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Varied Aspects of Energy Efficient Green Building Technology

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***Abstract*—At present the Earth is threatened under various environmental issues like pollution, green house effect and global warming, etc. and the building accounts a considerable part of green house gas emission/carbon emission as well as their energy consumption is about 30% to 40% of total consuming energy in the world. Thus the solutions for energy efficient green building design and several factors of green building like thermal insulation, HVAC system, effectuation of renewable resources, optimize use and recycling of energy, water and other materials are cited in this paper.**

Keywords—energy efficiency; green building; green roof; hydrological cycle, Optical light tube; PV system; ZEB

I. INTRODUCTION

The varied factors comprising construction, using it and devastation of buildings and manufacturing of building material, normally put adequate impingement on the environment in diverse ways. A number of environmental crisis such as carbon emission, greenhouse effects [8], gradually declension of state of energy, scarcity of energy, gradual transformation of habitable land into desert, water and air pollution, environmental degradation have come to the picture due to unprecedented rate of urbanization and industrialization as a natural outcome of rapid population explosion. Buildings are called as gulpers of energy. In industrialized nations the building construction as well as their operation and maintenances consume 40% of the natural resources used, 70% of electricity and 12% of drinking water and produce 45-65 percent of the total waste in landfills and also a huge amount of hazardous emissions, approximately 30% of GHG [11], [9]. U. S. Government record [6] says, buildings consume 60% of the raw materials, 65% of electricity, 12% of potable water used in the United States and contribute 40% of non-industrial solid waste, 48% of greenhouse gas emissions. Hence at present the sustainability of buildings, cities as well as the environment is the major societal concern [8]. Hence different methods are developed and adopted for the evaluation of Green building criteria, such as LEED [10], BREEAM [9], HK-BEAM, BEPAC and Green Star with the environmental, cultural, societal and economical considerations [9].

II. WHAT IS GREEN BUILDING TECHNOLOGY ?

The main motto of Eco-friendly construction or energy efficient green building is optimized utilization of resources like energy, forest, land, water, and materials which are the most precious resources catering to a long, healthy and hygienic life and protecting the environment by adopting various innovative technologies and maximal resource conservation. During the construction process, proper quality, safety, security and sustainability has to be ensured by reducing such activities adversely affecting the environment. Green building practices such as green roofs and water recycling can reduce these impacts and improve efficiency to a highly appreciable extent [3].

An Eco-friendly way of designing building exclusively aims at [1]:

- Minimizing the dependencies on non-renewable conventional resources;
- Optimal utilization of available resources;
- Maximizing reuse of the available resources so as to escape from the energy crisis anticipated at every moment at present considering the current trend.

Efforts are being made to Green building practise since 1970s and since then some successful projects have been designed and used. Here some pertinent examples can be cited [8]:

- Commerz Bank Headquarters, Frankfurt in 1997
- New German Parliament, Berlin in 1999
- Portcullis House, London, 2000

Also some famous green technology projects for manifestation and research in China are as follows [8]:

- Tsinghua University Design Centre, Beijing in 2001
- Shanghai Research Institute of Building Science, Shanghai, 2004
- Super Low Energy Consumption Demonstration Building of Tsinghua University, Beijing in 2005

The major facets for design of green building [1] are, (1) Site planning; (2) Design of building outer envelope; (3) HVAC (heating ventilation and air conditioning), water heating, lighting, and economic consumption of electricity; (4) Consolidation of renewable energy sources; (5) Water and waste management; (6) Ecologically sustainable materials selection having recycled capacity and zero emission; (7) Interior environmental quality (i.e. interior visual and thermal comfort as well as air quality).

The green building technology comprises of the following major steps.

A. Site Planning

Before going for a building construction site selection and planning plays a vital role in maintaining harmony with the surrounding and also in achieving a cost-effective building design and construction. The planning ensures [4]:

- deterring development on previously undeveloped land
- denigrating a building's impact on environment
- regionally appropriate landscaping
- smart transportation choices
- diminution of erosion, light pollution, heat island effect and other constructions related pollution
- the surroundings should have some biological and ecological value

Fig. 1: Aspects for a sustainable design
[Source: http://www.conservationcenter.org/assets/GreenBuildingresourcesfinal_000.pdf]

B. Building Envelope Design

The Power and energy costs can be minimised by using Cool Coat, Cool wrap etc and the building outer wall should be painted with light colour, especially white in order to prevent the solar radiations by reflecting back most part of sun light and heat. During the construction of wall, insulating materials such as glass-wool are provided in the gaps, to avoid the temperature fluctuation inside the building so as to maintain a cooler environment inside the building even switching off the air conditioner for a sizable time and saves about 8 to 10% of energy used up by the air conditioners [1]. Window glasses should be double layered, one of which is photosensitive, that to obturate the direct sunlight entering into the house [1].

To lower down the energy consumption level the architects now-a-days are using various thermal performance simulation software, like BLAST, DOE, EnergyPlus, DeST, ESP-r, etc. These can simulate the thermal insulation of a building outer walls, roof etc under different environmental considerations [8].

A popular technique used with green buildings design is the eco-roof, better known as a green roof which is one of the most effective methods to manage storm water runoff in a building. A green roof typically achieves water retention rates from 60-80%. In the summer and during periods of little rainfall a green roof can achieve up to 100% water absorption. The green roof also acts as a layer to filter some chemicals out of the water. It can naturalize the radiation from the sun, thus making an effective insulation layer that retains heat in the winter and cools the building during summer. This can lead to a large saving on energy costs. A green roof garden typically lasts twice as long, 40 years, as a traditional roof with little to no maintenance [5].

C. Day Lighting and Natural Lighting

Day Lighting is an art of placing windows, reflective surfaces and other openings in order to get ample natural light for internal lighting during day time aiming at maximizing visual comfort and to reduce energy cost. Optical light tubes or pipes are also used for better quality lighting. These are aluminium pipes used as sun pipes installed on the roof top having a clear acrylic dome on its top and bottom part is connected to a translucent acrylic dome. Reflection losses are minimized because of the silver coated pipes [1]. The function of the translucent dome is to provide diffuse light in the living space and the pipe contains several ducts provided with mirrors and opened at various levels for transporting the light coming from the skylights or other openings of the house. Also highly reflective silvered polyester semi-collimated mirrors can be used to transmit the light over 30m with a little loss [1].

D. Energy Efficiency and Renewable Energy

Energy efficiency of a building can be achieved by using high efficiency equipments and renewable energy sources. Also a better envelope design plays a key role in reducing the heating and cooling demands. These types of residential or commercial buildings having considerably reduced energy demands are called net zero energy building (ZEB) [2]. Mechanical and electrical systems are used for improving energy efficiency and reducing the energy consumption cost of the building. The mechanical system deals with HVAC systems, i.e., Heating and cooling systems, Ventilation systems, and proper Air Conditioning in the building and the electrical system is associated with lights and electrical motor of the building. Commercial LED, organic LEDs are aimed at reduced energy cost for lightening purpose during night hours over incandescent lights.

Renewable sources of energy are the resources which can be renewed or recreated continually such as solar energy, wind, biomass, geothermal heat, tide etc. But generally near the building site, solar energy, wind and biomass can be used to generate renewable energy [2]. The photovoltaic system converts solar energy directly into electricity and this electric energy can be directly availed by connecting a wire. Vertical axis wind turbine can be chosen to meet the energy demand when PV panels do not work decently or during night or cloudy days. As the photovoltaic systems have no moving parts, thus noiseless, no rotor losses and nearly emission free. Photovoltaic heaters are used for cooling and heating purposes.

E. Water Efficiency and Waste Management

Water Efficiency refers to smart use of available water i.e., collection of rainwater or storm water as it runs off the building and would be stored in cisterns until it is required. This water can be used to water the rooftop garden or treated for potable uses within the building. This can reduce water use and utility bills. Water efficiency can be achieved through more efficient home appliances such as toilet, shower, and faucets; human attitude; reuse of waste water [10] and hydrological cycles [5].

In the buildings, water is used in a variety of ways. There are two types of wastewater generated from these uses: grey water and black water [5]. The wastewater created by activities such as cooking, cleaning, and washing is called grey water. Grey wastewater often contains chemical substances and food wastes. It accounts for about 50-80% of wastewater generated by households. The other type of wastewater is black water, which is water that was used to flush toilets. Black water is often more contaminated and needs further treatment. This waste water has to be treated and purified at a treatment plant to prevent any harmful effects to human health before it is used.

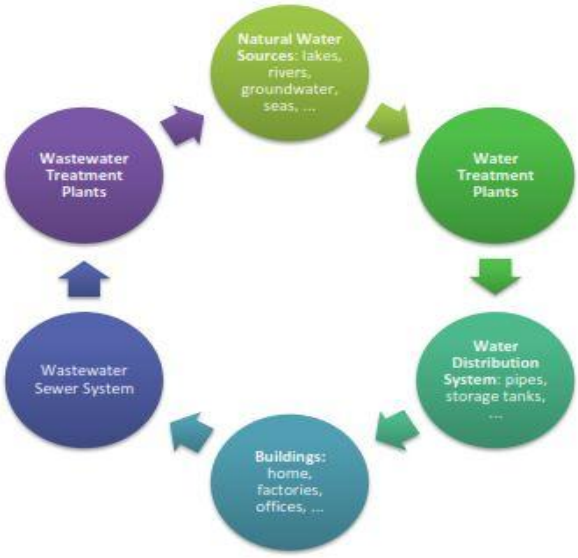

Fig. 2: Hydrological Cycle
[Source: "Analysis of Green Building Water Infrastructure Technologies at the EPA NCER", Project Number: CXP0802]

F. Ecologically Sustainable Materials and Resources

The Green building materials should be 'green' and 'clean', i.e., atoxic, renewable, reusable and recyclable, pollution-free and should not have any bad effects on human health. The products should possess good features, like antimicrobial, sterilization, anti-mildew, deodorization, thermal insulation, heat preservation, fire prevention, thermoregulation, temperature adjustment, and degaussing, anti-radiation, anti-static electricity and so on [3]. In order to prevent secondary pollution and its consequences the EPA (Environmental Protection Agency) [5] has suggested to use industrial wastes, such as fly ashes, foundry sand, and demolition dust particles in the construction works. It also leads to save the landfill spaces.

Building materials should be fabricated near the construction area in order to save the energy and transportation cost. If possible or if manufacturing location is not very far away, then building elements can be manufactured off-site and brought back to the site; this is to minimise unwanted noise, dust and waste generation in the construction area as well as to maximise recycling of the quality materials.

III. CONCLUSION

In the present scenario environmental pollution, carbon emission, global warming and quick disappearance of natural resources is the main head storm of each country. Buildings contribute a considerable part of carbon emission. Thus Green building construction and the Green building materials plays a vital role in reducing the above said problems. Each part of a building, i.e., foundations, roof, walls, windows, etc, plays key roles in energy and cost saving. Natural lighting increases the visual comfort inside a building as well as it reduces electricity consumption bill. Proper water management and HVAC system are mostly needed for an energy efficient building. All these depend upon the site planning and pre-design of a building using various simulating software. Thus before going for such project one should emphasize on innovative management and sustainable design and implementing green concept in the construction project.

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