SOLAR AND GREEN BUILDING GUIDELINES FOR HOT ARID CLIMATE IN INDIA

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There are, presently, two schools of thought when it comes to designing buildings that promote sustainable development. One school emphasizes materials use and “green” buildings, while the other emphasizes energy use and energy efficient buildings. The promoters of “green” buildings often claim that the reduced energy use during operation of the low energy and solar buildings is counteracted by the increased embodied energy in these buildings. This paper gives categorical analysis of the technologies available for Low energy and green architecture and emphasizes the need to integrate both in residential buildings to of lower the energy use in operation during the lifetime in a residential building in hot arid climate. The results also show that there should be little difference between the approaches of the two schools of thought. The best buildings will generally be those that are both low energy, and “green”. This paper also gives policy guidelines to integrate them in the building bye-laws for hot arid climate.

Keywords: green architecture, green buildings, solar architecture, hot arid climate, low energy intensive materials, orientation of building, building bye-laws

1. Introduction

In order to produce buildings that promote sustainable development, several problems have to be addressed. One of the major problems is energy use in these buildings. Other problems, for instance material use, involving issues such as recyclability, waste minimization, and the impact on indoor air quality, are also important, but energy is the single most important factor. The reasons for this are:

- energy is one of the most important resources used in buildings (both in the production of the building and during its operation), and
- energy use often has serious environmental impacts, both locally and globally.

The total amount of energy used in buildings during operation constitutes a significant part of the total amount of energy used in a country (Winther and Hestnes, 1999) Housing forms by far the most common building type throughout the world. Over 15 % of all savings in developing countries is invested in residential construction. The buildings use 1/3rd of all energy consumed in India and 2/3rd of all electricity.

The term “green architecture” is used for the integration of construction of all separate technologies disciplines involved in the research and promotion of sustainable solutions. It aims at creating environment friendly and energy efficient buildings. This entails active harnessing

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“solar energy” and using materials which do the least damage to air, water and ground. The idea is to first reduce the light and energy demands through architecture and space designing and then meet those demands by using energy.

This paper gives categorical analysis of the technologies available for solar and green architecture and emphasizes the need to integrate the solar and green architecture in residential buildings to of lower the energy use in operation during the lifetime in a residential building in hot arid climate.

2. Climate and green architecture

2.1 Hot Arid Climate

Climate in North West India, which lies between latitudes 15° and 35° (Fig. 1) north of equator, is hot arid composite climate. The sun is almost overhead at noon in the hottest months but in the winter months it has an altitude of approx. 45° at noon and in this climate hot dry winds increase the discomfort. Another climatic feature which often occurs in hot dry climates is the temperature inversion with large variation between day and night temperatures. Mean maximum air temperature for summer months is between 43 to 48°C and minimum is between 27 to 30°C while in winters mean maximum air temperature is between 24 to 30°C and minimum is between 17 to 22°C . The precipitation is slightly variable throughout the year from 300 to 600 mm per annum with maximum during the monsoon months.

Figure 1. Various climatic zones of India; Solar path diagram for latitude 26° [2]

The sky conditions are normally clear with few clouds. The sky is usually sky blue with a luminance of 1 700 to 2 500 cd/m^2 . Solar radiation is direct and strong during the day, but the absence of clouds permit easy release of heat stored during the day time in the form of long wave radiation towards the night sky. Winds are usually local often caused by temperature inversion due to hot ground and cooler upper air resulting in local whirlwinds. Vegetation is sparse and difficult to maintain because of the lack of rain and low humidity.

The factors which affect the design of a residential building in hot arid climate are topography, water, ground surface, vegetation, windbreaks and orientation. The design features in hot arid climate include features like compact form, use of materials with absorptive, insulation, and high thermal capacity, evaporative cooling, use of internal courtyards, use of reflective surfaces and brise-soleils or sun breakers.

2.2 Green Architecture

Green architecture is a general term that describes environmentally conscious design techniques in the field of architecture. Green architecture is framed by the larger discussion of sustainability. The term can be used to describe an energy and ecologically conscious approach to the design of the built environment [3].

In a building the heat loss from the body to the surroundings mainly related to the air temperature, humidity and air movement. The inter relationship of the various factors is complex and to a degree affects the other. Movement of air for instance, reduces the effect of the humidity and radiation may increase the temperature. To control the climate conditions with energy conservation in mind methods for climate control can be divided into passive and active methods (Vale and Vale, 1991).

Green buildings are buildings in which all of the materials and systems are designed with an emphasis on their integration into a whole for minimizing the impact on the globe and on the occupants. While green architecture recognizes that buildings play a role in the environment and tries to optimize the performance of the building, to conserve important resources like water land and energy [4]. For this energy intensiveness of materials is taken into consideration while selecting the building materials (Table 1).

2.3 Solar Passive Architecture

Physiological uncomfortable conditions in arid climates are mainly caused by the extreme heat and dryness and to a lesser extent by sand and dust storms. Human thermal comfort is usually found when the mean skin temperature is maintained by various means below 33.9°C and above 31.1°C [2].

Table 1. Energy Intensiveness of Materials (Krishan, A., 2001)

S no.	Material	Energy Content KWh/kg
1	Sand	0.01
2	Wood	0.1
3	Concrete	0.2
4	Sand Lime Concrete	0.4
5	Light Weight Concrete	0.5
6	Plaster Board	1.0
7	Brick Work	1.2
8	Cement	2.2
9	Glass	6.0
10	Plastics	10
11	Steel	10
12	Copper	16
13	Aluminium	56

Passive energy conserving climate control is the use of the building itself to provide warmth in winter and comfortable temperatures in the summers. This can be achieved with insulation, window shading, and placement of the building to admit the breeze or keep it away as required i.e. thermal conductivity and form of the building (Tables 2 and 3).

Table 2. Requirement for building form in relation to climate (Vale, B. and Vale, R., 1991)

Climate	Element and requirement	Purpose
Hot Arid Composite Climate	Minimize South Walls and West Walls	To Reduce Heat Gain
	Minimize Surface Area	To Reduce Heat Gain and Loss
	Maximize Building depth	To increase thermal capacity
	Minimize window wall	To control ventilation heat gain and light

Table 3. Time Lag Values of different Materials (Vale, B. and Vale, R., 1991)

Material	Thickness	U-Values	Time Lag (Hours)
Brick	4	0.61	2 - 21/2
	8	0.41	5 - 21/2
	12	0.31	8 - 21/2
Concrete	4	0.85	2 - 21/2
	8	0.67	5
	12	0.55	8
Insulating fibre board	2	0.61	0.7
	4	0.09	0.3
Wood	½	0.68	0.2
	1	0.47	0.4
	2	0.30	1

Table 4. Effect of colour and its reflectance (Krishan, A., 2001)

S. No.	Material	% Total Incident Heat Reflected
1	Tar and gravel	7
2	Slate	15
3	Grass	30
4	Copper foil:	
	Tarnished	36
	New	75
5	Paints:	
	Light gray	25
	Red	26
	Aluminium	46
	Light green	50
	Light cream	65
	White	75
6	White wash	80
7	Aluminium foil	95

While active energy conserving climate control usually starts with an energy distribution system very much like conventional one to heat and cool the building. The energy required to produce the heat or cold and to operate the required pumps and fans is taken, as much as possible from sources other than fossil fuels. The most promising untapped source of energy for this purpose is solar energy. Light colours tend to reduce building heat gain in summer. Accordingly the light coloured walls with high mass will have lowest equivalent temperature differential values (Table 4).

Hence the buildings with large thermal mass with light coloured walls and reflective surfaces are suitable for climates which require heating in winter and cooling in summer and can reduce the energy needed considerably, other than these passive cooling devices are also used to reduce the internal temperatures these are mainly of two types – radiation cooling and cooling by evaporation. Active climate control using solar energy in building is by use of air conditioners, water heaters, solar collectors and lighting powered by solar power by using photovoltaic cells. These can be integrated in the building design on the roof and south and west walls and can reduce the energy demand by $2/3^{\text{rd}}$ in a residential building in hot arid climate (Krishan, 2001).

3. Conclusion and recommendations

- Energy consumption can be reduced by adopting energy conservation techniques which begins at planning stage like – orientation, use of common walls, zoning of spaces, use of low energy intensive materials.
- Building forms should be compact and low rise, using small courtyards to provide light and air. With inward looking form of residential buildings and windowless boundary walls, the building sheltering the next.
- Massive buildings with high volume to surface ratio are advantageous since this will reduce the high external temperature.
- Medium rise apartment blocks are suitable to provide a dense and continuous urban form and to avoid exposure to west sun.
- Pale surfaces, double roofs, reflective foil insulation roof and walls is necessary.
- Small north facing windows, and no windows on eastern or western side of the house shading of any south facing opening if house site is north of 23.5° S.
- Southerly orientation calls for the combinative shadow mask.
- Westerly orientation will receive solar radiation when air temperatures are high from high altitude and low angle of sun, hence windows are to be avoided.
- For north westerly orientation vertical devices would serve well having radial mask when inclined toward north they give more protection from southern positions of sun.
- East facing windows will receive morning sun at low angle when it is warm but it could be comfortable in winters.
- Vegetation and verandahs around the house to provide shade.
- This is perfect climate for solar power.
- Evaporative coolers work well in this climate along with cooling effect of plants.
- Considerable heat storage capacity with low energy intensive materials like – bricks, stones, concrete to keep day time temperatures low.

So by incorporating these changes in design and use of green materials for construction will result in residential buildings with low energy consumption. This indicates that best buildings are those that combine equally solar, low energy and green aspects.

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