FACTORS GOVERNING THE DESIGN ASPECTS OF SUSTAINABLE BUILDING IN DIFFERENT CLIMATIC ZONES

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Abstract- A structure is essentially a modifier of microclimate; the space is isolated from humidity fluctuations and climate temperature sheltered from precipitation, prevailing winds and with an enhancement of natural light. We are ignoring the environment in today's age of urbanization, it leads to an environmental imbalance and mainly the construction industry plays massive role in this. The resources are wasted and pollution is created, during and after the construction process due to faulty planning. The sustainable building design provides solutions to above mentioned problems. It makes the environment green and clean. The sustainable building will minimize the demand of usage on non-renewable resources and maximize the recycling, utilization of renewable resources and reuse. By understanding the factors, techniques and design that governs the sustainable building, we can construct the sustainable building which will consume the resources without compromising the future needs. The minimization of mechanical appliances for lighting and ventilation purpose, minimization of resources and prediction of the solar radiation for the existing or newly constructed buildings is explained in this article which will be helpful for the design and construction use.

Index Terms- Sustainable Building, Climatic Zones, Modeling, Radiation

I. INTRODUCTION

According to Giaccardo, (2004) the green design is defined as a planning and construction which will eliminate or reduce the negative impact of buildings on occupants and environment in five areas namely sustainable site planning, energy efficiency and renewable energy, safe guarding water and water efficiency, indoor environmental quality and conservation of materials and resources [1].
Sustainable building will reduce the natural resources to the least possible during its operation and construction. This paper explains about the maximum usage of efficient building materials and construction process, equipments to meet air-conditioning, lighting with minimum power consumption and use of the renewable energy. By this we can achieve comfortable, pleasant and conductive structures that ensure psychological and physiological comfort to the occupants in the buildings.

II. KEY PRINCIPLES ASSOCIATED WITH GREEN BUILDING DESIGN

The key principles associated with the green building design are sustainable site design, water conservation and quality, energy and environment, indoor environmental quality, conservation of materials and resources [2].

Sustainable site design: Site analysis is carried out to break down the site in to basic parts, to isolate an areas and the systems requiring protection and also to identify the on-site and off-site factors that may require modification. It includes the identification of soil types and its properties and slope orientation [3]. It also minimizes the urban sprawl, unnecessary destruction of valuable land, green space and habitat, which result from the incompetent low density development. Encourage the higher density urban development, urban renewal, urban re-development and brown field development as a means to preserve the valuable green space [2].

Water conservation and quality: Emphasis must place on on-site filtration, retention on storm water and ground water recharge using techniques that closely match natural systems. Reduce the needless usage of potable water on the site. Maximize the reuse and recycling of water, including storm water, harvested rain water and grey water [2]. The waste water that comes from cloth washers, baths and showers is called grey water and can be irrigated through sub-surface irrigation. The sub-surface distribution systems used are Evapotranspiration systems, shallow trench and shallow mound [4].

Indoor environmental quality: Provide a design for building which gives good ventilation, indoor air quality, thermal comfort access to day lighting and natural lighting and effective control of acoustical environment [2].

Energy and environment: Reduce adverse effect in the environment by optimized building design, optimized building siting, and aggressive usage of energy conservation measures and material selection [2]. The consumption of energy in the building can be reduced by adopting new equipment's and techniques instead of using conventional equipment's for domestic works such as solar water heater, solar lantern, use of biogas etc. [4].

Conservation of materials and resources: Green building materials are made of renewable resources instead of non-renewable resources and also result in low maintenance and replacement cost throughout the life of a building. The materials should be zero or low toxic content, highly recyclability, longevity, durability and local production [5]. Utilization of highly recycled contents material in the structure and the finishes will minimize the waste disposal. Encourage blended concrete using slag, fly ash, recycled concrete aggregate and further admixtures to recycled content materials such as ceiling and floor tiles, structural steel, carpet padding, gypsum wallboard and sheathing will conserve the resources [2].

III. TECHNIQUES USED FOR SUSTAINABLE DESIGN

3.1 ADVANCED PASSIVE HEATING TECHNIQUES

The techniques used for sustainable building design to achieve thermal comfort in the cold climate are classified into direct gain, indirect gain and isolated gain systems.

3.1.1 Direct gain system

The commonly used system is termed as direct gain system. In the living space the radiant heat directly shines through the south facing windows and it was absorbed by a thermal mass. Here the building itself act as some storage devices for the heat. Then the heat will be re-radiated from the buildings (inner walls/ floors) core and heat (outer walls and air) interior space during the night [7].

3.1.2 Indirect gain system

The water wall, trombe wall, mass wall and roof pond are an indirect gain system that combines a collection, storage and the distribution functions within some parts of building envelope, which encompasses the space [10].

Trombe and water wall- Trombe wall is a thermally massive wall provided with vents at the top and bottom. The outer surface of the wall is usually painted black for maximizing absorption and the wall will be placed behind glazing with an air gap in-between. The air in the space between the wall and glazing gets heated up and enters living space by convection through the vents. Solar radiation is stored as sensible heat by the wall. The vents are closed during night and heat stored in the day time heats the room by conduction and radiation. The **water wall** will work same as trombe wall except they employ water as the thermal storage material. This is a thermal storage wall made of drums of water stacked behind glazing and they are painted black to increase absorption. Heat transfer is more in the trombe wall. Main disadvantage is this method needs more amount of water [6].

Roof based air heating system- In this the incident solar radiation are trapped by the roof and used for heating the interior spaces. Between the insulation and roof, an air pocket is formed, which is heated by the solar radiation. The moveable insulation can also use to minimize heat loss during night by glazing panes [6].

3.1.3 Isolated gain systems

Sunrooms- Sunrooms are constructed using overhead or sloped glass. A thermal wall on back of the sunroom against the living space will work as an indirect gain thermal mass wall. By this, the additional heat can be brought into the room via low and high vents like an indirect gain thermal wall [8].

3.2 ADVANCED PASSIVE COOLING TECHNIQUES

3.2.1 Ventilation and wind tower

For **ventilation** the air movement is created by outdoor breezes through the interior of the house by the "push-pull effect of negative pressure on the leeward side and positive air pressure on the windward side. In wind tower, the hot air will enter the tower through the openings in the tower, they will get cooled and become heavier and they sink down. The tower wall will absorb the heat during daytime and release it during night time, thus warming the cool night air in the tower [6].

3.2.2 Evaporative cooling

Evaporative cooling is employed to improve the thermal comfort in the structure. The direct evaporative cooling is introduced into the conditioned space air that is exposed to liquid water. There is a conversion of sensible to latent heat by evaporation at a constant wet bulb temperature, so the air supplied is not only in cooler condition, but also humid. Indirect evaporative cooling minimizes the air dry bulb temperature without increasing its moisture content: that the air supplied to a conditioned space will be fed into the heat exchanger that will contain water or air that has been separately cooled by a direct evaporative cooler [11].

In courtyards from the ground level the cool air flows through louvered openings of foams surrounding the courtyard, hence produce air flow [6]. At the depth of 4m below the ground level, a earth air tunnel is fixed which is in the form of pipe, so an ambient air ventilated through the tunnel will get warmer in winter and cooler in summer [6].

IV. DESIGN FOR VARIOUS CLIMATIC ZONE

4.1 Design aspects for Hot-Arid Zone

Grid diagonal to east west axis: The grid pattern maximizes radiation throughout its straight streets, but by orienting the grid pattern diagonally to the east-west axis, the sun exposure and shade is better distributed on the streets, such a grid still supports the dynamic movement of air [5].

Narrow, zigzagging alleys: Winding or zigzagging narrow alleys receive minimum radiation, reduce the effect of stormy winds, establish shaded spaces throughout the day which provide a cool and comfortable microclimate and also stay relatively warm during cold nights and in winter [5].

Blocked streets and alleys: Street orientation and the housing patterns are significant and should be planned carefully. Straight and parallel streets open the city to wind ventilation. Storm effects can be reduced by blocking streets. Two-storey buildings with a closed patios open to the sky will minimize radiation, maximize shade, yet still retain ventilation and reduce the effects of stormy winds. Buildings should be attached (cluster) to reduce exposed surfaces [5].

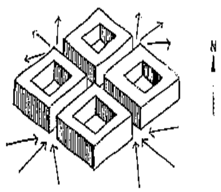

Fig.4.1 (a) Grid diagonal to east west axis

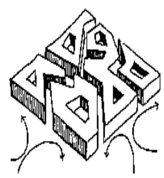

Fig.4.1 (b) Zigzagging alleys

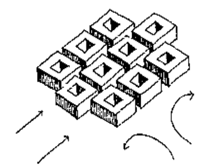

Fig.4.1 (c) Blocked streets

4.2 Design aspects for Warm Humid Region

To provide sufficient air circulation, buildings should be scattered and have a low population density. Buildings should be separated with large, free spaces between them. This allows airflow, which provides ventilation for hygienic environment and cooling.

Sun orientation: Settlements should place on northern or southern slopes that are facing away from equator. So north and south slopes will receive less radiation than east and west slopes.

Room arrangements: The Bedrooms can be adequately located on the east side, where it is coolest in the evening. Good cross-ventilation is especially important for these rooms because, at rest, the human body is more sensitive to climate. On the other hand, the stores and other auxiliary spaces can be located on the west side.

Kitchen: The kitchen is mainly used during morning and midday hours; it can be located on the west side as well.

Main room-The main rooms which are in use most times of the day, such as living rooms, should not be located on the east or west side.

Rooms with internal heat load: Rooms where internal heat occurs, such as kitchens, should be detached from the main building, although they can be connected by a common roof.

Wet Rooms: Special attention should be given to the arrangement of rooms with a high humidity (bathrooms). Here a proper cross-ventilation is especially important to avoid mould growth.

Cross-ventilation: The high humidity and warm temperatures require maximum ventilation, which leads to very open buildings. This is valid not only for the design of the elevations, but also for the floor plan.

4.3 Design aspects for Temperate and Upland Zones

To resist the heat gain, the exposed surface area to be decreased by proper shape and orientation of the building. To increase the thermal resistance roof insulation should be done on west and east walls. The shading to be increased in east and west walls, if there is a glass window it can be protected by overhanging roof and shading can be provided by trees and fins. To promote heat losses provide exhausts and windows. The air exchange rate is increased by arrangements of openings and courtyards.

The orientation of building must be faced on south direction. The form will depend on the precipitation patterns. In winter there must be a heat gain and in summer there must be a shade for the building. The ventilation provided also is in a controllable condition. The building must be in elongated shape towards the east-west axis. For the utilization of winter sun, the southern front can properly have designed and also there will be protection from summer sun. the windows can be placed along the eastern side to receive the heat in the morning time, which will more valued in winter time. In west side, the large windows should be avoided; if not the incoming solar heat gain will coincide with the greater air temperature.

V. MODELING

In sustainable buildings, orientation is a major design aspect, mainly regard to solar radiation, daylight, and wind. The orientation of the building should be based on whether cooling or heating is predominant requirement in the building. The amount of solar radiation

falling on the surface varies with orientation. The modeling was carried out using Autodesk Ecotect Analysis software for three climatic conditions namely, warm humid climate (Chennai), hot arid climate (Jodhpur) and temperature climate (Bangalore).
The solar radiation chart for various regions along all four directions namely orientation along North, East, South and West were prepared and presented in Fig. 4.2 to Fig.4.4 respectively.

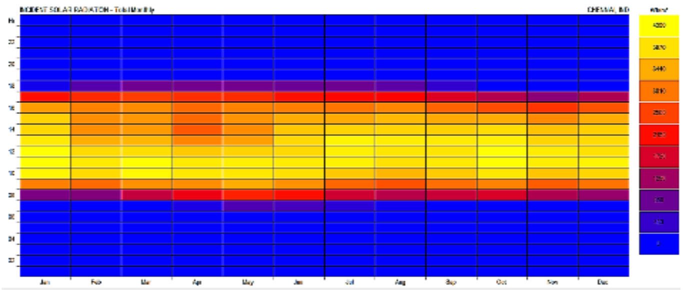

Fig.4.2 (a) Chennai Region Solar Radiation North axis

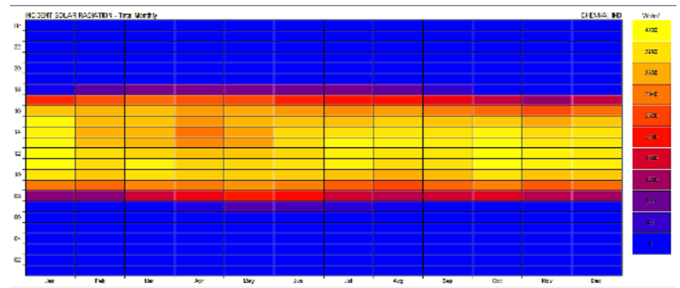

Fig.4.2 (b) Chennai Region Solar Radiation South axis

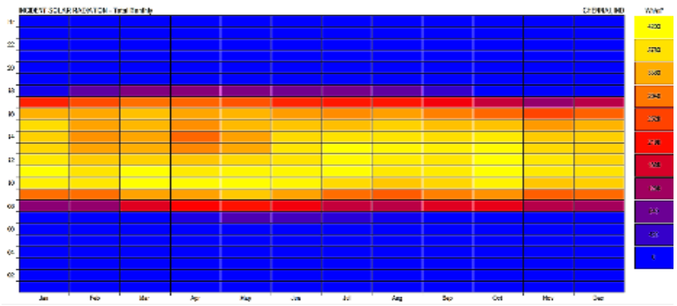

Fig.4.2 (c) Chennai Region Solar Radiation East axis

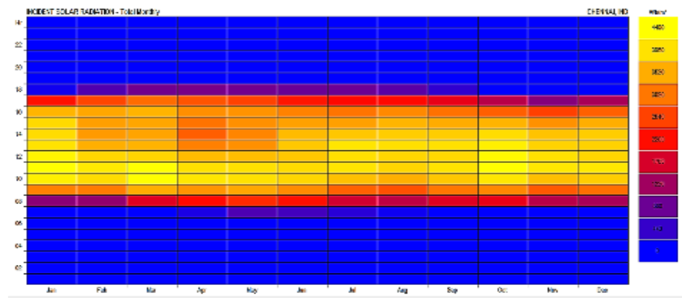

Fig.4.2 (d) Chennai Region Solar Radiation West axis

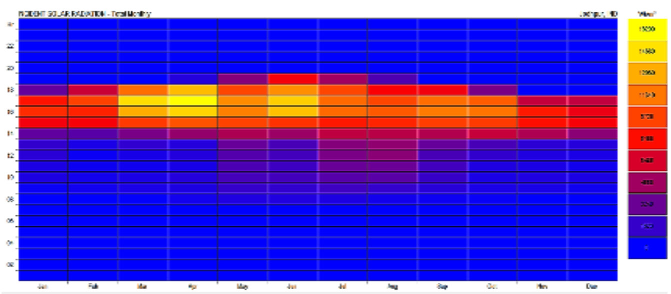

Fig.4.3 (a) Jodhpur Region Solar Radiation North axis

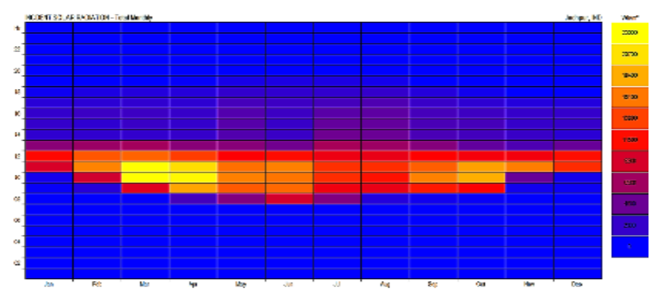

Fig.4.3 (b) Jodhpur Region Solar Radiation South axis

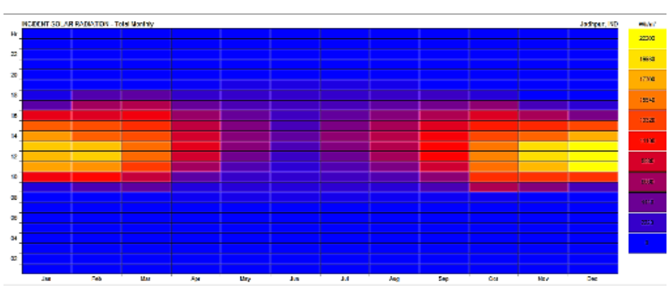

Fig.4.3 (a) Jodhpur Region Solar Radiation East axis

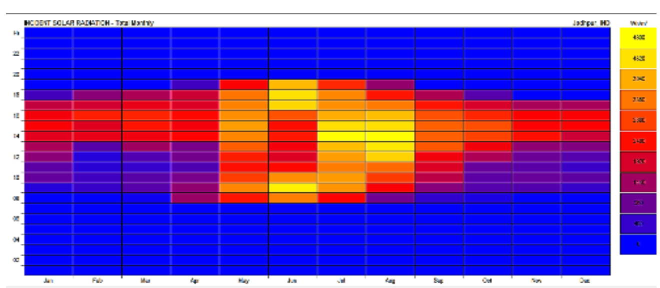

Fig.4.3 (b) Jodhpur Region Solar Radiation West axis

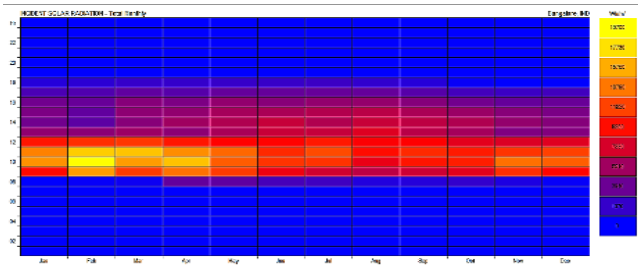

Fig.4.3 (a) Bangalore Region Solar Radiation North axis

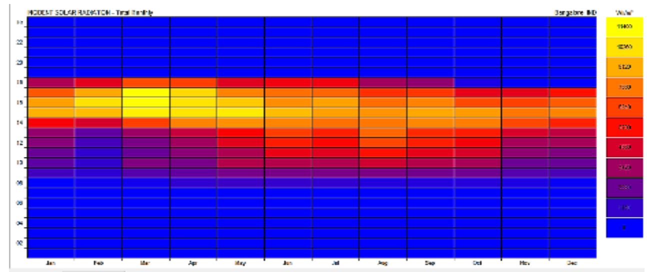

Fig.4.3 (b) Bangalore Region Solar Radiation South axis

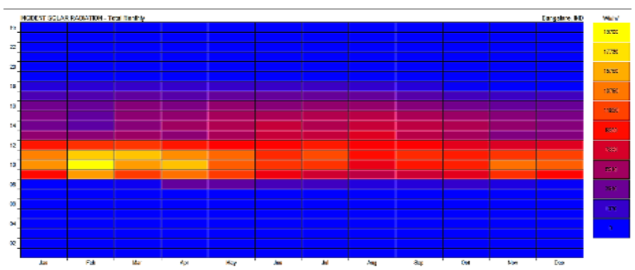

Fig.4.3 (a) Bangalore Region Solar Radiation East axis

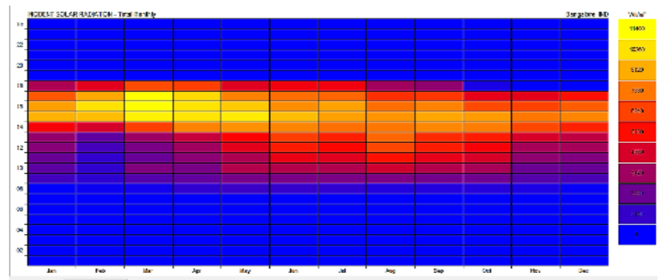

Fig.4.3 (b) Bangalore Region Solar Radiation West axis

From the solar radiation charts it was observed that, in India building oriented towards north-south are preferred. South orientation receives a maximum radiation during winters, which is preferable for India condition. East and West receives maximum radiation during summer, West orientation will have maximum solar radiation during evening which is more crucial climate.

VI. CONCLUSION

The sustainable building design was carried out to achieve comfortable, pleasant and conductive structures that ensure psychological and physiological comfort to the occupants in the buildings. It was observed that north-south orientation is preferred for Indian climatic conditions.

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