

# CLIMATE RESPONSIVE DESIGN FOR COMPOSITE CLIMATE IN AMRITSAR

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## Abstract

This paper talks about the climate responsive design techniques for composite climate. The use of natural resources i.e. solar heating natural lighting, natural ventilation is essential in building and site planning to achieve a climate responsive design which will help in achieving ecologically sustainable development. The paper describes design methods for the composite climate in the city of Amritsar, Punjab, for the design and development of buildings and sites to achieve climate responsive and ecologically sustainable development. These design techniques helps not only in ecological balance but also has an impact on economic, social and cultural environment of the place and results in evolution of different forms of urban structures.

Keywords: Climate Responsive design, Composite Climate, ecologically sustainable development, ecological balance.

## 1. Introduction

Climate responsive design to achieve ecologically sustainable development is the key to meet the needs of today, without compromising the ability to meet the needs of the coming generations. In today's world, due to modern urbanization, transition in development is required in different fields. All these developmental activities will definitely have some environmental impacts. Climate responsive design will surely find solutions for comprehensive development which will address environmental issues by upgrading economic, ecological and social gains. Architects works upon different active and passive techniques and practices to minimize the energy requirements of buildings and improve the ability of buildings to become energy efficient at its own. The designs, materials and orientation which exploit the natural energy flows around the inhabitants shall be chosen. Basic form and material shall be carefully refined to introduce solar heat or to keep out the sun as per requirement. This paper discusses in detail the various passive design techniques to achieve full use of natural resources like wind flow to for natural ventilation, passive heating and cooling techniques, which helps to achieve economic and environmental sustainability. The study will provide an assessment to understand passive design techniques and strategies for composite climate.

## 2. Research background

Climate responsive design is the important element of the urban environment and its ecosystem. The environmental, social and economic bonding holds together the stakeholders or the urban population. The existence of climate responsive urban spaces and buildings has a direct impact on the development of urban ecosystem and its non existence is responsible for degradation of urban environment. The active participation of planning experts, architects, landscape designers and stakeholders directly has an impact on sustainable development of our towns and cities, which in return upgrades the well being, health, social, economic and ecological standards of the urban settlements. Therefore climatic and environmental focus in planning plays an unprecedented part in the sustainable development of cities. Climate responsive design also provide urban environment a distinctive identity and characters like in the case of Amritsar city, distinctive architecture, arched openings, colonnades, jali for free air flow, canopies, brick façade, projected windows for better thermal performance of structures, projected wooden balconies for shades from sun, etc.

The arrangement of buildings, legibility and design of enclosures between roads, streets and open spaces, especially, high population zones, can help in preserving, shielding sun radiations, resources like wind and natural light as per design and place requirement. Hence while planning the focus shall be on adaption of the existing pattern of development to provide a quality exposure to the natural site resources like sunlight, wind flow and solar heat which are important for passive temperature control, either temperature increase or temperature reduction or natural light in building or other public spaces.

## 2.1 Hypotheses

The research gains from the hypothesis that Climate responsive design can help in reduction of use of manmade energy resources by maximum use of natural energy resources like sun, wind, light and passive techniques of energy conservation. By examining performance of traditional buildings and modern energy conservation technology, we will be able to create models of development, which can be used to positively affect the quality of urban spaces in cities from the standpoint of sustainable development. We likewise expect the results of the research to contribute to the development of workable theories of Climate responsive design for future towns and cities and villages.

## 2.2 Methodology

Climate responsive design needs the effective blending of socio-economic and environmental conformity with making of decision process. The aim of climate responsive design is to meet the needs of the today's generations and not compromising the ability of the coming generations to fulfill the needs of its own. Its base is the understanding of ecology which ensures comprehensive approach towards development and also ensures a holistic, dynamic, responsive and intuitive approach. It is a long-standing and internationally recognized concept.

Civilizations are known and identified by their legacy of architectural practices. We find in them the wisdom which has been accumulated in them over a period of thousands of years, due to comprehensive understanding of sustainable practices of survival. The arising environmental issues have forced the researchers to work upon sustainable techniques which are necessary for conservation of ecological system and protection enhancement of urban environment quality and find out solutions for problems arising out of development of physical infrastructure. The holistic approach to Climate responsive design refers to any development, urban or rural understanding, and integrating abiotic, biotic and cultural developmental components. Climate responsive design responds to the problems and opportunities of context whether social, cultural, natural, or a combination of all.

A Climate responsive building is designed, constructed and operated to minimize the total environmental and ecological negative effects while improving the energy efficiency of building and making it comfortable the users. The main dominating features of the climate responsive building is Sustainable Site planning, design optimization of building, effective energy performance of the building, use of clean renewable energy, rain water, waste water and solid waste management, sustainable construction techniques and use environment friendly building materials, sound environmental quality, maximum use of natural clean energy resources and conservation of resources like land, water, natural habitat, fauna, and improve the efficiency of the ecosystems and its operations. Climate responsive Site Planning shall focus on Site Selection, design of ecologically sustainable landscape, preserve and protect the natural flora and fauna during the designing and construction stages, soil conservation and top soil preservation, till construction is in progress. The sustainable design shall include all the existing site features at palling stage.

Use of passive cooling techniques is another measure to make buildings climate responsive in regions like Amritsar. Passive cooling techniques are most economic way of temperature control in a house which increases the energy efficiency of the building and its envelope without mechanical devices been used. These techniques are mostly dependent on natural source of heat sinks to reduce heat from the structure. It extracts cooling directly from convection, radiation and evaporation without the use of any devices run by electricity.

All passive cooling techniques depend on diurnal temperature changes and relative humidity. The application of these systems for city like Amritsar is effective due to its nature of climate being composite.

These design strategies reduce and increase heat gains to internal spaces as required. Natural Ventilation, earth air tunnels, shading, evaporative cooling, wind towers, passive down draught cooling, traditional courtyard planning effect, roof sprays etc can play its role during changing climatic conditions throughout the year in composite climatic conditions as required in a particular part of the year.

### 3. Climatic study of Amritsar

Amritsar has seen immense growth in recent times and it is expanding very rapidly and its urban morphology is also experiencing rapid changes. The increasing urban sprawl and rapid urbanization is resulting in degradation of urban environment and ecology. The urban fabric of the city is reaching the stage of breakdown in terms of social structure, ecological balance, and energy efficiency, cultural and communal expressions. The city is in urgent need of evolution of climate responsive urban development parameters and principles for the design of the urban environment that are based on comprehensive approach.

Geographical location of Amritsar is 31.6340\* N latitude and 74.8723\* E longitude. It is located at an altitude of 234 meters above the mean sea level. Amritsar is in composite climatic zone. Average temperature in winter varies between 3.7\* C to 19.4\* C and in summer it varies between 25\* C to 40\* C, in monsoon temperature drops down to 35\* C. longest days are in the month of May, June and July where average daylight is 14 hours and shortest days are January and December having average daylight 10 hours. The highest sunshine is in May average sunshine of 9.5 hours and lowest sunshine is in December and January having average sunshine of 5.9 hours. Highest average relative humidity is in August 77% and lowest relative humidity is in May 38%. Highest UV index is in June and July 12 and lowest UV index is in December and January 3. Highest rainfall is in July 231mm and lowest rainfall is in November 6mm. highest rainy days are in July 11.4 days and lowest rainy days are in November 1.2 days (source, department of weather, Government of India website)

#### 3.1 Natural Ventilation

The architectural designing with high ceilings combined with clerestory windows following the direction of the breeze at the level of double height ceiling on three walls of the building living area the warm rising air is been allowed to move out. This air rise will create zone of low pressure on the cooler floor area, thus forcing the air near the floor from other parts of the house and openings in the living areas. This will result in low pressure zone which will pull the air in larger extent from outside through openings. Using the local wind direction with right orientation of the building this air exchange can be achieved free of cost. These small ideas can save lot of energy requirements.

#### 3.2 Fenestrations and Shading

Solar radiation control is an important need for both solar heated building with passive techniques as well as cooling-load dominated structures. The most effective way of temperature control in the building is shaded fenestrations for cooling and bay windows and sun spaces for heating. Heavily insulated walls and roofs need less shading. Large shading overhangs protect the building facade from heat gains. Each project should be evaluated depending on its relative cooling needs, extend the overhang beyond the sides of the window to prevent solar gain from the side. Use of louvered shades allows more daylight to enter, while windows shall be shaded from direct sun. Solar heat gains can be reduced by recessed windows into the walls.

#### 3.3 Wind Towers

The wind towers have been a very effective traditional practice of heat control in buildings. Even in some modern buildings like solar passive hostel Jodhpur it has been used very successfully. The functioning of wind towers is very simple based on basic science of air movement with differences. The wind tower, oriented in the direction of air flow catches the hot air and it enters the tower through the openings at the

top. The adobe structured wind tower cools the hot air which move down wards and enters the living area through low openings as it gets cooled, and thus becomes heavier and sinks down. The inlet and outlet of rooms induce cool air movement. In the presence of wind, air is cooled more effectively and flows faster down the tower and into the living area. After a whole day of air exchanges, the tower becomes warm in the evenings. During the night, cooler ambient air comes in contact with the bottom of the tower through the rooms. The walls of the tower will gain heat in the daytime and shall release that heat back in night hours, thus making the air warmer during night inside the tower. Warmer air will move upwards, thus creating an upward movement, and this will bring cooler air through openings into the building. This mechanism shall work with great effect during one part of the Amritsar climate where fluctuations are high.

### 3.4 Courtyard Effect

Traditionally courtyard has been part of the planning in Amritsar. The courtyard effect for temperature control in hot season of composite climate is very effective. When the incident solar rays enters courtyard, the air in the courtyard becomes hot and with stack effect it rises above thus creating low and high pressure situation which brings in the cooler air from outside as it is heavier and fills the air gap created, thus resulting in air change. Cooler air near the earth surface moves through the louvered openings of rooms around the courtyard. During the night hours the warmer roof area loses heat due to radiation and convection. This exchanging of heat results in temperature drop at surface of the roof, which results in further temperature drop. In courtyard planning the sloping roofs which are sloping towards courtyards are more effective, as the slope in roof towards courtyard helps the air to sink in to it and further entering the living space through low windows towards courtyard. The warmer air which is lighter in weight moves out from openings at higher level in living areas. The planning of courtyard shall be such that it do not receive intense radiations from sun as it can create high temperature conditions in courtyard thus resulting in temperature rise.

### 3.5 Earth Air Tubes

Diurnal and annual temperature differences are least at a depth below the earth surface. At and below the depth of 4 m under the ground surface, the temperature remains nearly constant throughout the year and is almost equal to the annual average temperature of that area. A tube or a pipe laid at a depth of 4 m below the ground level will acquire the same temperature as the surrounding area of pipe below earth surface will have. Therefore, the ambient air passed through this tube will attain same temperature and will supply cool air in summers and warmer air in winter. This system shall be very effective in this region of composite climate. This is an economic effective system of temperature control in buildings. This system of earth tube cooling has been successfully used in composite climatic conditions of Gurugram Retreat building.

### 3.6 Evaporative Cooling

Evaporative cooling lowers indoor air temperature by evaporating water. In evaporative cooling system, the hot air is passed over the water body which helps in evaporation of water and resulting in cooling down of the hot air thus bringing down the room temperature. More is the contact between air and water higher is the evaporation rate of water. The natural or artificial water body like lake, pond, pool, or any other type closer to building or urban areas or cascades in a courtyard can effectively bring cooling effect. Traditionally in religious buildings in Amritsar water bodies has been a part of the scheme.

### 3.7 Passive Down Draught Cooling

This is another effective traditional passive cooling technique which can be successful in composite climate of Amritsar as it can be continued and discontinued as required in different part of the season. In this system, wind catchers are designed in such a way that it helps the air from outside to pass over water-filled containers, casing evaporation which results eventually in temperature drop significantly prior to the

entry of air into internal areas. These wind catchers are basically essential elements of the aesthetic character of building in terms of architectural design. Passive draught evaporative cooling can effectively be used in the hot and dry period of composite climate.

### 3.8 Alternative Energy Systems

Amritsar has good sun exposure in major part of the year thus creating a big scope for use solar energy. Electricity from hydro and other resources is becoming very expensive every year. This alternative resource of energy is pollution free and provides clean carbon free energy and is not responsible for emission of any kind of green house gases, like carbon dioxide, into the atmosphere. Solar heating and lighting systems are designed to completely make a building energy efficient. Increase in the use of commercially available energy resources, including solar, wind, geothermal, and hydroelectric, is an important component in a policy regulations to improve energy efficiency. Compact Fluorescent Lights and Light Emitting Diodes have risen in popularity in recent years due to their longer life and energy-efficient design. These bright, compact lights are designed to reduce energy consumption without compromising light or productivity. Replacing CFL by LED saves cost and energy extensively.

### 3.9 Rain water harvesting and water recycling

Water conservation is the need of the time, since it is a scarce natural resource. With growing population the water resources are getting insufficient and there is an acute need of water conservation. Water conservation can be done in three ways. The first is by reducing the water usage, like using drip irrigation system in farming and gardening, using waterless bio toilets in public buildings, using modern toilet fixtures which reduce water usage etc. Second is by collecting and harvesting rain water and after treatment in water treatment plant it can be brought to potable quality. But the process is bit expensive. Still without treatment during collection process the water can be filtered with simple sand filter process through its collection channel and used in toilet flushing, gardening, car washing and floor cleaning. The collection can be done in rain water collection tanks and excessive water can be released into swales or harvesting pits, bores, which helps in maintaining ground water table. Third way of conservation of water is recycling of sewage water after treatment in decentralized sewage treatment plant. It can be reused for irrigation in gardening etc. Sewage treatment plants now a days are easy to maintain operate as the technology has advanced in past few years. These systems are very effective and reliable in public urban projects. The popularly used decentralized wastewater treatment technology modules are septic tanks, biogas digesters, anaerobic baffled reactors, anaerobic filters, and planted gravel filters.

### 3.10 Landscaping

Vegetation has an effective part in modifying microclimate of an area. Landscaping helps in bringing down the temperature of a place as the vegetation absorbs the radiations for photosynthesis and green covers help in reduction of heat island effect. Landscaping help in reduction of air pollution, noise pollution, prevent soil erosion and help in reduction of land degradation. Ecologically sustainable landscape is the holistic approach to landscape design and it is dynamic, responsive and intuitive. Vegetation also creates different air flow patterns and if used smartly in design by landscape professionals it can reduce the energy requirements of a building to a great extent. Trees can be planted in an area such that it acts as windbreakers to protect both structures and outer spaces such as front and rear lawns and open spaces around buildings from both warm and cold winds. The velocity of the wind can be reduced by careful plantation of trees as per their shape, size and height as required by the site conditions in terms its climatic data analyzed at the time of site study.

## 4. Conclusion

This study shall provides an opportunity to understand the climate responsive design techniques for composite climate and also suggests the various methods of passive cooling and heating techniques as well as modern ideas. The designers shall take an advantage of local climatic conditions (micro climate) to achieve human comfort. The absolute comfort conditions achieved will be circumstantial and shall depend

on the building type, building material and design specifications. The forgoing description of vernacular architectural practices if examined recurrent forms, materials or life patterns may lead to newer ideas. The arrangement of buildings, streets, and open areas can either preserve or shield exposure to solar heat, wind flow and solar light resources. Ecologically sustainable design practices are available to be incorporated into design of public spaces, public realms and urban area planning and regulations, that if implemented today will provide the self sustained buildings and the use of site based energy resources will become the precedent in the coming renewable energy economy. Climate responsive design can promote and stimulate a healthier connection with the ecology and environment. Though study here describes specific reference to Amritsar it should be of value for other urban areas in the same climatic region of northern parts of India.

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