the mandatory E.U. "nearly Net-Zero-Energy-Building (NET-ZEB's) 2018 and 2020 regulations" for all new buildings are now set up to help minimizing carbon emissions and reverse the negative impact. (Spiegelhalter, 2012).

In order to accommodate the global climate change, the idea of constructing zero-carbon green buildings has become the main stream and highest standard in building design in many countries. The energy consumption in the buildings can be reduced up to 70% by using three major design strategies: selection of a 28 July Agric Eng Int: CIGR Journal Open access at http://www.cigrjournal.org Vol. 15, No.2 low air conditioning load location, using high energy efficient appliances, and application of energy conserving habits. Followed by renewable energy evaluation, it is Possible to put zero-carbon green building into practice. (Chang et al., 2011).

stated that buildings account for almost half of energy consumptions in European Countries and energy demand in building continues to grow worldwide. (Xing et al. 2011)

Fossil fuels are finite reserves. Impacts of peak oil will be perceived soon or later in the next decades. The scale of the challenge in reducing fossil fuel dependency in the built environment is vast and will require a dramatic increase in skills and awareness amongst the construction professions. Building refurbishment towards zero-carbon is established itself as one critical aspect to decouple from fossil fuels and tackle with future energy crisis However, it is a very complex phenomenon cuts across disciplines.
Xing et al. (2011)

Categorized a range of technologies for building refurbishment in a sequential manner. They presented a hierarchical process with embedded techniques (insulations, energy efficient equipment and micro-generation) as a pathway towards zero-carbon building refurbishment.(Terlizzese and Zanchini, 2011)

Investigated two zero carbon plants, where the first is composed of air-to-water heat pumps for space heating and cooling, PV solar collectors, air dehumidifiers, thermal solar collectors and wood pellet boiler; in the second, the air-to-water heat pumps were replaced by ground-coupled heat pumps. The conventional plant was composed of a condensing gas boiler, single-apartment air to air heat pumps, and thermal solar collectors. The economic analysis showed that both zero carbon plants are feasible, and that the air-to-air heat pumps yield a shorter payback time. The energy analysis confirmed the feasibility of both plants, and showed that the ground coupled heat pumps yield a higher energy saving.

B. Energy And Green Buildings

Green buildings are designed to save energy costs by reducing the energy consumption. Traditional buildings consume more of the energy resources than necessary and generate a variety of emissions and waste. The solution to overcome these problems will be to build them green and smart.

C. Low-Energy Building

The Kyoto protocol committed the developed countries to reduce the greenhouse gas emissions at least by 5% by 2008–2012 to tackle global warming and climate change. Some of the measures of the governments to achieve this goal are to promote new building constructi ons and to retrofit existing buildings while satisfying low energy criteria. This means improving energy efficiency of buildings and energy systems, developing sustainable building concepts and promoting renewable energy sources. The design of a low energy building requires parametric studies via simulation tools to optimize the design of the building envelope and HVAC systems. These studies are often complex and time consuming due to a large number of parameters to consider.

Developed a methodology that simplifies parametrical studies during the design process of a low energy building. The methodology is based on the Design of Experiments (DOE) method which is a statistical method widely used in industry to perform parametric studies that reduces the required number of experiments. (Chlela et al 2009)

Stated that costs and benefits of building energy efficiency are estimated as means of reducing greenhouse gas emissions. (Blackhurst et al. 2011)

Building components as well as inconsistencies in the way in which this information is derived. Whilst numerous tools exist to help facilitate the low-energy building design process, these typically require large investments of time and money that are often beyond those available within any particular project. Therefore, Crawford et al. (2011) developed a comprehensive model for streamlining low-energy building design to reduce building life cycle energy consumption. Building assemblies are ranked based on an assessment of the life cycle energy requirements associated with their use within a building. This facilitates early stage assessment, negating the need for a resolved design before the relative energy requirements of alternate design solutions are known.

They presented a sensitivity analysis of variations to the floor area, shape and orientation of the model, to test the reliability and applicability of the ranking approach across a broad range of circumstances. They found that these variations did not influence the ranked order of the assemblies in terms of their life cycle energy requirements. Thus, the ranking of assemblies appears to provide an appropriate approach for streamlining the selection of construction elements during

the building design process. Mahdavi and Doppelbauer (2010) compared the performance of passive buildings with the performance of low-energy buildings. They found that passive buildings use significantly less heating energy and offer slightly better indoor conditions.

Thereby, the required additional expenditure of resources and environmental impact (CO2emissions) are offset in a rather short period. Moreover, the required additional construction cost does not appear to be either excessive or prohibitive.

D. Passive Building

Building energy efficiency can be improved by implementing either active or passive energy efficient strategies. Improvements to heating, ventilation and air conditioning (HVAC) systems, electrical lighting, etc. can be categorized as active strategies, whereas, improvements to building envelope elements can be classified under passive strategies. A building envelope is what separates the indoor and outdoor environments of a building. It is the key factor that determines the quality and controls the indoor conditions irrespective of transient outdoor conditions. Various components such as walls, fenestration, roof, foundation, thermal insulation, thermal mass, external shading devices etc. make up this important part of any building (Sadineni et al., 2011). Aksoy and Inalli (2006) added that passive design parameters include building shape and orientation. Badescu and Sicre (2003) stated that a passive house description uses a three-temperature zone approach. The structure and physical properties of both high andlow thermal inertia components of building's thermal envelope should be considered. Recent years have seen a renewed interest in environmental-friendly passive building energy efficiency strategies. They are being envisioned as a viable solution to the problems of energy crisis and environmental pollution (Sadineni et al., 2011).

IV. INDOOR AIR QUALITY AND VENTILATION OF GREEN BUILDINGS :-

Buildings and their related activities are responsible for a large portion of the consumed

energy. It is therefore worthwhile to investigate methods for improving the energy efficiency of buildings. A hybrid ventilation system which employs both natural and

mechanical ventilation can be used for the buildings even in severe climates. On the other hand, natural ventilation for the buildings is viable in the mid-seasons. The hybrid ventilation system is a feasible, low energy approach for building design, even in sub tropical climates (Ji et al., 2009).

Khaleghi et al. (2011) concluded that, in general, mechanical ventilation can provide better indoor air-quality, but noise is an issue if the system is not properly designed. The results suggest that the acceptability of environmental factors in buildings depends on the degree of compliance of the design and its Implementation with standards and design guidelines (i.e. for ventilation, air quality, thermal comfort, etc.), whether the original design concept is ‘green’ or non-‘green’.

Gou et al. (2012) stated that green buildings can have a more significant impact on their occupant health and productivity through improving indoor environment quality (IEQ). However, post-occupancy studies invariably pointed out that green buildings were not always more comfortable and productive than non-green buildings. They presented a comparison study between three buildings (two green buildings and one non-green building) aiming to examine the actual performance of green buildings from occupant point of view. The two

green buildings marked a higher satisfaction on the health and productivity perception. However, in-depth examinations on IEQs showed some weaknesses in the two green buildings. On the comfort and satisfaction with the indoor air and temperature, the two green buildings performed better in summer but worse in winter. Indoor air quality (gaseous concentrations, temperature, humidity…etc.) and ventilation of green buildings and airflow, controlling natural light (building orientation; design, materials and area of windows) are

very important for air quality and thermal comfort inside green buildings.

V. CONSTRUCTION OF GREEN BUILDINGS

Using less materials, modular design for deconstruction, long life structure, using recoverable materials are emerging concepts to reduce environmental impacts and increase the resource and economic efficiency of buildings (Aye and Hes, 2012).

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VI. GREEN BUILDINGS IN INDIA

India's economic growth can only be sustained with corresponding to growth in infrastructure. Presently, the growing demand is being meet by crumbling infrastructure, such as road network, city transport, water and sanitation etc. A solution to contradiction requires a massive enlargement of urban infrastructure which will further require newer green and sustainable techniques for building this infrastructure. These newer techniques encapsulate the foundation of green building (Ramesh and Khan, 2013).

Green building construction has taken of significantly over large decade in India. Several institutional and government bodies have come forward to built sustainable buildings (Mehta and Porwal,2013).

The green building movement in India started with the establishment of the IGBC in 2001, which was an initiative of Confederation of Indian Institutes (CII) along with the World Green Building Council and the USGBC. The first green building in India

CII- July 2004, this was a great symbolic achievement. Since then, the number and volumes of green buildings in India has been phenomenal (Roy and Gupta, 2008).

However, capacity buildings for green building professionals, green building materials and technologies is needed to achieve the goal of sustainable construction in India.

Emerging green building technologies and green building material market is established around 40 billons USD and it is expected to grow (Kats, 2003). The green building concept has been gaining prominence in India with an increasing number of initiatives, primarily by Indian green building Confederation of Indian Industry (CII), striving to impart knowledge, offering advisory services to the industry on environmental aspects and practices for green buildings (Times of India, 2015).

VII. ASPECTS OF GREEN BUILDING

Sustainable Site: It refers to a site that would pose the least environmental threat during construction phase. The sites have access to basic amenities thereby, reducing pollution caused because of transportation. The landscape design should be such that it preserves all existing trees and restore natural topography, use drought resistant trees. Optimize the use of on-site storm water management treatment and provision for ground water recharge. Measures are adopted to preserve top soil through effective methods (Gupta and Shrivatava, 2015).

Water Efficiency: The main goal here is to increase water efficiency use within the building, thereby reducing the amount of water needed for 26 operations. Some methods which can be adopted for this include efficient landscaping techniques and use of innovative wastewater management technology.(Gupta and Shrivatava, 2015).

Technologies for reuse of water such as Rainwater Harvesting, Wastewater treatment plant, for conservation of water waterless urinals are installed (Elattar and Ahmed, 2014).

Energy Efficiency: It involves the installation of various methods of on-site renewable energy production can reduce the overall footprints of the building and other means of using green power. The optimization of building orientation, massing, shape, design and interior colors and finishes is done which maximizes the use of natural day lighting. This reduces the dependence on artificial lighting energy. Window frames, sashes and curtain wall system are so designed to optimize energy performance. Use of BEE rated electrical equipments is encouraged (Gupta and Shrivatava, 2015).

CFC-free refrigerants are used in Air conditioners and refrigerators are installed. Renewable sources of energy such as solar, wind, geothermal etc. are used to reduce the electricity loads (Elattar and Ahmed, 2014).

A. Low-Emitting Materials

Selecting low emitting materials and products not only improves human health but also goes long way in protecting the overall environment. In addition to that, it also helps the building projects achieve Green building credits from agencies like LEED, IGBC, and GRIHA, hence it is an important consideration in today's design and construction world.

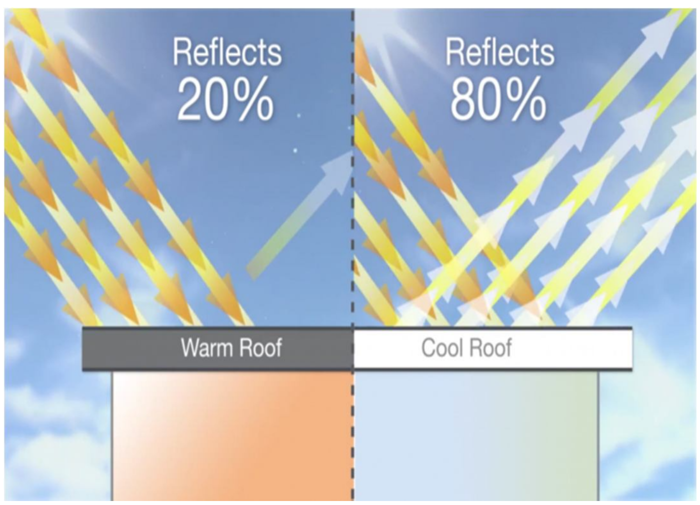
In general, low-emitting materials credit applies to a very wide range of building products which include the following:

1) Interior paints and coatings applied on-site
2) Interior adhesives and sealants applied on-site
3) Flooring
4) Composite wood
5) Ceilings
6) Walls
7) Thermal and acoustic insulation

In addition to the above, it also applies to the commercial and residential furnishings which later fill the living spaces. The reduction or no use of low emitting materials is better for the environment, for indoor air quality and are approved for use around people with environmental sensitivities, number of the product itself has been made keeping sustainability in mind with optimal usage of natural resources.

One of the best examples of low emitting building materials used is Wienerberger's environmentally friendly yet technologically advanced specialized clay bricks under the brand Porotherm. The desig tural resources and energy with a very high level of automation enabling large-scale production to cater to the growing demand from this segment.

B. Cool Roofs



The effect a roof can have on energy is often ignored, the impression of which can be momentous. In winter, inadequate or damaged roof insulation allows heat to easily escape and during summers, heat gained through the roof not only upsurges the cooling load but also increases the electricity demands.

A cool roof is one sustainable green building technology which aims at reflecting the heat and sunlight away. It helps largely in keeping the buildings at standard room temperatures by depressing heat absorption and thermal emittance. Simply put, they reflect more of the sun's rays than average shingle roofs and avert the warm/cool air inside the home from escaping through the top of a building.

The typical design of cool roofs makes use of special tiles and reflective paints which absorb less heat and also reflect most of the solar radiation away. Typically, cool roofs easily reduce temperatures by more the 50 degree Celsius during the summer months. Cool roofs help in minimizing the dependence on air conditioning systems, which in turn helps in reducing the energy use and lowering greenhouse gas emissions that result from powering our heating and cooling.

Cool roofs can be constructed with a number of materials, including special reflective paint and cool roof shingles and tiles. Check out Wienerberger's Clay Roof Solution, its one of the most environmentally responsible roofing material.

C. Green Insulation

Energy-efficient heating can only keep a building warm if there is sufficient thermal insulation to keep the heat inside. Another fact that might surprise you is that Insulation is one of the greatest concerns when it comes to the construction of buildings and homes. But, most people don't understand that these insulators are simply wall filters which do not necessarily demand the use of expensive and highly finished materials.

While choosing the best possible insulating materials, there are some prerequisites that one could consider. Some of them are discussed below.

1) Costing of the insulating material
2) Measurement of the area where insulation is to be done
3) Degree of insulation required
4) Costing of energy being consumed for heating and cooling
5) Sensible fire-proof
6) Non- absorption of moisture
7) Non – vulnerable to undergo deformation
8) Insolent of attack of little insects

Identifying basic insulating materials is very important. Here is a list of basic insulating materials; wool insulation materials, slag slabs, natural fibre insulation materials, porotherm bricks, gypsum board, vermiculite, and perlite insulation materials, cementitious foam insulation materials, gasket cork sheet, insulation facings etc.

VIII. CONCLUSION AND DISCUSSIONS

Green building is a way of implementing sustainable development within the construction industry it offers several social economic and environmental benefits to the construction industry. However little scholary attention has been given to the need to provide systematic review studies on this large number of benefits which would be useful for promoting green building.

Researchers have published studies that report various tangible and intangible benefits of green building this project reports a review of existing body of knowledge about green building benefits. This study identified a number of benefits that could be derived from implementing green building. It was found that the most reported and hence most important benefits of green building in the literature are reduced life cycle cost, energy saving, inhance occupants health and comfort,improved overall productivity, and environmental protection.The practical impication is that stakeholders who want to reduce their occupancy cost,improve their business performance , reduce their environmental impact and inhance their health and well being should not only focus on the potential high investment cost, but should also consider this benefits in theor descisions to implement green building practices

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