GREEN BUILDINGS: PRESENT INNOVATION AND FUTURE NECESSITY

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Abstract: This paper represents the modern techniques which can be implemented for enhancing the efficiency with which building can be designed to meet the needs of occupants for thermal and visual comfort, beautiful and healthy work environment at reduced levels of energy waste and resources consumption. This paper aims to study the energy efficient design techniques and provisions of making building energy efficient. It also provides an overview of existing energy efficient building with different provisions and technique. This paper provides an overview of various energy efficient techniques and low energy materials used for energy efficiency in building, so that slight modification and changes in an existing building can lead to energy saving with payback period of about 2-5 years. It includes study of various energy efficient techniques used in green buildings and listed major energy saving approaches that can be used in designing a building to meet certain objectives such as occupant health, use of renewable energy, water and other resources more efficiently and reducing the overall impact on environment with cost savings. Existing green building examples with their salient features are reviewed for easy understanding of modification that can be done as per green building concept. Green retrofitting can increase credits of chosen building for its various green features which is supported by various government and private agencies financially to inspire construction in direction of green buildings.

Keywords: cavity walls, energy efficiency, fenestration, green building, urban heat island

I. INTRODUCTION

"Energy Efficient Building" is a building which includes unique construction techniques for increasing the energy efficiency with which building use free natural resource of energy, water and material while minimizing energy waste , ensuring occupants health, safety and comfort throughout the building lifecycle without requiring special materials or construction skills is called an energy efficient building or green building. It uses processes that are environmentally responsible and resource efficient throughout a building life-cycle like construction, operation, maintenance, renovation and deconstruction.

Globally, building sector consumes 42% electricity, which is comparatively higher than other sectors. India's growth rate in construction industry is 10% as compared to world average which is 5.2%. In next

20 years, 30% rural Indian shift to urban areas estimating an increment of 25 billion ft² to 100billion ft² construction area, while there is very little margin between existing power supply and electricity demand. In 2016, total electricity coverage is 81% in which 66.2% are share of fossil energy (particularly coal) and 31.8% are share of renewable energy. The potential for energy saving is 40-50% in buildings, while slight modification and green retrofitting can save upto 20-25% energy in an existing building. The incremental cost incurred in energy saving is 5-8% with an attractive payback period of 2-5years.

II. ENERGY EFFICIENT TECHNIQUES

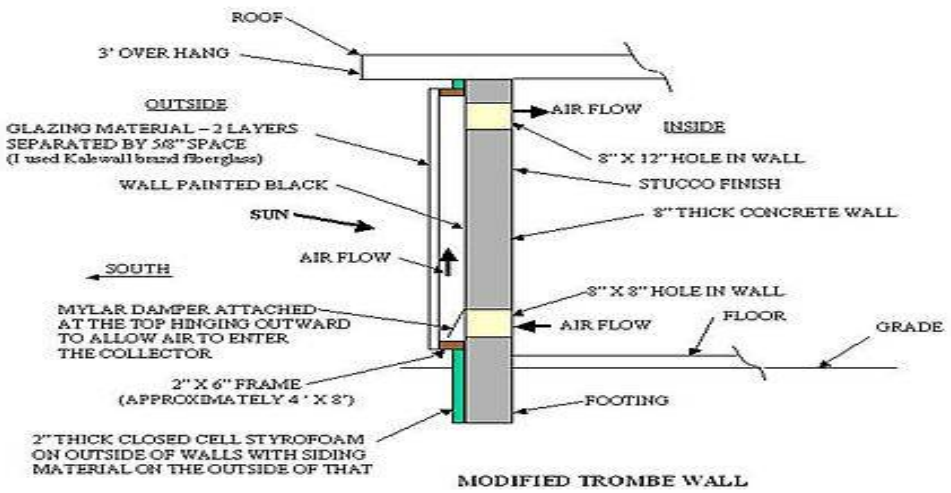
In ancient times, building is designed with maximum use of natural resources and eco-friendly concept. At present, when heat enters inside high rise concrete buildings it will not escape easily, causing urban heat island effect heat so to overcome this A.C. and other electrical devices are used which pollute environment by emitting toxic gases, green house gases as well as heat released from these devices also increases dependence on electricity. Major energy efficient techniques are listed below:

(i) Orientation of Building: Proper orientation can help increase or decrease the heat load by 5%. For hot climates, minimize exposure on the south and west. Keep long façade towards north-south direction. North facing wall receive solar radiation in winter while south facing wall in summer. Keep longer wall towards north to minimize exposure to sun in summer and maximize in winter. In hot humid or hot dry climate, use tree or adjoining building to shade every façade which exclude direct sun and capture or funnel cool breezes. Fenestration recommendations given in IS 3362-1977 code of practice for natural ventilation in residential buildings. Cavity wall construction in east and west façade provides better heat and sound insulation also avoiding rain penetration. Use simulation tools and techniques which can help in designing the orientation to minimize heat ingress and enhance energy efficiency by proper coordination in building design according to its geography, vegetation, surrounding water resources etc.

(ii) Earth Air Heat Exchanger: Daily and annual temperature fluctuation decreases with the increase in depth below the ground surface. The temperature inside the earth below 4m of ground remains nearly constant round the year and is nearly equal to the annual average temperature of any place. Earth tunnel system has a pipe which embedded at a depth of about 4m below the ground surface. It will acquire same temperature of about 26°C as the temperature of surrounding earth at its top surface and hence the ambient air ventilated through this system will give the cooling in summer season and heating in winter. It uses air blower of 0.5 hp connected with thermo-stat device. The electricity cost incurred is only 0.08 units for ceiling fan and heat exchanger fan as compared to A.C. system of 1400Watts with 1.4units consumption per hour.

(iii) Solar Chimney: It consists of a vertical shaft for utilizing solar energy to enhance the natural stack ventilation through a building. The solar energy heats up the chimney during daytime so that air within it creates an updraft of hot air inside the chimney. The suction created at the chimney's base can be used to ventilate and cool the building below.

(iv) Trombe Wall: A typical trombe wall comprises 20cm to 40cm thick masonry walls. These walls are painted by a dark black heat absorbing colour and faces of wall having single or double layer of glass. To create a small air space the glass is placed between 2cm-15cm far from the masonry wall. The sun's heat passing through the glass panes is absorbed by the dark painted surface and this heat is stored in the wall and conducted slowly towards inward through the mass of the wall. The glass protects escape of radiant heat from the hot surface of the storage wall. The heat radiated by the wall is trapped within the air gap, again heating the wall surface. It takes at most 10 hours to heat up and to reach the sun rays upto interior of the building so that the room behind remains comfortable throughout the whole day and after the sun sets, it receives slow heating evenly for many hours.



MODIFIED TROMBE WALL

(v) Evaporative Cooling: It is used to lower indoor air temperature by evaporating water. This technique is used in areas of lower atmospheric humidity or hot-dry climatic zone. In this process, the sensible heat of air is utilized to evaporate water so that it cools the air which in turn cools the interior space of the building. The rate of evaporation is increased with increase in contact between water and air. The presence of any water body such as pond, lake, sea etc. near the building or fountain in a courtyard provides cooling effect. The most common application is desert cooler which comprises of water, evaporative pads, a fan and a pump.

(vi) Photovoltaic Cell System: Photovoltaic cell capture solar energy and convert it directly to electric current by separating electrons from parent atoms and accelerating them across a one way electrostatic barrier. Efficiency of energy capture of PV cell is increased ten times in past 25 years having vast future scope in generating electric power. These are silicon based punch which receives sun heat and converted into electricity through photoelectric effect which can be directly utilized for lighting and can be stored in invertors.

(vii) Energy Efficient Roofing: The heat ingress through the roof can be as high as 12-15%. Techniques to reduce heat gain through roof include green roof, high reflective materials on roof top, thermal insulation and external shading of roof.

(viii) Rain water harvesting: A rainwater collection system is a simple way for the operation of a building to conserve water use. The rainwater would be collected as it runs off the building and would be stored in cisterns until it is needed. The rainwater can be diverted to garden and toilet overhead tank through pipelines for flushing, washing etc. Collected water can be treated to be used in sanitation, washing and even drinking after reverse osmosis.

(ix) Miscellaneous Techniques:

● *Air lock lobby at the entrance*, to minimize heat loss during entrance and exit: This is double glazed and reduces the infiltration of air within the building.

● *Solar heat collector Wall*: This is a glazed wall provided in the front of the building to allow and collect sun heat in the space behind it.

● *Wall insulation by Polyurethane board*: In this system, insulation against sun heat through outer wall is provided through a layer of 40mm thick polyurethane form in the outer face of outer walls. This technique is used in TCI (Transport Corporation of India) building, Gurgaon.

● *Solar water heating system*: It is used to absorb the sun's energy to heat up water and water circulates to the reservoir. The excessive heating is avoided by thermostat device which drains back water when preset temperature is reached.

● *Sun shading by vegetation*: To provide direct entry of sun rays into the building through doors and windows trees and creepers are provided for shading.

● *Fountain court with water columns*: These are provided to cool the inner atmosphere of the building and acts as an environment moderator.

● *Earth Berming*: It is a technique for reduction of heat by sun gain. It is the earth collection over outer walls acts as an insulation buffers. It is in the form of slope around the outer walls of the building to cool the building through cooling effect effect of south and by insulation of outer walls against sunrays and sunheat.

● *White reflecting colour on walls*: White coloured wall surfaces reflects and reject sunradiation and prevents heat gain in the building. This is used in the residence of Mahendra Patel Ahemdabad.

●*Day light with skylights*: In this system the roof is provided with glazed panels to allow sunlight in dayhours for energy saving against lighting the space. This is used in workshop building of solar energy center Gurgaon.

● *Fenestration and shading*: Fenestration is the proper design of windows and ventilators in the rooms. Proper location, sizing and detailing of window and shading are important for proper lighting and ventilation openings at higher levels naturally aid in venting out hot air. Size shape and orientation of openings moderate air velocity and flow in the room. A small inlet and large outlet increases the velocity and distribution of air flow through the room to help the heat and wind out of a building as allow when needed. Shading over outer doors and windows reduces heat gain during summer. This technique is provided in office-cum-lab of West Bengal pollution Control Board, Kolkata.

● *Energy Efficient Lighting systems* like Light Emitting Diodes(LEDs), energy efficient fans and tube-lights with electronic chokes that are developed for energy saving.

● *Reduction of heat gain by air cavity in walls and roofs*: Hollow air spaces within walls as an attic space, in the roof ceiling combination reduces the solar heat gain factor, thereby reducing space conditioning loads. The performance improves if void is ventilated. Ventilation reduces convective heat transfer but radiative component of heat transfer can be reduced using high reflective coating (e.g. aluminum foil) on either surface facing the cavity. The example of building using this system is Dilwara Bagh, Country house for Reena and Ravi Nath, Gurgaon.

● *Hybrid system with upto 50KW bio mass gasifier*: This utilizes waste organic materials which get converted into gas which is then used for electric power generation. Retreat building, Gwal pahari, Gurgaon is an example of building using this system.

● *Hollow concrete blocks to reduce heat gains*: These blocks provide thermal insulation against outside sun-heat and keep inside of building cool and are provided on outer walls. Solar energy center, Gwal Pahari, Gurgaon is an example of building using this system.

● Adjustable venetian blinds in double window sandwiched to cutoff insulation and allow daylight

● The roof finished with china mosaic and is insulated using 30mm thick polyurethane board insulation above the RCC slab. This system is used by-Development of property at Civil Lines, Delhi. Sangath- an architect's studio, Ahemdabad.

● Sunspaces on the south side: It is a system to maximize solar gains The sun-spaces is south facing collector space attached yet separated from building by thermal storage wall directly heats up by the solar radiation which heats up the living space by convection and conduction through the masonry of wall. Sunspaces may be used as a winter garden.

● To resist heat, select high performance glazing with low Shading coefficient and low U-value(heat gain). Insulate the wall using insulation materials like Extruded and Expanded polystyrene (thermocol), Glass wool, polyurethane board, gypsum board panels, hollow terra cotta blocks, Fly ash bricks and Autoclaved Aerated Concrete (AAC) Blocks. Exterior finish using low voc paints, white wash and dry distempers, Stone cladding, Grit wash etc. are eco-friendly and looks beautiful. Use of broken china mosaic and light colored tiles at roof finishes, green roof and landscaping can reduce heat gain to 15-18%.

Following example of green building in India illustrate its features and adopted green design techniques:

(i) Head Office for Spectral Services Consultants Pvt. Ltd. Gurgaon: It is located on plain land with moderate climate. Its features includes top lit atrium and building fenestrations for day lighting, storm water management and reuse rain water harvesting, soft landscape to reduce urban heat island effect, solar water heating system, shading devices on south and west façade, high performance glazing, use of local regional materials and certified green woods, insulation in roofs and walls, hermetically sealed glazing. Air intakes away from contaminated sources, ventilation effectiveness by displacement ventilation system, building envelope to optimize air change, harnessing maximum sunlight by orientation, night lighting by smart lighting, motion sensitive occupancy sensors control lighting in toilets and meeting rooms.

(ii) Energy Research Institute, Bangalore: Green design techniques adopted in the building includes orientation along NE-SW direction as S-W is the primary wind and light direction in Bangalore. South wall is double wall to provide insulation from southern sun. PV cells for electricity generation, solar heater to generate all hot water in guest house. Ventilation by solar chimney and vents create negative pressure for pulling fresh air. Fenestrations, creating atrium spaces with sky lights reduces dependency on artificial lights. Rainwater harvesting system preserves water to maximum extent. Water run-off from roof and paved areas is collected and stored in collection sump which is used in landscaping and toilet.

Green roof is used to reduce inside temperature. Eco-friendly materials, filler slabs, fly ash blocks, laterite blocks and soil stabilised blocks etc. are used.

III. METHODOLOGY OF GREEN BUILDING

(i) Site: Recycle job site construction and Demolition waste, salvage reusable building material, remodel for mixed use, adaptive reuse, and Historic preservation, and protect native soil. Minimize disruption of existing plants and trees. Implement construction site storm-water practices. Protect water quality with landscape design and design resource-efficient landscapes and gardens.

(ii) Foundation: Incorporate recycled fly-ash in concrete, use recycled-content aggregate and insulate foundation before backfill.

(iii) Structural Frame: Substitute solid sawn lumber with engineered lumber. Use Forest Stewardship Council (FSC) certified wood for framing. Use wood I-Joists for floors and ceilings. Use recycled-content steel studs for Interior Framing. Apply advanced framing techniques. Use Structural Insulated Panels (SIPs)

(iv) Exterior Finish: Recycled-content decking, Forest Stewardship Council (FSC) Certified Wood Decking, use treated wood that does not contain chromium or arsenic for decking and sill plates and use fiber-cement sliding materials.

(v) Plumbing: Install water heater jacket, insulate hot and cold water pipes, and retrofit all Faucets and showerheads with flow reducers. Replace toilets with ultra-low-flush models, install chlorine filter on showerheads, water filtration units at faucets, on-demand hot water circulation pump. Convert Storage tank to tank-less water heaters.

(v) Electrical Lights: Install insulation compatible air-tight (IC-AT) recessed lighting fixtures with Compact Fluorescent Lamps (CFLs) and Light Emitting Diodes (LEDs), lighting controls, high efficiency ceiling fans with LEDs.

(vi) Appliances: Install energy star dishwasher, washing machine with water and energy conservation features, energy star refrigerator and built-in recycling center.

(vii) Insulation: Upgrade wall and ceiling insulation. Install floor insulation over crawl space, recycled-content, fiberglass insulation with no added formaldehyde and alternative insulation materials

(viii) Windows: Install double pane energy-efficient windows or low solar heat gain coefficient (SHGC) window film on single-glazing.

(ix) Heating Ventilation and Air-Conditioning (HVAC): Install new ductwork within conditioned space, attic ventilation systems and whole house fan.

(ix) Renewable Energy and Roofing: Pre-plumb for solar water heating. Install solar water heating Photovoltaic (PV) System and radiant barrier. Select safe and durable roofing materials.

(x) Natural heating and cooling: Incorporate Passive Solar Heating. Install overhangs over south facing windows. Plant deciduous shade trees on the west and south sides.

(xi) Indoor air quality and finishes: Use low/no VOC (volatile organic compound) paint, low VOC water-based wood finishes and adhesives. Use engineered sheet goods with no added formaldehyde and exterior grade plywood for interior uses.

(xii) Flooring: Select Forest Stewardship Council (FSC) certified wood flooring, rapidly renewable flooring materials, recycled-content ceramic tile, exposed concrete as finished floor. Install recycled-content carpet with low-VOCs.

V. CONCLUSION AND DISCUSSION

Retrofitting and slight modification in an existing or a new structure by energy efficient techniques can boost the use of natural resources and ultimately making it eco-friendly and energy saving throughout the life cycle. Further work can be done for similar other energy efficient techniques for lighting, heating, ventilation and air-conditioning with cost-effectiveness in comparison to conventional methods. Since the life cycle of the building is 50 years so it is fruitful for the remaining period to enjoy free energy and this study will provide an overview for the construction of energy efficient buildings by using energy efficient materials and construction techniques, which when adopted, can cut the overall energy consumption additionally by 25% to 30% as per literature studies available.

Indian Green Building Council is targeting 10 billion square feet area of green building by 2022. Also, government is continuously emphasizing on energy saving schemes and lowers the cost of various equipments like solar panels, low power devices etc. to popularize green technology so that adoptability of energy efficient system among public can be increased.

REFERENCES

1. American Society for Civil Engineers – “green project management practices for sustainable construction” Journal of Management in engineering, January-2011.
2. Devarshi Tathagat, Dr. Ramesh D. Dod, “Role of Green Buildings in Sustainable Construction – Need, Challenges and Scope in the Indian Scenario” IOSR-Journal of mechanical and civil engineering, vol.12 pp.01-09, March-2015
3. Energy conservation building code tip sheet for building envelope, March 2011.
4. Energy efficient buildings in India by TERI and MNRE, New Delhi (2001).
5. P.S. Jatav, Deepak Rastogi, Dr. M.K. Trivedi “Energy saving in building by using energy efficient green building materials” IRJMST vol.5, 2014

6. Ramesh S.P., Emran Khan M, "Energy Efficiency in green buildings- Indian Concept". International Journal of Emerging Technology and Advanced Engineering vol.3, pp.329-336, February 2013.
7. Rakesh D Patel, P.V. Ramana "Experimental Analysis of Horizontal and Vertical Buried Tube Heat Exchanger Air Conditioning System" Indian Journal of Science and Technology, September 2016.
8. Shahi R.V.(2006) "Energy Efficiency in Buildings" Keynote addressed for Indian-International Energy agency (IEA) in joint workshop on Energy Efficiency in Buildings and Building codes, held on 4-5 October in New-Delhi.
9. Sharan Girija and Jadhav Ratan, "Performance of Single Pass Earth-Tube Heat Exchanger: An Experimental Study". Published by Indian Institute of Management, Ahemdabad.(2003)
10. Sneha Shahare, T. Harinarayana "Energy Efficient Air Conditioning System Using Geothermal Cooling – Solar Heating in Gujarat, India".2016
11. SVAGRIHA "The energy and research institute and association of development and research of sustainable habitats" 2011.
12. U.S. green building council (USGBC) 2006 & UNEP 2007
13. www.energystar.gov. "Energy Star Ceiling Fans" (2010)
14. www.export.rehau.com "Some Notes on Earth Tubes" (2008)
15. www.terijn.org "Energy and Resource Institue"
16. www.architecturelive.in "energy efficient buildings of India"
17. www.synergycarbon.com "energy efficient building design"
18. www.trombe-wall.org
19. www.isover.com "how to design and build an energy efficient building"