Research Article Impact Factor: 4.226 ISSN: 2319-507X
Malini Nathe, IJPRET, 2016; Volume 5 (2): 383-393 IJPRET

INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

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SPECIAL ISSUE FOR
INTERNATIONAL CONFERENCE ON "INNOVATIONS IN SCIENCE & TECHNOLOGY: OPPORTUNITIES & CHALLENGES"

ENERGY EFFICIENCY AND SUSTAINABILITY IN ARCHITECTURE

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Accepted Date: 07/09/2016; Published Date: 24/09/2016

Abstract: *Sustainability can be defined as the continued ability of society, an eco-system, or any such interactive system to function without exhausting key resources and without adversely affecting the environment. Sustainable development has been defined by the Brundtland Commission (1987) as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs.' The concept of living within the capacity of supporting eco-system has also been suggested as basis for sustainable development. In the context of habitat design sustainability recognizes the intricate relationship between human civilizations and natural habitat. It realizes the fact that nature must be preserved and perpetuated if the human community itself is to survive. Any development will have some environmental impact. Thus, one must think to develop so as to minimize the environmental impact, while maximizing the environmental, economic and social gains. Design strategies for making Building energy efficient and sustainable in terms of site planning, climatic conditions, landscaping etc. are suggested in this paper.*

Keywords: *Climatic design, sustainability, energy efficiency.*

PAPER-QR CODE

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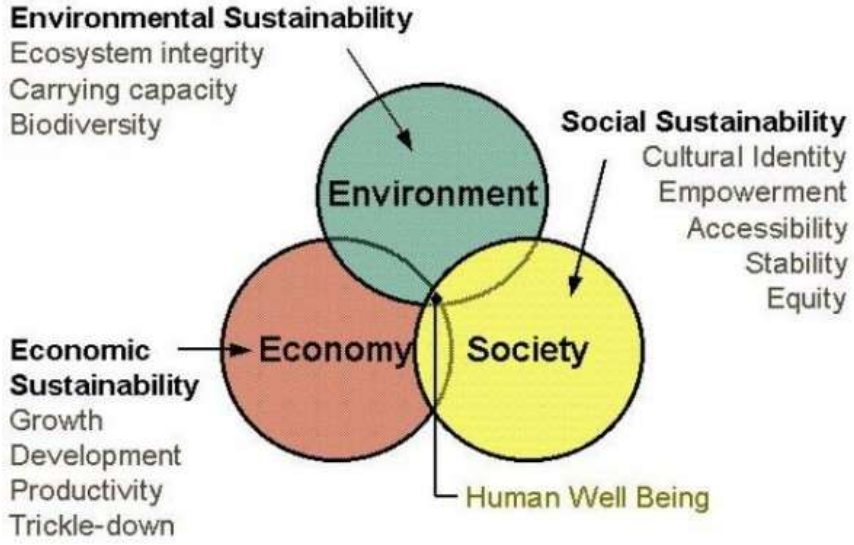
How to Cite This Article:

Malini Nathe, IJPRET, 2016; Volume 5 (2): 383-393

INTRODUCTION

Basic need of mankind is shelter food and clothing. Building sector in our country is one of the largest energy consuming sectors. Building continues to play a significant role in the global total energy balance; about 25% of the total energy demand of the nation is due to the building material manufacture and another 30% goes into the running needs of buildings with the increasing awareness of the ecological consequences of energy consumption. The need for energy optimization in building design has become the need of the hour



Buildings as they are designed and used today, contribute to serious environmental problems because of excessive consumption of energy and other natural resources.

The close connection between energy use in buildings and environmental damage arises because of energy intensive solution to construct a building and meet its demand for heating, cooling, ventilation and lighting which causes damages to the invaluable environmental resources.

II. SCOPE OF STUDY

The study of energy optimization in building design leads to the:

1 Creating awareness of designing energy efficient building envelope by taking advantage of the climatic conditions of a particular region.
2 To develop or propose some other techniques which would help in optimizing energy.
3 To advocate the application of renewable energy systems.

The energy crises confronting the energy supply sector can still be overcome by designing and developing future buildings on the sound concept of energy efficiency and sustainability. Thus

the study would prove to be a source of inspiration to correct our modern building concepts and practices. Buildings can be designed to meet occupants' needs, thermal as well as living comfort as reducing level of energy consumption. Energy efficiency in the building can be achieved by adopting an integrated approach to the building design.

Aims and Objectives of Sustainable Design:

1 Energy optimization by integrated design approach to building design
2 To conserve energy to creating sustainable environment.
3 Incorporate solar passive techniques in a building design to minimize load on conventional system.
4 Designs for optimization of energy in lighting, heating, ventilation and cooling.
5 Use of renewable energy systems(solar photovoltaic system/solar water heating systems etc)
6 Use of low energy materials and methods of construction and reduce transportation energy, use of locally available materials i.e. cost effectiveness.
7 Recycling or reuse of water for landscaping.
8 Rain water harvesting.
9 Efficient water management and Waste water treatment

Climate

Climate affects man both physically and psychologically. Hence it plays important role in determining the design & construction of building.

1 Climate has a major effect on building performance and energy consumption. Energy-conscious design requires an understanding of the climate.

2 Energy efficiency can be achieved by studying macro and microclimate of site, and applying bioclimatic architectural principles to combat adverse conditions and taking advantage of desirable conditions.

Climatic Elements influencing Physical Comfort are – Air, Humidity, Solar radiations, Wind, Precipitation, Sky condition. Climatic zones such as tropical, arid, temperate and cool are commonly found for representing climatic conditions. The general climate (macroclimate) is influenced by the topography, the vegetation and the nature of the environment on a regional scale or at a local level within the site itself (microclimate). Because climate is the only factor that determines the comfort of a built form and if it is not designed accordingly the building will consume energy to achieve comfort.

Thus our very first step towards energy optimization is understanding and analyzing the climatic data for design of structures with an aim to minimize energy.ie Temperature, Humidity, Solar radiation, Wind, Rainfall.

III. DESIGN CONSIDERATIONS

Design considerations for cost effectiveness and energy efficiency.

1. Site And Building Orientation
2. Plan forms.
3. Internal Layout Of Building I.E. Space Efficient Building
4. Fenestration And Shading
5. Courtyard
6. Landscaping
7. Building Materials And Construction Techniques
8. Use of Energy Efficient Appliances.
9. Waste Management
10. Water Harvesting

1. Site and Building Orientation

1. Building orientation is a significant consideration related to solar radiation and wind.
2. Orientation should be such that the building should not gain maximum solar radiation but at the same time should gain winter sun for hot regions. In cold regions buildings should be oriented for maximum solar gain.
3. The solar radiation affects the external surface temperature, thermal expansion and contraction of building element, durability and weathering capacity. This in turn affects the internal temperature too.

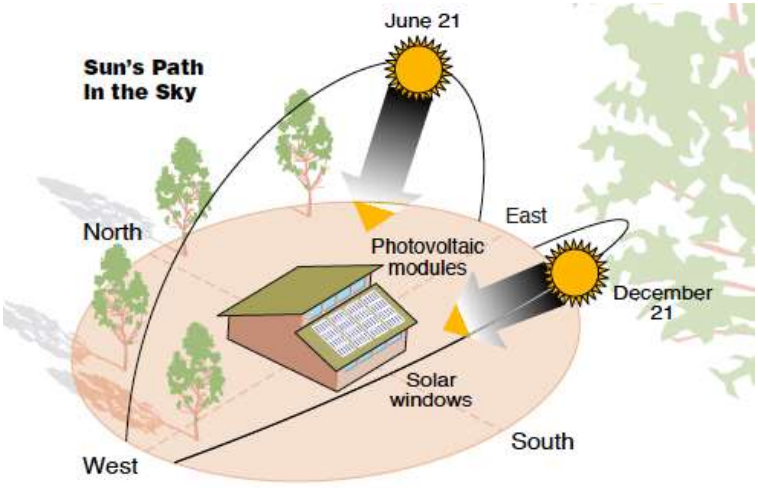


Fig. Minimize the outer surface of the building direct towards Sun, it help in summer season to minimize the heat conduction and radiation.

2. Plan Forms

Energy performance of building also depends upon the plan forms used for the building design. It affects the building block by means of temperature, natural cross ventilation, heat loss, day lighting and other parameters such as structural stability, construction cost, labors, cost, materials etc. The plan form in regular shape like rectangular, square etc. have better performance than triangular, circular or other dynamic shape.

Thus in rectangular plan form window openings works effectively than in circular walls.

Mutual Shading Platforms -Plan form should be such that a structural component of the building or building element acts as shading to the building. Also the clusters of building acts as shading on each other which reduces the cooling load of the adjacent building.

Thus energy optimization in terms of electricity cost and other savings takes place. Plan form also affects the wind velocity and wind speed striking to the wall which affects the ventilation and inside conditions of the building which in turn affects the energy performance of building.

3. Internal Layout of Building i.e. Space Efficient Building,

Spaces can be classified according to need of the user. Grouping rooms with similar uses together for creating diff. zones will help in evolving proper design solution.

4. Fenestration and Shading

1 It means the arrangement of windows, openings in the building or a room. Thus of all the element in the building envelope, windows and other glazed areas are most venerable to heat gain and losses. Proper location, sizing and detailing of windows and shading form an important aspect in energy optimization in building design.

2 The location of openings for ventilation is determined by prevalent wind direction openings at higher levels naturally aid in ventilating out hot air, size shape and orientation of openings moderate air velocity and flow in the room. A small inlet and large outlet increase the wind velocity and distribution of air flow inside the room. The house should be so designed that it takes it takes advantage of prevailing wind.

3 Fenestration having 15% to 20% of floor area are found adequate for both ventilation and day lighting in hot and dry, hot and humid regions.

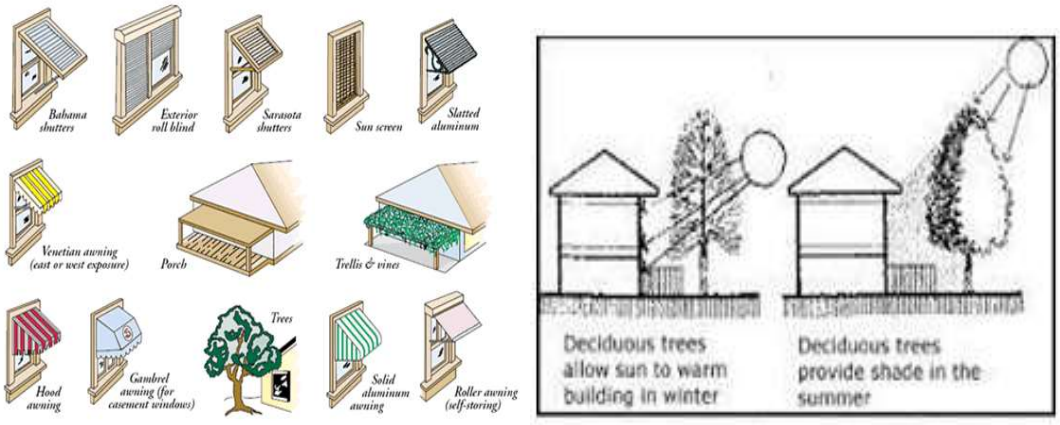


Fig. Sun shading

Well designed sun control and shading devices can dramatically reduce building peak heat gain and cooling requirements and improve the natural lighting quality of building interiors. Depending on the amount and location of fenestration, reduction in annual cooling energy consumption of 5% to 15%. Sun control and shading devices can also improve users visual comfort by controlling glare and reducing contrast ratios. Thus, solar control and shading can be provided by a wide range of building components including:

- Landscape features such as mature trees or hedge rows;
- Exterior elements such as overhangs or vertical fins;
- Horizontal reflecting surfaces called light shelves;
- Low shading coefficient (SC) glass; and,
- Interior glare control devices such as Venetian blinds or adjustable louvers.

5. Courtyard

Due to incident solar radiations in courtyard, air gets warmer and rises.Cool air from the ground level flows through the openings of rooms surrounding courtyard. They facilitate not only natural air & light into inner areas but also high degree of cross ventilation. Courtyard makes building safe from large heat intake and glare. Acting as a large evaporator cooler during summer, it promotes enormous cooling without mechanical aids.

Landscaped courts are great moderator of microclimate within building.

6. Landscaping

Landscape is an important element in altering the microclimate of a place. Proper landscaping reduces direct sun from striking and heating up the building surfaces. It prevents light carrying heat into a building from the ground or other surfaces.

1. Landscaping creates different airflow patterns and can be used to direct the wind advantageously by causing a pressure difference.
2. A shade created by the tree reduce the temperature to the adjoining wall a structure element by 2 degree c to 3 degree c
3. The trees mostly affect solar radiation. Trees absorb mostly solar radiation by way of evaporation due to which cooling effect is developed. Planting of trees and shrubs can reduce the cooling load of the surrounding buildings by 15 to 35%.
4. Plantation of deciduous plants on southern side cut off direct sun during summer and allows the sun to heat the building in winter.
5. Properly designed terrace gardens help to reduce heat gain in building.
6. Water is good modifier of microclimate it takes up large amount of heat in evaporation and causes significant cooling especially in hot and dry climate.

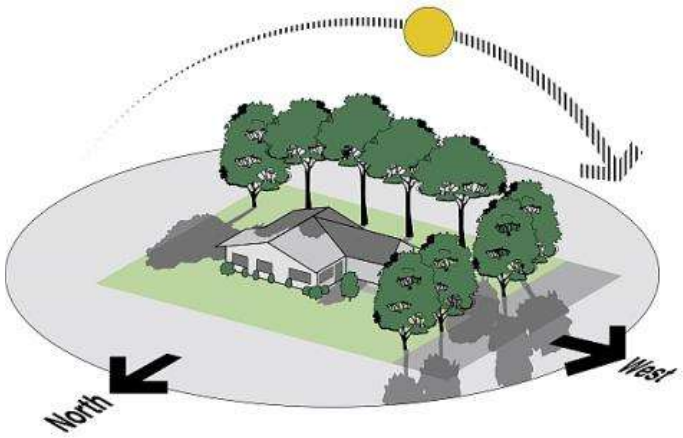


Fig. Landscaping in Optimizing Energy.

7. Building Materials and Construction Techniques

The building envelope and its components are key determinants of amount of heat gain & loss and wind that enter inside. The primary elements affecting the performance of building envelope are

1. Materials and construction techniques,
2. Roofs
3. Walls
4. Fenestration and shading
5. Finishes

Materials with low embodied energy. Strain on conventional energy can be reduced by use of low energy materials, efficient structural design and reduction in transportation energy.

i) Foundation-In normal building 20% will be foundation cost of overall building cost. By using stone or brick load bearing foundation or the locally available materials are used than there will be much saving in material cost and transportation energy

ii) Roofing: It receives significant solar radiation and plays an important role in heat gain or losses, day lighting and ventilation. Broken china mosaic can be used as top most layer in roof for reflection of incident radiation. A cover of deciduous plants or creepers can be provided. Evaporative from leaf surface will keep the rooms cool. Filler slab can provided.

Fig.: Roofing : Broken china mosaic

Fig.: Filler Slab

iii) Walling: Walls are major part of building envelop and receives large amount of solar radiations. The heat storage capacity and heat conduction property of walls are key to meeting desired thermal comfort condition. Brick jali work-It cashes light and air and diffuse light allowing the privacy and security and thereby reducing the quantity of bricks.

Rat Trap Bond- In rat trap bond 25% quality of bricks are saved. This bond requires less cement mortar and hence there is saving up to 40% cost. Such walls give better performance in insulation and acts as cavity walls.

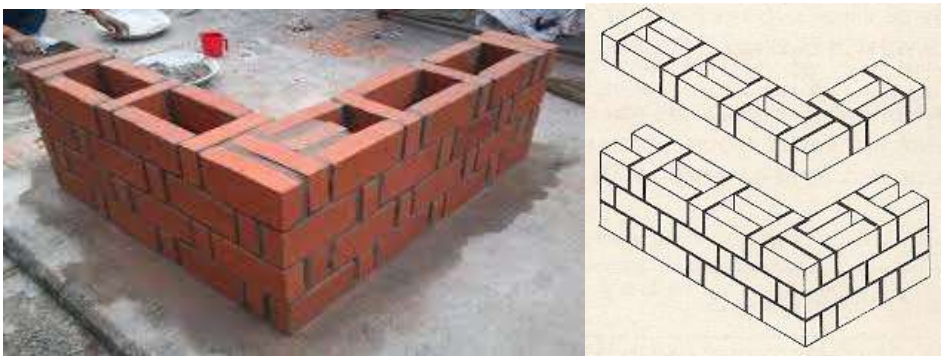


Fig.: Rat Trap Bond

iv**) Finishes:**

External finishes of surfaces determine the amount of heat absorbed. I.e. smooth and light colour surface reflect more light and light, it have higher emissivity and can be ideally used for warm climate.

8) Uses of Energy Efficient Sources and Its Appliances.

By using the renewable energy sources the load on the conventional system will be reduced and there will be high cost saving and energy optimization. Renewable sources are like solar energy, wind energy etc. The biggest advantage of renewable energy sources is that they do not pollute the atmosphere

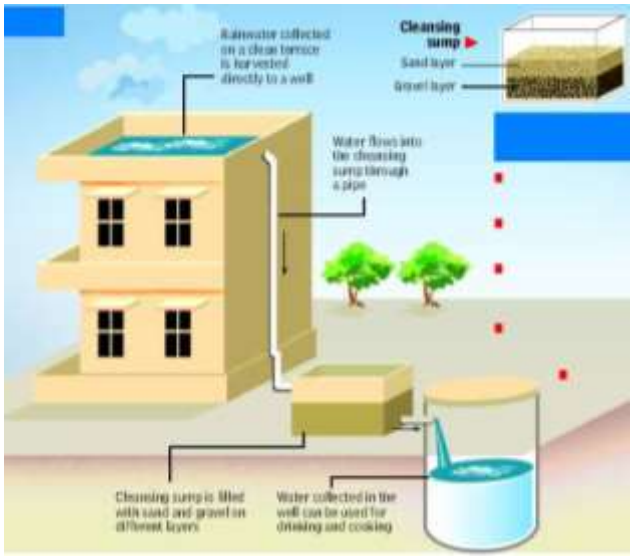
Renewable energy technologies such as solar photovoltaic energy will play an important role in creating a sustainable electricity system while reducing the harmful effects that current electricity production has on natural environment. Solar energy has the ability to transform produce our electricity needs without compromising the well being of the natural environment and all that inhabit our earth.

Fig.: Renewable Sources

Wind power involves converting wind energy into electricity by using wind turbines. Wind power is a clean energy source that can be relied on for the long-term future. A wind turbine creates reliable, cost-effective, pollution free energy. It is affordable, clean and sustainable. One wind turbine can be sufficient to generate energy for a household. Because wind is a source of energy which is non-polluting and renewable, wind turbines create power without using fossil fuels, without producing greenhouse gases or radioactive or toxic waste. Wind power reduces global warming

9) Waste Management-Wastewater treatment is a process used to convert wastewater which is water no longer needed or suitable for its most recent use - into an effluent that can be either returned to the water cycle with minimal environmental issues or reused.

10) Water Harvesting-



Water harvesting is nothing but collection & storage of rain water & other activities harvesting surface & ground water, preventing loss through evaporation & seepage

IV) CONCLUSION-

Thus by studying the energy optimization in building design ,we can conclude that an energy efficient building balances all the aspects of energy use in building –lighting ,space conditioning ,ventilation etc.-by providing an optimized mix of passive solar design strategies .energy efficient equipments ,and renewable sources of energy. Use of materials with low embodied energy also forms a major component in energy efficient building design. Also the use of

renewable energy sources for meeting the energy demands of building contributes a lot in optimizing energy use in building sector. Also another neglected portion is the reuse or recycling of the waste or deriving energy out of it ,which may lead to reducing energy load a little bit. Thus a study of it may surely lead to awareness among the society and some new innovations in this direction. Thus better hope for a sustainable future ahead.

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